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RESEARCH ARTICLE

Variability, correlation and path-coefficient analysis in linseed (*Linum usitatissimum* L.) under late sown conditions in the north central plateau zone of Odisha in India†

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Abstract

The 140 accessions of linseed (*Linum usitatissimum* L.) germplasm including local land races, cross-derivatives and selections were evaluated under late sown conditions to study the extent of genetic variability, the association of yield component characters *inter se* and with seed yield, and the path coefficient to partition their correlations with seed yield into direct and indirect effects. Observations were recorded for eight quantitative characters, *viz*., days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of capsules per plant, number of seeds per capsule, 1000-seed weight (g) and seed yield per plant (g). The study through the analysis of variance revealed highly significant differences among the genotypes for all the eight characters. Again, the germplasm exhibited a wide range of variation for all the characters, which provides better chances of selecting the desired traits. The PCV and GCV estimates revealed that the differences in magnitude of both the estimates in case of number of primary branches per plant, number of capsules per plant and seed yield per plant were relatively higher, indicating higher degree of influence of environment. Moderate heritability coupled with moderate genetic advance for 1000-seed weight suggested the predominant role of non-additive gene action. Basing on phenotypic and genotypic correlations of seed yield with other component characters, for improvement of seed yield due importance should be given to days to 50% flowering, number of capsules per plant, 1000-seed weight, plant height, and number of seeds per capsule. High positive direct effects of days to 50% flowering, number of capsules per plant and 1000-seed weight was observed on seed yield both at phenotypic and genotypic levels in a path coefficient analysis. So, under late sown conditions for improvement of seed yield the selection criteria should be more days to 50% flowering and higher number of capsules per plant with moderate 1000-seed weight.

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Introduction:

Linseed (*Linum usitatissimum* L) is the second most important winter (*rabi)* oilseed crop and stands next to rapeseed- mustard in area and production in India. Although linseed plants have several utilities, it is commercially cultivated for its seed, which is processed into oil and after extraction of oil, a high protein livestock feed is left (Sankari, 2000; Kurt and Bozkurt, 2006). Linseed oil has been used for centuries as a drying oil whose oil content varies from 33-45% (Gill, 1987). 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, oilcloth, linoleum, printing ink etc. Linseed has an important position in Indian economy due to its wide industrial utility. But the national average productivity of linseed seed is quite low as compared to other countries (Srivastava, 2009). As per Food and Agriculture Organization (FAOSTAT, 2014), India ranks 4th among world's linseed producing countries. However, in terms of productivity, India (392 kg/ha) is far below than Switzerland (2647 kg/ha), Tunisia (2633 kg/ha), U.K. (2600 kg/ha), France (2121 kg/ha) and New Zealand (1853 kg/ha). In India during 2013-14 linseed is grown in an area of 292.1 thousand hectares with annual production of 141.2 thousand tonnes and productivity of 484 kg/ha. Out of 15 linseed growing states, the major are Madhya Pradesh (110.4 thousand ha), Maharashtra (31.0 thousand ha), Chhattisgarh (26.2 thousand ha), Uttar Pradesh (26.0 thousand ha), Jharkhand (25.5 thousand ha), Odisha (22.9 thousand ha) and Bihar (18.7 thousand ha) (Anonymous, 2015a). In Odisha, the annual production is 11 thousand tonnes with productivity of 478 kg/ha. The North Central Plateau Zone of Odisha comprising the districts of Mayurbhanj and Keonjhar contributes to about 50.6 % of the total area of the state (Anonymous, 2015b). However, a significant number of farmers are forced to sow linseed one month late due to excess moisture in the field. Seed setting is highly affected due to higher temperature during later phase of growth decreasing seed yield significantly (Dash *et al*., 2011). So, an experiment was laid out to evaluate the nature and extent of variability, correlation of the component characters *inter se* and with seed yield, and also to partition their correlations with seed yield into direct and indirect effects under late sown conditions. It would facilitate identification of selection criteria for late sown conditions.

