RESEARCH PAPER

ADVANCE RESEARCH JOURNAL OF
C R P
IMPROVEMENT
Volume 7 | Issue 1 | June, 2016 | 121-128
e ISSN-2231-640X

DOI :
10.15740/HAS/ARJCI/7.1/121-128
Visit us: *www.researchjournal.co.in*

# Genetic variability and heritability estimates for morphological and quality traits in linseed (*Linum usitatissimum* L.)

■ V.K.CHOUDHARY, S. RAM[1], RAJESH KUMAR[2], A.K.CHOUDHARY[3], S.BHUSHAN[3] AND P. MEDHA[4]

AUTHORS' INFO

**Associated Co-author :**

[1]Birsa Agricultural University, Kanke, RANCHI (JHARKHAND) INDIA

[2]Rajendra Agricultural University, Pusa, SAMASTIPUR (BIHAR) INDIA

[3]Bihar Agricultural University, Sabour, BHAGALPUR (BIHAR) INDIA

[4]Directorate of Rapeseed-Mustard Research, BHARATPUR (RAJASTHAN) INDIA

**Author for correspondence:**
**V.K. CHOUDHARY**
Department of Seed Technology (STR), Tirhut College of Agriculture, Dholi, MUZAFFARPUR (BIHAR) INDIA
Email:vkchoudharypat12@gmail.com

**ABSTRACT :** The present investigation was undertaken to evaluate the mean performance, variability, heritability and genetic advance for 17 morphological traits including yield and quality of six generations in linseed crosses under two locations with five genetically divers varieties of linseed in Randomized Block Design with three replications during *Rabi* season 2013-2014. The results indicated that the mean performance of $F_1$S of nearly all the crosses showed significant superiority for all the characters under study at both the locations except fatty acid profile which was recorded for only Ranchi location. Among parents Meera and Shekhar showed significant superiority over LC-54 (check) for most of the characters at both the locations. Characters like, plant height, number of primary branches per plant, number of capsules per plant, wilt disease reaction, rust disease reaction, seed yield per plant showed high PCV and GCV at both the locations including all the fatty acids. High heritability coupled with high to moderate genetic advance was found for traits like wilt disease reaction, oleic acid content and linolenic acid content and rest characters exhibited low heritability and low genetic advance at both the locations.

**KEY WORDS :** Linseed, PCV, GCV, Heritability, Genetic advance

**How to cite this paper :** Choudhary, V.K., Ram, S., Kumar, Rajesh, Choudhary, A.K., Bhushan, S. and Medha, P. (2016). Genetic variability and heritability estimates for morphological and quality traits in linseed (*Linum usitatissimum* L.). *Adv. Res. J. Crop Improv.*, **7** (1) : 121-128, **DOI : 10.15740/HAS/ARJCI/7.1/121-128**.

**Paper History :** **Received :** 28.12.2015; **Revised :** 21.04.2016; **Accepted :** 18.05.2016

Linseed or flax (*Linum usitatissimum* L.) is commonly known as alsi or tisi. Linseed is one of the most important industrial oilseed crops of India. The seeds of linseed contain about 33-45 per cent oil. It is generally unsuitable for culinary purposes due to high linolenic acid content (47-58%) but it is an excellent source for industrial purposes. Its oil is used in manufacturing of surface coating oils, varnish, linoleum, oil cloth, printing inks and similar other products. Recent discovery is the use of linseed oil in processing of cementing roads in USA (Walsh, 1965). Linseed oil is rich in Omega-3 and Omega-6 fatty acids known to influence blood platelet aggregation lower the blood cholesterol concentration and prevent coronary heart disease. On global scenario, India ranks second in an area (approx. 2.96 lakh hectares) and third in production with 1.49 lakh tones (Anonymous, 2014). In spite of vast area and varied utility of crop, country has very low productivity (502 kg/ha) against world average of 827 kg/ha (Anonymous, 2014). The main reasons for low productivity of linseed in the country are inherent low yielding capacity of existing varieties and late maturity,

susceptibility of present day's varieties to diseases and pests, lack of stability of yield and cultivation of crop under poor agronomic management on marginal lands. The development of superior varieties than the existing ones mainly depends on judicious selection of promising parents from the gene pool for hybridization to obtain transgressive segregants. Thus, for assessing the existing genetic variability among the parents and their crosses for yield and its contributing characters along with quality parameters and disease resistance was the aim of the present investigation.

