Genetic Variability and Path Analysis for Yield and its related Traits in Linseed (*Linum usitatissimum* L.)

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**A B S T R A C T**

An experiment was conducted to study the nature and magnitude of genetic variability with a view to identify promising genotypes for yield and related traits in linseed. Eighteen diverse linseed (*Linum usitatissimum* L.) genotypes were evaluated in randomized block design in three replications during *rabi* 2019-20 for twelve agro morphological characters to assess the genetic parameters of variability. Analysis of variance indicated presence of a wide range of genetic variability among genotypes for all the traits. The higher phenotypic coefficient values than corresponding genotypic coefficient values depicted influence of environment in the expression of traits. Technical height exhibited highest GCV value while the lowest GCV was observed for days to 75% maturity. High estimates of PCV and GCV indicate sufficient variability, signifying the effectiveness of the selection of desirable types for improvement of such characters. The high expected genetic advance expressed as percentage of mean were recorded for technical height, aerial biomass per plant, plant height, primary branches per plant and secondary branches per plant. High heritability with moderate genetic advance was observed for technical height indicating the presence of additive and non-additive gene action. Path analysis revealed, direct and indirect effects of genotypic path coefficient were higher in magnitude than the corresponding phenotypic path coefficients. Highest positive direct effect on seed yield was shown harvest index followed by aerial biomass, plant height, secondary branches per plant and days to 75% maturity. The obtained results could be used further in breeding programmes.

**Key words**

Variability, Heritability, Genetic advance, Linseed

**Article Info**

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Introduction

Linseed, *Linum usitatissimum* L. (n=15) is a member of genus *Linum* of family Linaceae. It is a self-pollinated species grown during *rabi* season and is one of the oldest plant species cultivated for oil and fibre (Lay and Dybing 1989). The center of origin of linseed is considered in India, from where it spreaded globally including Ethiopia (Wakjira *et al.*, 2004). Linseed is commercially grown for extraction of high quality fibre called ‘linen’ along with oil from its seeds. It contains a varying oil content of about 33-45 per cent. Linseed is unique among oilseeds and has gained new interest in recent past in emerging market of functional food due to the presence of high content of omega-3 i.e. alpha linolenic
acid (36-57%), an essential polyunsaturated fatty acid along with omega-6 i.e. linoleic acid (18-24%) (Ganorkar and Jain 2013). The medicinal properties of linseed help in reducing blood cholesterol, heart diseases, rheumatoid arthritis along with some antioxidant properties due to lignans. Linseed oil plays an important role in the manufacturing of paints, varnishes, printing ink, pad ink, etc., due to the fast-drying properties it imparts.

Globally linseed covers an area of 3.26 million ha with the production of about 3.18 million tons and productivity of 1011.20 kg/ha. India ranks fifth in the world with the area, production and productivity of 0.32 million ha, 0.17 million tons and 543.8 kg/ha, respectively (FAOSTAT 2018). While in Himachal Pradesh, 0.80 thousand ha is under linseed cultivation with the production of 0.24 thousand ha and average productivity of 243 kg/ha (Statistical year book of H.P 2018).

Variability is the foremost prerequisite for any breeding programme. The large extent of genetic variability in the segregating population depends on the amount of the genetic variability among genotypes and offer better scope for selection. Thus the assessment of variability is important for economically important traits. Since, genetic parameters such as genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance are useful in detecting the amount of variability in germplasm along with path analysis studies which represent the relative importance of each factor contributing towards economically important traits such as seed yield. Path co-efficient analysis developed by Wright (1921) helps in partitioning the correlation co-efficient into direct and indirect effects, so that contribution of each component character to the end product yield could be evaluated.