Materials and methods:

One hundred forty genotypes of linseed including six local land races of Odisha and 134 cross-derivatives and selections from different sources within and outside Odisha were sown one month late during November, i.e., on 22.11.2006 and 22.11.2007. The local land races were purified during previous two years. The field trial was laid out in a randomized complete block design with two replications at the Regional Research and Technology Transfer Sub-station of OUAT at Jashipur, Mayurbhanj, Odisha (latitude : 21^{o} 57' N, longitude : 86^{o} 06' E, altitude : 400 m above mean sea level, annual rainfall : 1475 mm, soil : red lateritic, sandy loam and acidic). Each genotype was sown in a single row of 3 m length with a spacing of 30 cm × 5 cm between and within the row respectively. The sowing depth was 2-3cm. Recommended package of practices was followed to raise a good crop. Ten randomly selected competitive plants from each row were used to record the biometric observations of plant height (cm), number of primary branches per plant, number of capsules per plant, number of seeds per capsule and seed yield per plant (g). But days to 50% flowering, days to maturity and 1000- seed weight (g) were recorded on whole row basis.

The replication wise mean values for the individual character of different treatments and pooled means over two years were undertaken for analysis of variance. Character wise range, mean, Standard Error of Mean (SEm), Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), Heritability in broad sense (H) and Genetic Advance as percentage of Mean (GA%M) at 5% selection intensity were estimated following standard biometrical methods. Phenotypic and genotypic correlation coefficients were estimated from the respective variance and covariance components (Singh and Chaudhary, 1985). Path-coefficient analysis was done as described by Dewey and Lu (1959), which was subjected to statistical analysis through Statistical Package for Agricultural Research (Doshi and Gupta, 1991).

Results and discussion:

A. Variation and genetic parameters

The experiment was conducted during winter (*rabi)* seasons of 2006-07 and 2007-08. The analysis of variance (ANOVA) was carried out for both the years individually and also over pooled data for all the eight characters. The pooled analyses of variance for eight quantitative characters in linseed are presented in Table 1. The analysis of variance and F-test revealed highly significant differences among the genotypes for all the eight characters in both the years. Pooled analysis also exhibited highly significant differences among the genotypes for all the characters. However, year × genotype interaction was highly significant for all the characters. It revealed that the genotypes had shown different responses in different years.

The pooled estimates of genetic parameters of variability such as range, Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), Heritability in broad sense (H), Genetic advance (GA) and Genetic advance as percentage of mean (GA **%**M) presented in Table 2 were computed to have a better understanding of the nature of the gene action for various quantitative characters for an effective breeding programme.

Range

The range indicated a broad base of variation among the 140 test genotypes for all the characters except number of primary branches per plant (0.00-1.73) and number of seeds per capsule (6.60-9.02). A wide range of variation was also found for all or almost all these characters by Satapathi *et al*. (1987), Muduli and Patnaik (1993), Naik and Satapathy (2002), Sarkar (2005) and Rao (2007). However, Gupta *et al.* (1999) observed broad range only for number of primary branches, capsules and seed yield.

PCV and GCV

The phenotypic coefficient of variation (PCV**)** ranged from 3.07% for days to maturity to 77.92% for number of primary branches (Table 2). The PCV estimates would show that the phenotypic variability was low (below 10%) for days to 50% flowering (5.39%), days to maturity (3.07%), plant height (8.66%) and number of seeds per capsule (8.95%), moderate (10-20%) for 1000-seed weight (12.86%) and high (above 20%) for number of primary branches per plant (77.92%), number of capsules per plant (31.84%) and seed yield per plant (26.96%). The values of genotypic coefficient of variation (GCV) exhibited similar pattern of PCV for all the eight characters. Among the characters studied, the estimates of GCV ranged from 1.62% for days to maturity to 38.17% for number of primary branches per plant. This higher value of GCV for number of primary branches per plant indicates high potential for effective selection (Bibi *et al*., 2013). The PCV and GCV estimates revealed that the differences in magnitude of both the estimates in case of number of primary branches per plant, number of capsules per plant and seed yield per plant were relatively higher, indicating higher degree of influence of environment. The environmental effects could be due to the heterogeneity in soil fertility status and other unpredictable factors (Reddy *et al*., 2012).