## RESEARCH PROCEDURE

The present investigation was undertaken to obtain information on means, components of genetic variances (variability, heritability and genetic advance) for some quantitative and qualitative traits. The basic materials for the present investigation comprised of five improved varieties of linseed namely, Meera, Shekhar, T-397, KL - 221 and JLS -9 through which six different populations *viz*., $F_1$s, $F_2$s, $BC_1$s, $BC_2$s were developed and evaluated along with five parents and one check (LC-54)in Randomized Block Design with three replications at two locations *i.e*. an experimental area of plant breeding and genetics, BAU, Kanke, Ranchi ($E_1$) and Zonal Research Station farm, Chianki, Daltengang ($E_2$) during *Rabi* season of the year 2013-14. Recommended package and practices for linsed were adopted to raise good crop.

Observations were recorded on 17 quantitative and qualitative characters *i.e*. days to 50 per cent 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), seed yield/ plant (g), oil content (%), fatty acids content in per cent (only at Ranchi location), wilt disease reaction and rust disease reaction at both the locations. Data were recorded on 10 randomly selected plants from $P_1$, $P_2$, $F_1$s and check, 30 from $F_2$s and 20 from $BC_1$s, $BC_2$s.

## RESEARCH ANALYSIS AND REASONING

The results obtained are presented in Tables 1 to 4.

At both the locations the $F_1$, $F_2$, $BC_1$ and $BC_2$ population showed earlier days to 50 per cent flowering specially at Ranchi location. Three $F_1$s, three $F_2$s, two $BC_1$s and $BC_2$s were significantly earlier days to 50 per cent flowering than check indicating that $F_1$ and $F_2$ were showing superiority over mid parental value for earliness in this character (Table 1). The cross number six *i.e.* $6F_1$, $6F_2$, $6BC_1$ and $6BC_2$ including parents Shekhar and JLS-9 showed significant superiority for dwarfness over check as both the parents were also significantly shorter for plant height. This indicates that as the parents had the alleles for shorter height, the crosses also exhibited superiority for shorter height. Meera as a parent was significantly superior than check at both the locations for number of primary branches per plant. The $F_1$s of all the crosses except cross 6 $F_1$ were significantly superior at both the locations with higher number of primary branches per plant for most of the crosses. All the $BC_1$s at Ranchi location and all $BC_2$s at Chianki location were significantly superior over check for number of primary branches per plant. Most of the $F_1$s showed significant superiority at both the locations for number of seeds per capsule while $F_2$s, $BC_2$s showed varying trend. The data for days to maturity showed that parents T-397, KL-221and JLS-9 and crosses of cross number 5 and 6 *i.e.* $5F_1$, $6F_1$, $5F_2$, $6F_2$, $5BC_1$, $6BC_1$, $5BC_2$ and $6BC_2$ were significantly earlier days to maturity than the check over both the locations (Table 2). All the $F_1$s and nearly all the $BC_1$s except $6BC_1$ showed significant and higher seed yield per plant at both the locations over check LC-54. All the parents and $F_1$s were significantly superior over check at Chianki location for oil content. The $BC_1$s and $BC_2$s including parents *i.e*. Meera, Shekhar, T-397, KL-221 showed superiority for all the fatty acids *i.e*. palmitic acid content, stearic acid content, oleic acid content, linoleic acid content and linolenic acid content over local check LC-54 (Table 3). Only one parent Shekhar and Four $F_1$ *i.e.* $1F_1$, $2F_1$, $3F_1$ and $4F_1$ along with four $BC_1$s *i.e.* $1BC_1$. $2BC_1$, $3BC_1$ and $4BC_1$ showed less incidence of wilt disease than the check. Three $F_1$s and three $BC_1$s indicated that there is preponderance of dominant effect of the allele for rust disease reaction (Table 4).

The estimates of PCV and GCV at Ranchi location ($E_1$) revealed high phenotypic co-efficient of variation for almost all the characters under study. The moderate phenotypic co-efficient of variation was observed for only one character *i.e.* test weight while rest of the traits showed low PCV. Genotypic co-efficient of variation (GCV) which provide information about extent of genetic variability in characters revealed almost similar trends as that of PCV estimates except two character *i.e*. days to 50 per cent flowering and test weight.