Materials and Methods

Testing location and layout of experiment

The experimental material comprised of 18 genotypes, which were sown in randomized block design with 3 replications during rabi 2019-2020 at Experimental Farm of Genetics and Plant Breeding, CSK HPKV Palampur. The experimental plot of size 1 × 0.75 m² with three 1 meter long row, having inter-row and plant to plant distance of 25 cm and 5 cm, respectively. The recommended package of practices was adopted for the proper growth of the linseed. Data were recorded from 5 randomly selected competitive plants for traits such as; primary branches per plant, secondary branches per plant, plant height (cm), technical height (cm), number of capsules per plant, number of seeds per capsule, seed yield per plant (g), aerial biomass per plant (g), harvest index (%) and 1000-seed weight (g) while days to 50% flowering and days to 75% maturity were recorded on plot basis.

Experimental material

The experiment was conducted using 18 genotypes namely; KL-305, KL-306, KL-307, KL-308, KL-309, KL-310, KL-311, KL-312, KL-313, KL-314, KL-315, KL-316, KL-317, KL-318, KL-319, K 1 Raja, JRF-4 and Nagarkot.

Statistical analysis

The data obtained were subjected to analysis as per Panse and Sukhatme (1984). The genetic parameters phenotypic, genotypic and environmental coefficients of variation were analyzed as suggested by Burton and De Vane (1953) and Johnson et al., (1955) along with heritability (h^2) which was calculated as a ratio of genotypic variance to the sum of genotypic and environmental variance. The
expected genetic advance for various traits was calculated as per Burton and De Vane (1953) and Johnson et al., (1955). Direct and indirect effects of component characters on seed yield were computed using appropriate correlation coefficient of different component traits as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

**Results and Discussion**

Analysis of variance revealed the significance of all the characters under investigation, indicating the presence of wide range of genetic variability among genotypes for yield and its related traits (Table 1). Payasi et al., (2000), Singh (2001), Diederichsen and Fu (2008), Bibi et al., (2013), Singh et al., (2015), Kumar and Paul (2016), Patial et al., (2018), Ankit et al., (2019) and Banjare et al., (2019), Paul et. al (2020) also reported a high amount of genetic variability for these traits.

Variability parameters such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h²bs) and expected genetic advance expressed as per cent of mean for twelve morphological characters has been represented in table 2. The higher phenotypic coefficient values than corresponding genotypic coefficient values showed an important role of environment in the expression of these traits. The characters harvest index (33.47%), aerial biomass (27.22%), seed yield per plant (26.61%) and technical height (25.48%) exhibited high PCV values. The least PCV was recorded for days to 75% maturity (1.11%), days to 50% flowering (4.31%) and seeds per capsule (8.74%). Technical height exhibited the highest GCV (25.33%) value while the lowest GCV was observed days to 75% maturity (0.92%), days to 50% flowering (3.10%), seeds per capsule (6.16%) and 1000-seed weight (7.55%). These findings were in accordance with various researchers such as Payasi et al., (2000) observed high GCV for fibre length; Savita (2006) recorded high PCV value for seed yield per plant. High PCV, high heritability and moderate genetic advance (15-30%) was recorded for aerial biomass per plant.

Estimates of heritability in broad sense (h²bs) ranged from 19.24% in 1000-seed weight to 98.88% in technical height. Days to 75% maturity (69.07%), primary branches per plant (96.70%), secondary branches per plant (97.73%), plant height (98.73%), capsules per plant (98.54%) and aerial biomass (65%) exhibited high heritability which indicates the ability of genotypes to transmit genes to their offsprings. Similar results were reported earlier by Singh et al., (2015) and Bhushan et.al (2019). Moderate heritability was recorded for characters days to 50 % flowering (51.77%), seeds per capsule (49.80%) and harvest index (37.51%). Moderate to high heritability estimates for all characters were observed by Yadav and Gupta (1999). The high expected genetic advance expressed as percentage of mean were recorded for technical height (51.89%), aerial biomass per plant (36.44%), plant height (34.20%), primary branches per plant (33.82%) and secondary branches per plant (33%). The traits capsules per plant (29.67%) and harvest index (25.86%) exhibited moderate genetic advance as percentage of mean whereas, low estimates for genetic advance were reported for seed yield per plant (13.52%), seeds per capsule (8.96%), 1000-seed weight (6.78%), days to flowering (4.60%) and days to 75% maturity (1.57%). High heritability with moderate genetic advance was observed for technical height indicating the presence of additive and non-additive gene action. Pali and Mehta (2013) found high heritability with moderate genetic advance for oil content and all fatty acid
components. Leelavathi and Mogali (2018) reported high heritability with moderate to high level of genetic advance for all characters. However, high heritability and the low genetic advance was recorded for most of the characters which are in agreement with Bibi et al., (2013) who reported high heritability with low genetic advance for various traits such as days to 50% flowering and days to 75% maturity.