In the present investigation, as expected**,** the PCV estimates were higher than the GCV estimates because the former includes the variation due to environment as well as variation due to interactions. However, there was a close correspondence between the estimates of PCV and GCV for the characters, *viz.*, days to 50% flowering, days to maturity, plant height, number of seeds per capsule and 1000-seed weight under study indicating the fact that these characters were less influenced by the environmental factors as evidenced from the less differences in magnitude of PCV and GCV. In contrast, other characters, *viz*., number of primary branches per plant, number of capsules per plant and seed yield per plant were highly influenced by environment as evidenced from high magnitudinal difference between the estimates of PCV and GCV. Hence, selection for these characters sometimes may be misleading. These environmental factors could be due to the heterogeneity in soil fertility status and other unpredictable factors (Reddy *et al*., 2012). Similar pattern of PCV and GCV was reported by several workers for all or most of these characters (Satapathi *et al.*, 1987; Muduli and Patnaik, 1993; Malik and Singh, 1995; Gupta *et al*. 1999; Naik and Satapathy, 2002; Rao, 2007 and Tadesse *et al*., 2010).

Heritability

In the present study, the heritability in broad sense (H) ranges from 14.5% in number of capsules per plant to 50.3% in 1000- seed weight (Table 2). Moderate estimate of heritability (30-60%) was found in 1000-seed weight (50.3%), plant height (43.2%) and days to 50% flowering (37.5%) under late sown conditions. The rest characters showed low estimates of heritability (below 10%). It showed that the phenotypic variability in these characters had greater share of environmental one. High estimates of heritability were reported earlier for seed weight (Gupta and Godawat, 1981; Satapathi *et al.* 1987; Muduli and Patnaik, 1993**;** Khan and Gupta, 1995; Malik and Singh, 1995**;** Naik and Satapathy, 2002; Sarkar**,** 2005; Rao**,** 2007; Pali and Meheta, 2013), and for plant height (Gupta and Godawat,1981**;** Satapathi *et al*. 1987**;** Muduli and Patnaik. 1993; Malik and Singh,1995; Gupta *et al*.1999; Naik and Satapathy, 2002; Sarkar, 2005**;** Rao, 2007; Pali and Meheta, 2013) and days to 50% flowering (Gupta and Godawat**,** 1981; Satapathi *et al.* 1987; Muduli and Patnaik, 1993; Malik and Singh**,** 1995; Naik and Statapathy, 2002; Sarkar, 2005**;** Rao, 2007; Pali and Meheta, 2013). However, Khan and Gupta (1995) and Tadesse *et al*. (2010) reported moderate estimate of heritability for plant height.

Genetic advance

In the present study, the GA % M ranged from 1.77% (days to maturity) to 39.29% (number of primary branches per plant). But it was low (below 10%) for rest of the characters except 1000-seed weight of 13.35% (moderate).

Moderate heritability (50.30%) coupled with moderate GA% M (13.35%) was observed for 1000- seed weight indicating that this character seems to be heritable and can be improved by selection. But moderate heritability with low GA%M was observed for plant height and days to 50% flowering. However, number of primary branches per plant had low heritability (24.0%) with high genetic advance (39.29%) which indicated the greater influence of environment and selection would be ineffective. Vijayakumar and Rao (1975) and Gupta and Godawat (1981) reported high genetic advance for branches per plant, capsules per plant, yield per plant and seed weight but low genetic advance for plant height. Low genetic advance for seed weight, plant height and days to 50% flowering was reported by Muduli and Patnaik (1993) and Naik and Satapathy (2002) and high genetic advance for number of primary branches per plant was observed by Naik and Satapathy (2002). However, Pali and Meheta (2013) observed high heritability coupled with moderate genetic advance for days to flower, days to maturity, 1000-seed weight, plant height and low heritability with low genetic advance was found for number of seeds per capsule. High heritability with high genetic advance for 1000-seed weight was reported by Vardhan and Rao (2012).

B. Correlation of seed yield with other characters

At the phenotypic level, seed yield had highly significant positive correlations with days to 50% flowering (0.354), plant height (0.237), number of capsules per plant (0.301) and 1000-seed weight (0.288), and significant positive correlation with number of seeds per capsule (0.193). The magnitude of correlation of seed yield with days to maturity (0.031) and number of primary branches per plant (0.106) is low and non significant (Table 3).