**Table 1: Mean performance of parents and crosses for seventeen traits at ($E_1$) and ($E_2$) location**

| Location / Parents | Days to 50% flowering | | Plant height (cm.) | | No. of primary branches/ plant | | No. of capsules/ plant | | No. of seeds/ capsule | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki |
| Meera | 82.00 | 85.00 | 71.90 | 75.20 | 5.60* | 6.07* | 71.40 | 85.77* | 7.00 | 7.97* |
| Shekhar | 76.67 | 75.33 | 50.43* | 51.67* | 4.20 | 5.13* | 64.67 | 77.0 | 6.67 | 7.70* |
| T-397 | 71.67* | 73.67 | 63.77 | 62.67 | 3.60 | 4.03* | 59.07 | 77.13 | 6.47 | 7.50* |
| KL-221 | 75.67 | 74 | 55.13 | 60.53 | 3.40 | 4.60* | 57.53 | 66.0 | 6.47 | 7.0 |
| JLS-9 | 74.00* | 70.0* | 49.73* | 50.0* | 3.23 | 3.53 | 63.27 | 60.40 | 6.40 | 6.77 |
| **Crosses** | | | | | | | | | | |
| $1F_1$ | 72.67* | 74.33 | 66.87 | 67.33 | 7.17* | 4.40* | 91.33* | 93.47* | 7.53* | 7.93* |
| $2F_1$ | 75.00 | 76.67 | 59.87 | 64.20 | 6.70* | 5.6* | 84.97* | 91.60* | 7.20* | 8.07* |
| $3F_1$ | 80.00 | 75.0 | 58.40 | 60.67 | 7.13* | 5.0* | 90.37* | 87.93* | 6.87 | 7.63* |
| $4F_1$ | 75.00 | 73.33 | 60.33 | 66.53 | 6.53* | 7.20* | 91.60* | 96.40* | 7.80* | 8.03* |
| $5F_1$ | 72.33* | 75.0 | 55.33 | 56.40 | 5.13* | 4.80* | 84.53* | 94.07* | 7.47* | 7.17 |
| $6F_1$ | 67.67* | 71.33* | 53.20 | 51.60* | 4.23 | 3.4 | 90.63* | 81.80* | 5.87 | 6.53 |
| $1F_2$ | 74.33 | 77.67 | 59.07 | 56.93 | 4.03 | 3.0 | 55.67 | 56.80 | 7.00 | 7.50* |
| $2F_2$ | 73.67* | 75.67 | 60.60 | 58.40 | 3.70 | 3.8 | 53.07 | 49.60 | 6.80 | 7.03 |
| $3F_2$ | 73.67* | 72.0 | 61.93 | 62.47 | 3.97 | 4.0* | 51.60 | 72.40 | 6.40 | 7.27 |
| $4F_2$ | 74.67 | 75.0 | 56.87 | 61.73 | 4.40 | 5.6* | 88.30* | 76.67 | 6.67 | 6.50 |
| $5F_2$ | 74.33 | 72.0 | 56.00 | 58.13 | 3.93 | 3.8 | 58.80 | 79.20* | 6.53 | 6.77 |
| $6F_2$ | 73.67* | 70.67* | 52.43* | 51.73 | 3.70 | 3.0 | 63.53 | 70.0 | 6.33 | 6.57 |
| $1BC_1$ | 72.00* | 72.0 | 63.97 | 65.93 | 6.50* | 4.77* | 89.57* | 91.27* | 7.13* | 7.77* |
| $2BC_1$ | 74.67 | 75.33 | 62.07 | 63.67 | 5.60* | 4.07* | 81.37 | 86.00* | 6.93 | 7.97* |
| $3BC_1$ | 79.67 | 78.0 | 58.83 | 56.57 | 6.37* | 4.0* | 68.00 | 69.80 | 6.73 | 6.53 |
| $4BC_1$ | 79.00 | 70.67* | 59.33 | 60.0 | 6.03* | 7.0* | 86.70* | 92.13* | 7.50* | 8.0* |
| $5BC_1$ | 75.00 | 76.33 | 54.97 | 65.53 | 5.73* | 3.0 | 83.03* | 66.40 | 6.53 | 7.57* |
| $6BC_1$ | 71.00* | 74.67 | 50.40* | 50.0* | 4.53 | 4.40* | 73.07 | 63.00 | 5.87 | 6.90 |
| $1BC_2$ | 82.67 | 74.33 | 60.50 | 65.73 | 4.63 | 5.4* | 62.40 | 81.73* | 6.73 | 7.50* |
| $2BC_2$ | 82.00 | 84.0 | 58.17 | 60.20 | 3.67 | 4.27* | 65.63 | 84.0* | 5.73 | 6.8 |
| $3BC_2$ | 72.67* | 79.33 | 58.22 | 59.33 | 4.20 | 3.9* | 70.87 | 77.67 | 6.00 | 7.73* |
| $4BC_2$ | 78.00 | 73.67 | 60.30 | 57.47 | 4.07 | 4.3* | 60.93 | 55.40 | 6.53 | 7.7* |
| $5BC_2$ | 74.67 | 75.33 | 58.37 | 56.37 | 3.53 | 4.2* | 61.63 | 80.40* | 6.47 | 6.8 |
| $6BC_2$ | 69.67* | 70.67* | 52.20* | 51.47* | 3.47 | 4.53* | 46.87 | 58.0 | 5.93 | 6.83 |
| LC-4(Check) | 81.00 | 79.33 | 61.60 | 60.53 | 3.83 | 2.8 | 69.00 | 66.27 | 5.97 | 6.53 |
| Gross mean | 75.36 | 75.03 | 58.36 | 59.63 | 4.76 | 4.45 | 71.31 | 76.27 | 6.65 | 7.28 |
| S.E.± | 2.42 | 2.59 | 3.17 | 3.12 | 0.39 | 0.37 | 4.89 | 4.53 | 0.37 | 0.32 |
| C.D.(P=0.05) | 6.85 | 7.35 | 8.99 | 8.84 | 1.10 | 1.04 | 13.85 | 12.84 | 1.06 | 0.91 |