**Table 1** Analysis of variance for yield and related traits in linseed

| Sr. No. | Characters                        | d.f. | Replication | Treatments | Error |
|---------|----------------------------------|------|-------------|------------|-------|
| 1       | Days to 50% flowering            | 9.47 | 15,721.60*  | 6.321      | 34    |
| 2       | Days to 75% maturity              | 25.09| 9,555.46*   | 10.074     |       |
| 3       | Primary branches per plant       | 5.09 | 15,440.27*  | 11.062     |       |
| 4       | Secondary branches per plant     | 16.43| 9,573.82*   | 4.362      |       |
| 5       | Plant height (cm)                | 31.18| 15,062.10*  | 7.610      | 34    |
| 6       | Technical height (cm)            | 45.83| 9,437.74*   | 7.668      | 34    |
| 7       | Capsules per plant               | 23.22| 15,000.90*  | 10.781     |       |
| 8       | Seeds per capsule                | 137.72| 9,771.28*   | 35.701     |       |
| 9       | Seed yield per plant (g)         | 0.71 | 15,242.07*  | 3.784      | 34    |
| 10      | Aerial biomass per plant (g)     | 16.23| 9,310.86*   | 5.495      |       |
| 11      | Harvest index (%)                | 4.31 | 15,183.72*  | 14.988     | 34    |
| 12      | 1000-seed weight (g)             | 87.20| 9,552.99*   | 16.507     | 34    |

**Table 2** Genetic parameters of variability for different yield and related traits in linseed

| Characters                        | Mean± SE | Range | PCV  | GCV  | h²  | GA  | GAM  |
|----------------------------------|----------|-------|------|------|-----|-----|------|
| Days to 50% flowering            | 144.93±3.54 | 134.00| 157.00| 4.31 | 3.10 | 51.77| 6.62 | 4.60 |
| Days to 75% maturity             | 211.54±1.06 | 206.00| 214.00| 1.11 | 0.92 | 69.07| 3.32 | 1.57 |
| Primary branches/plant           | 6.32±0.16  | 4.00  | 8.30  | 16.99| 16.80| 96.70| 2.14 | 33.82|
| Secondary branches/plant         | 8.77±0.18  | 6.20  | 10.93 | 16.40| 16.20| 97.73| 2.89 | 33.00|
| Plant height (cm)                | 75.68±1.17  | 56.55| 111.12| 16.82| 16.70| 98.73| 25.88| 34.20|
| Technical height (cm)            | 45.22±0.99  | 27.45| 75.23 | 25.48| 25.33| 98.88| 23.46| 51.89|
| Capsules per plant               | 37.06±0.54  | 29.93| 48.56 | 14.62| 14.51| 98.54| 10.99| 29.67|
| Seeds per capsule                | 7.54±0.39   | 6.90 | 8.77  | 8.74 | 6.16 | 49.80| 0.67 | 8.96 |
| Seed yield per plant (g)         | 2.82±0.53   | 1.92 | 4.11  | 26.61| 13.21| 24.67| 0.32 | 13.52|
| Aerial biomass per plant (g)     | 41.01±5.40  | 31.95| 73.82 | 27.22| 21.95| 65.00| 14.94| 36.44|
| Harvest index                    | 7.23±1.56   | 4.60 | 12.26 | 33.47| 20.50| 37.51| 1.89 | 25.86|
| 1000-seed weight (g)             | 7.07±0.89   | 4.99 | 8.13  | 17.12| 7.55 | 19.24| 0.48 | 6.78 |
Table 3 Estimates of direct and indirect phenotypic (P) and genotypic (G) effects of different traits on seed yield in linseed