At the genotypic level, the correlations of seed yield with days to 50% flowering (1.164), days to maturity (0.468), plant height (0.787), number of capsules per plant (0.706), number of seeds per capsule (0.255) and 1000- seed weight (0.706) were highly significant and positive. The correlation of seed yield with number of primary branches per plant (-0.028) was low and non significant. Since phenotypic correlations were less than genotypic ones, there was greater masking effect of environment on the expression of the character (Table 4).

At the phenotypic level, significant positive correlations of seed yield with number of capsules per plant (Badwal *et al*., 1970; Chandra, 1978; Satapathi *et al.*,1987; Muduli and Patnaik, 1994; Malik and Singh, 1995; Varshney *et al*.,1995; Mahto and Mahto, 1997**;** Mahto and Rahaman, 1998; Gupta *et al*., 1999; Naik and Satapathy**,** 2002; Sarkar**,** 2005; Rao, 2007; Gauraha and Rao, 2011; Pali and Meheta, 2013), 1000- seed weight (Badwal *et al*.,1970; Chandra, 1978; Mahto and Rahaman, 1998; Naik and Satapathy, 2002; Gauraha and Rao, 2011 and Pali and Meheta, 2013) and plant height (Sarkar, 2005; Gauraha and Rao, 2011) have been reported by earlier workers.

Similarly, at the genotypic level, significant positive correlations of seed yield with number of capsules per plant (Satapathi *et al*.,1987; Muduli and Patnaik, 1994; Mahto and Rahaman**,** 1998; Gupta *et al*.,1999**;** Pal *et al*., 2000; Chimurkar *et al*., 2001; Yadav, 2001; Naik and Satapathy, 2002**;** Muhammad *et al*., 2003; Awasthi and Rao, 2005; Vardhan and Rao, 2006; Rao, 2007 and Dash *et al*., 2011) and 1000-seed weight (Muduli and Patnaik, 1994; Mahto and Rahaman, 1998; Naik and Satapathy, 2002; Sinha and Wagh, 2013) were observed earlier. In magnitude genotypic correlations were mostly higher than corresponding phenotypic correlations. Similar findings were reported by Sohan *et al.* (2004) and Joshi (2004). The low phenotypic correlations could result due to masking and modifying effect of environment on the association of characters at genotypic level.

In the present study, basing on phenotypic and genotypic correlations of seed yield with other component characters, for improvement of seed yield, due importance should be given to days to 50% flowering, number of capsules per plant, 1000-seed weight, and plant height.

C. Correlation among component characters of seed yield

Ten of the 21 phenotypic correlations among seven characters other than seed yield were significant and positive. Days to 50% flowering showed positive significant correlations with days to maturity (0.234), plant height (0.208), number of primary branches per plant (0.220), and number of capsules per plant (0.267). Naik and Satapathy (2002) obtained highly significant positive correlation with days to maturity and plant height but negative with 1000-seed weight, whereas Sarkar (2005) observed significant positive correlation for days to 50% flowering with days to maturity, plant height, number of primary branches per plant and number of seeds per capsule. However, significant positive correlation was observed for days to 50% flowering with days to maturity (Savita, 2006;

Gauraha and Rao, 2011 and Bibi *et al*., 2013) and significant positive association with days to maturity, plant height but significant negative correlation with 1000-seed weight were observed by Pali and Meheta (2013). Days to maturity registered positive and significant correlations with plant height (0.244), number of capsules per plant (0.205) and 1000- seed weight (0.177), whereas Savita (2006) found only with number of primary branches per plant, with number of capsules per plant and with 1000-seed weight. Significant positive correlation for days to maturity with primary branches per plant was observed by Gauraha and Rao (2011), and Pali and Meheta (2013) found significant positive correlation with plant height. Plant height had significant positive correlation with number of capsules per plant (0.287). Similar findings were reported by Naik and Satapathy (2002) and Savita (2006), whereas Pali and Meheta (2013) obtained significant negative correlation of plant height with number of primary branches per plant and 1000-seed weight. Number of primary branches per plant had positive significant correlation with number of capsules per plant (0.459), which confirms the results of Gauraha and Rao (2011) and Pali and Meheta (2013). Number of capsules per plant was significantly and positively correlated with number of seeds per capsule (0.202). This is in consonance with the findings of Gauraha and Rao (2011). However, Savita (2006) observed significant positive correlation of number of capsules per plant with plant height and 1000-seed weight.

Seventeen of the 21 genotypic correlations among seven characters other than seed yield were significant out of which twelve were positive. Days to 50% flowering had significant positive correlation with days to maturity (0.561), plant height (0.472), number of primary branches per plant (0.810) and number of capsules per plant (0.933), and significant negative correlations with number of seeds per capsule (-0.216) and 1000- seed weight (-0.259). Similar results were reported by Mahto and Rahaman (1998) for significant positive correlation of days to 50% flowering with days to maturity and negative correlation with number of seeds per capsule and 1000-seed weight. The result of Naik and Satapathy (2002) was also in aggrement with the present findings, whereas Savita (2006) found only with days to maturity. Days to maturity showed significant positive correlations with plant height (0.507), number of primary branches per plant (0.168), number of capsules per plant (0.573) and 1000-seed weight (0.310) and significant negative correlation with number of seeds per capsule (-0.752). These results were in confirmity with those obtained by Naik and Satapathy (2002) for significant positive correlation of days to maturity with plant height, number of primary branches per plant and number of capsules per plant. Plant height registered significant positive correlations with number of capsules per plant (0.324) and 1000-seed weight (0.243), and significant negative correlation with number of primary branches per plant (-0.276). However, Naik and Satapathy (2002) obtained significant positive correlation with number of capsules per plant and number of primary branches per plant. Number of primary branches per plant had significant positive correlation with number of capsules per plant (0.324). Similar result was reported by Gupta *et al*. (1999) and Dash *et al*. (2011). Number of capsules per plant was significantly and positively related with number of seeds per capsule (0.247), which was supported by Muduli and Patnaik (1994). However, Mahto and Rahaman (1998) and Naik and Satapathy (2002) found highly significant negative correlation between number of capsules per plant and number of seeds per capsule. Number of seeds per capsule was negatively and significantly related to 1000-seed weight (-0.395), whereas, Mahto and Rahaman (1998) and Naik and Satapathy (2002) observed highly significant negative association of number of seeds per capsule with days to 50% flowering.

D. Path coefficient analysis

At the phenotypic level, high positive direct effects of days to 50% flowering (0.398) and 1000-seed weight (0.363), moderate positive direct effect for number of capsules per plant (0.219) and low positive direct effect for number of seeds per capsule (0.134) on seed yield were observed. The direct effect of number of capsules per plant was increased by high positive indirect effect *via* days to 50% flowering (0.106) (Table 5). Similar positive direct effects were reported for number of capsules (Muduli and Patnaik, 1994; Mahto and Mahto, 1997; Mahto and Rahaman, 1998**;** Naik, and Satapathy, 2002; Sarkar, 2005; Rao, 2007; Gauraha and Rao, 2011), 1000-seed weight (Muduli and Patnaik, 1994; Naik and Satapathy, 2002; Sarkar, 2005; Rao, 2007; Gauraha and Rao, 2011) and number of seeds (Muduli and Patnaik, 1994; Mahto and Rahaman, 1998; Naik and Satapathy, 2002; Sarkar, 2005; Rao, 2007).

At the genotypic level, very high positive direct effects of days to 50% flowering (6.933), number of capsules per plant (4.578) and 1000-seed weight (2.433) were found. The direct effect of days to 50% flowering was increased by high positive indirect effect *via* number of capsules per plant (4.269) and number of seeds per capsule (1.637). Again, the direct effect of number of capsules per plant was also increased by high positive indirect effect *via* days to 50% flowering (6.466). The direct effect of 1000-seed weight was increased by high positive indirect effect *via* number of seeds per capsule (2.999) (Table 6). Earlier workers also found positive direct effects for number of capsules (Badwal *et al.*, 1970; Satapathi *et al*., 1987**;** Muduli and Patnaik, 1994; Naik and Satapathy, 2002**;** Rao, 2007) and 1000-seed weight (Badwal *et al*., 1970; Muduli and Patnaik, 1994; Naik and Satapathy, 2002 and Rao, 2007).