| Days to 50% flowering | Days to 75% maturity | Primary branches | Secondary branches | Plant height (cm) | Technical height (cm) | Capsules per plant | Seeds per capsule | Aerial biomass (g) | Harvest index (%) | 1000 seed weight (g) | Correlation with seed yield per plant |
|-----------------------|----------------------|-----------------|-------------------|------------------|----------------------|-------------------|-----------------|-------------------|-----------------|------------------|--------------------------------------|
| Days to 50% flowering | P                    | -0.0207         | -0.0004           | -0.0019          | -0.0075              | 0.1068             | -0.0638         | 0.0128            | 0.0001          | 0.0836           | 0.0446                 | 0.0069                 | 0.1606                 |
|                       | G                    | -0.3984         | -0.0356           | 0.0839           | 0.1530              | -0.5194            | 0.6720           | 0.0389            | 0.0339          | 0.3503           | -0.0524                | -0.0187                | 0.3075                 |
| Days to 75% maturity  | P                    | 0.0004          | 0.0229            | -0.0064          | 0.0213              | -0.2376            | 0.1681           | -0.0115           | 0.0002          | -0.1762          | -0.1590                | 0.0067                 | -0.3711                |
|                       | G                    | 0.0313          | 0.4537            | 0.1858           | -0.3450            | 1.0359             | -1.5881          | -0.0314           | 0.0195          | -0.5793          | -0.2033                | 0.0013                 | -1.0196                |
| Primary branches per plant | P                | -0.0013         | 0.0049            | -0.0303          | 0.0872              | -0.0660            | 0.0167           | -0.0336           | -0.0005         | 0.0960           | -0.3323                | -0.0156                | -0.2748                |
|                       | G                    | -0.0421         | 0.1061            | 0.7946           | -1.1695            | 0.2456             | -0.1396          | -0.0709           | -0.0340         | 0.2212           | -0.3461                | -0.0339                | -0.4687                |
| Secondary branches per plant | P                  | 0.0015          | 0.0049            | -0.0263          | 0.1007              | -0.0428            | 0.0012           | -0.0446           | -0.0004         | 0.1514           | -0.3583                | 0.0008                 | -0.2118                |
|                       | G                    | 0.0463          | 0.1190            | 0.7066           | -1.3152            | 0.1528             | -0.0031          | -0.0941           | -0.0237         | 0.4004           | -0.4216                | 0.0035                 | -0.4288                |
| Plant height (cm)     | P                    | -0.0053         | -0.0130           | 0.0048           | -0.0103            | 0.4164             | -0.2710          | -0.0100           | 0.0002          | 0.3056           | 0.1332                 | 0.0042                 | 0.5548                 |
|                       | G                    | -0.1403         | -0.3187           | -0.1323          | 0.1363             | -1.4747            | 2.1286           | -0.0207           | 0.0143          | 0.7630           | 0.1388                 | 0.0116                 | 1.1059                 |
| Technical height (cm) | P                    | -0.0047         | -0.0138           | 0.0018           | -0.0004            | 0.4057             | -0.2782          | -0.0069           | 0.0001          | 0.3058           | 0.1143                 | 0.0000                 | 0.5237                 |
|                       | G                    | -0.1238         | -0.3331           | -0.0513          | 0.0019             | -1.4512            | 2.1630           | -0.0148           | 0.0052          | 0.7558           | 0.1425                 | 0.0014                 | 1.0956                 |
| Capsules per plant    | P                    | 0.0027          | 0.0027            | -0.0104          | 0.0460             | 0.0426             | -0.0196          | -0.0976           | 0.0000          | 0.1614           | -0.2690                | 0.0432                 | -0.0981                |
|                       | G                    | 0.0773          | 0.0711            | 0.2812           | -0.6176            | -0.1524            | 0.1592           | -0.2004           | 0.0018          | 0.4026           | -0.2953                | 0.0997                 | -0.1728                |