Table 1: Pooled analysis of variance for eight quantitative characters in linseed

		MSS of characters							
Source	**df**	**Days to 50% flowering**	**Days to maturity**	**Plant height (cm)**	**No. of primary branches/plant**	**No. of capsules/plant**	**No. of seeds/capsule**	**1000 seed weight (g)**	**Seed yield/plant (g)**
Year	1	673.250**	6644.500**	2384.375**	21.962**	15569.625**	256.232**	51.736**	37.965**
Replication	1	101.000**	267.500**	1900.000**	3.379**	2016.313**	52.445**	21.381**	0.188**
Year x replication	1	26.500	4.000	237.875**	0.001	608.656**	4.547**	3.961**	0.02
Genotypes	139	39.560**	30.511**	69.527**	0.513**	57.135**	1.281**	1.501**	0.093**
Year x genotypes	139	18.050**	15.935**	32.344**	0.327**	40.126**	1.003**	0.450**	0.077**
Error	278	8.969	9.378	12.202	0.147	24.015	0.394	0.260	0.018

- Significant at 1% level: **df: Degree of freedom

Table 2: Genetic parameters for eight quantitative characters in linseed pooled over two years

Character	Range	Mean	PCV (%)	GCV (%)	H (%)	GA	GA % M
Days to 50% flowering	62.00-80.25	70.25	5.39	3.30	37.5	2.92	4.16
Days to maturity	111.00-123.75	117.73	3.07	1.62	28.0	2.08	1.77
Plant height (cm)	43.53-64.97	53.52	8.66	5.70	43.2	4.13	7.72
No. of primary branches / plant	0.00-1.73	0.56	77.92	38.17	24.0	0.22	39.29
No. of capsules/plant	8.98-27.62	16.64	31.84	12.13	14.5	1.58	9.50
No. of seeds/capsule	6.60-9.02	7.61	8.95	3.47	15.0	0.21	2.76
1000- seed weight (g)	4.03-7.20	5.62	12.86	9.12	50.3	0.75	13.35
Seed yield/plant (g)	0.25-1.06	0.55	26.96	11.38	17.8	0.05	9.09

PCV: Phenotypic coefficient of variation; **GCV**: Genotypic coefficient of variation; **H**: Heritability in broad sense; **GA**: Genetic advance; **GA%M**: Genetic advance as percentage of mean.

Table 3: Phenotypic correlation coefficients among eight characters in 140 genotypes of linseed pooled over two years

Character	DM	PH	PB	CP	SN	SW	SYP
Days to 50% flowering	0.234**	0.208**	0.220**	0.267**	-0.035	-0.146	0.354**
Days to maturity		0.244**	0.018	0.205*	-0.160	0.177*	0.031
Plant height (cm)			-0.020	0.287**	0.125	0.108	0.237**
No. of primary branches / plant				0.459**	0.114	0.008	0.106
No. of capsules/plant					0.202*	0.017	0.301**
No. of seeds/capsule						0.010	0.193*
1000- seed weight(g)							0.288**

* and ** are significant at 5% and 1 % levels respectively. **DM:** Days to maturity; **PH:** Plant height (cm); **PB**: Number of primary branches per plant; **CP**: Number of capsules per plant; **SN**: Number of seeds per capsule; **SW**: 1000-seed weight (g); **SYP**: Seed yield per plant (g).

Table 4: Genotypic correlation coefficients among eight characters in 140 genotypes of linseed pooled over two years

Character	DM	PH	PB	CP	SN	SW	SYP
Days to 50% flowering	0.561**	0.472**	0.810**	0.933**	-0.216*	-0.259**	1.164**
Days to maturity		0.507**	0.168*	0.573**	-0.752**	0.310**	0.468**
Plant height (cm)			-0.276**	0.324**	0.022	0.243**	0.787**
No. of primary branches / plant				0.324**	-0.092	-0.127	-0.028
No. of capsules / plant					0.247**	-0.011	0.706**
No. of seeds / capsule						-0.395**	0.255**
1000- seed weight(g)							0.706**

* and ** are significant at 5% and 1 % levels respectively. **DM:** Days to maturity; **PH:** Plant height (cm); **PB**: Number of primary branches per plant; **CP**: Number of capsules per plant; **SN**; Number of seeds per capsule; **SW**: 1000-seed weight (g); **SYP**: Seed yield per plant (g).

Table 5: Path coefficient analysis of phenotypic correlation coefficients in 140 genotypes of linseed pooled over two years

Correlated character	Direct (diagonal & bold) and indirect effects via							Total indirect effect	Total effect	Correlation with seed yield
	DF	DM	PH	PB	CP	SN	SW			
Days to 50% flowering	**0.398**	-0.039	0.015	-0.021	0.058	-0.005	-0.053	-0.045	0.353	0.354
Days to maturity	0.093	**-0.165**	0.018	-0.002	0.045	-0.022	0.064	0.196	0.031	0.031
Plant height (cm)	0.083	-0.040	**0.073**	0.002	0.063	0.017	0.039	0.164	0.237	0.237
No. of primary branches/ plant	0.088	-0.003	-0.001	**-0.095**	0.100	0.015	0.003	0.202	0.107	0.106
No. of capsules/plant	0.106	-0.034	0.021	-0.044	**0.219**	0.027	0.006	0.082	0.301	0.301
No. of seeds/ capsule	-0.014	0.026	0.009	-0.011	0.044	**0.134**	0.004	0.058	0.192	0.193
1000-seed weight (g)	-0.058	-0.029	0.008	-0.001	0.004	0.001	**0.363**	-0.075	0.288	0.288

Residual effect- **P**: 0.6606

DF: Days to 50% flowering; **DM**: Days to maturity**; PH**: Plant height (cm); **PB**: Number of primary branches per plant; **CP:** Number of capsules per plant; **SN**: Number of seeds per capsule; **SW:** 1000-Seed weight (g)

Table 6: Path coefficient analysis of genotypic correlation coefficients in 140 genotypes of linseed pooled over two years

Correlated character	Direct (diagonal & bold) and indirect effects via							Total indirect effect	Total effect	Correlation with seed yield
	DF	**DM**	**PH**	**PB**	**CP**	**SN**	**SW**			
Days to 50% flowering	**6.933**	-6.455	-0.051	-4.541	4.269	1.637	-0.629	-5.770	1.163	1.164
Days to maturity	3.890	**-11.504**	-0.054	-0.944	2.622	5.704	0.755	11.973	0.469	0.468
Plant height(cm)	3.273	-5.834	**-0.107**	1.545	1.484	-0.164	0.591	0.895	0.788	0.787
No. of primary branches / plant	5.617	-1.938	0.030	**-5.606**	1.482	0.696	-0.309	5.578	-0.028	-0.028
No. of capsules / plant	6.466	-6.589	-0.035	-1.815	**4.578**	-1.874	-0.0270	-3.874	0.704	0.706
No. of seeds / capsule	-1.496	8.653	-0.002	0.514	1.131	**-7.583**	-0.962	7.838	0.255	0.255
1000- seed weight(g)	-1.793	-3.568	-0.026	0.711	-0.050	2.999	**2.433**	-1.727	0.706	0.706

Residual effect- **G**: -4.7794

DF: Days to 50% flowering; **DM**: Days to maturity**; PH**: Plant height (cm); **PB**: Number of primary branches per plant; **CP**: Number of capsules per plant; **SN**: Number of seeds per capsule; **SW:** 1000-Seed weight (g)

Conclusions:

In the present study, positive direct effects of days to 50% flowering, number of capsules per plant and 1000-seed weight were observed on seed yield. Again, these characters had significant positive correlation with seed yield. Days to 50% flowering and number of capsules per plant were positively and significantly correlated. Days to 50% flowering was negatively correlated with 1000-seed weight and number of capsules per plant had low correlation with 1000-seed weight. So, under late sown conditions in the North Central Plateau Zone of Odisha, for improvement of seed yield the selection criteria should be more days to 50% flowering and higher number of capsules per plant with moderate 1000-seed weight on the basis of genotypic coefficient of variation (GCV), heritability in broad sense (H), genetic advance as percentage of mean (GA%M), correlation and path coefficient analysis.

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