| Seeds per capsule     | P                    | -0.0012         | 0.0023            | 0.0067           | -0.0163            | 0.0363             | -0.0149           | 0.0012           | 0.0024          | 0.0524           | -0.0720                | 0.0238                 | 0.0208                 |
|                       | G                    | -0.1274         | 0.0836            | -0.2547          | 0.2937             | -0.1984            | 0.1058           | -0.0035           | 0.1059          | 0.2066           | 0.0253                 | 0.0629                 | 0.2998                 |
| Aerial biomass (g)    | P                    | -0.0030         | -0.0070           | -0.0050          | 0.0264             | 0.2204             | -0.1473          | -0.0273           | 0.0002          | 0.5775           | -0.3980                | -0.0030                | 0.2339                 |
|                       | G                    | -0.1199         | -0.2258           | 0.1510           | -0.4524            | -0.9665            | 1.4042           | -0.0693           | 0.0188          | 1.1641           | -0.4975                | 0.0436                 | 0.4504                 |
| Harvest index (%)     | P                    | -0.0010         | -0.0039           | 0.0108           | -0.0386            | 0.0594             | -0.0340           | 0.0281           | -0.0002         | -0.2461          | 0.9340                 | 0.0146                 | 0.7231                 |
|                       | G                    | 0.0320          | -0.1415           | -0.4221          | 0.8509             | -0.3142            | 0.4729           | 0.0908           | 0.0041          | -0.8889          | 0.6516                 | -0.0350                | 0.3006                 |
| 1000 seed weight (g)  | P                    | 0.0013          | -0.0014           | -0.0042          | -0.0007            | -0.0156            | 0.0001           | 0.0378           | -0.0005         | 0.0153           | -0.1222                | -0.1115                | -0.2019                |
|                       | G                    | -0.0661         | -0.0053           | 0.2396           | 0.0415             | 0.1515             | -0.0278           | 0.1776           | -0.0592         | -0.4521          | 0.2030                 | -0.1125                | 0.0902                 |
Path coefficient analysis allows the partitioning of the correlation coefficients into components of direct and indirect effects. Table 3 represents the results obtained by keeping seed yield as the dependent variable and rest as independent variable. The direct and indirect effects of genotypic path coefficient were higher in magnitude than the corresponding phenotypic path coefficients. The results were in accordance with Gauraha and Rao (2011) and Reddy et al., (2013). The residual effect for path coefficients was (0.097). At phenotypic level, harvest index followed by aerial biomass, plant height, secondary branches per plant and days to 75% maturity had highest positive direct effect on seed yield. This indicated significant role of accumulation of harvest index and its partitioning into seed yield. The significant positive correlation of days to 50% flowering with seed yield was mainly due to indirect effects via plant height, aerial biomass per plant and harvest index. Similarly, significant positive correlation of technical height with seed yield was mainly due to indirect effects via plant height and aerial biomass per plant whereas, indirect effects via other traits were low in magnitude. Significant positive correlation of seeds per capsule with yield was mainly due to indirect effects via aerial biomass per plant, plant height, 1000-seed weight and primary branches per plant. Harvest index exhibited the highest direct effect with seed yield per plant. The above results were also reported by Chimurkar et al., (2001) and Patial et al., (2018).

In conclusion, high estimates of PCV and GCV indicate the presence of sufficient variability among genotypes for different characters studied, signifying the effectiveness of selection of desirable types for improvement of such characters. High heritability accompanied with high genetic advance for technical height revealed additive gene effects in inheritance of these traits. Whereas, high heritability coupled with moderate genetic advance indicates the presence of additive and non-additive gene effects. High positive direct effects of characters such as harvest index, aerial biomass, plant height, secondary branches per plant and days to 75% maturity would be helpful to improve economically important characters such as seed yield.

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