* indicate significance of value at P=0.05

**Table 2: Mean performance of parents and crosses for seventeen traits at ($E_1$) and ($E_2$) location**

| Location / Parents | Capsule diameter (mm.) | | Days to maturity | | Seed yield/ plant (g.) | | Test weight (g.) | | Oil content (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki |
| Meera | 8.13 | 8.53* | 135.67 | 137.33 | 5.83* | 6.90* | 8.60* | 8.40* | 37.00 | 36.67* |
| Shekhar | 8.53* | 8.20* | 135.33 | 134.67 | 5.53* | 6.40* | 8.10* | 8.13* | 37.00 | 37.00* |
| T-397 | 6.90 | 7.4 | 125.33* | 126.0* | 5.33* | 5.87 | 7.80 | 7.93* | 36.50 | 37.67* |
| KL-221 | 7.87 | 8.13* | 121.67* | 124.0* | 4.50 | 5.70 | 7.33 | 8.00* | 35.50 | 37.50* |
| JLS-9 | 7.50 | 7.87 | 121.33* | 122.0* | 4.20 | 5.43 | 7.57 | 7.63* | 36.0 | 37.50* |
| **Crosses** | | | | | | | | | | |
| $1F_1$ | 9.17* | 9.07* | 130.00 | 134.0 | 9.00* | 8.50* | 8.20* | 8.43* | 36.53 | 36.83* |
| $2F_1$ | 6.83 | 8.53* | 132.33 | 133.33 | 7.97* | 7.53* | 8.53* | 8.83* | 35.50 | 37.50* |
| $3F_1$ | 8.17 | 8.80* | 133.67 | 136.0 | 6.47* | 7.83* | 7.80 | 8.30* | 36.0 | 37.50* |
| $4F_1$ | 8.40 | 8.60* | 127.67* | 129.33 | 9.50* | 8.47* | 8.43* | 9.23* | 36.37 | 37.00* |
| $5F_1$ | 7.97 | 8.00 | 125.00* | 126.67* | 5.97* | 8.20* | 8.67* | 9.43* | 36.50 | 36.67* |
| $6F_1$ | 8.73* | 8.40* | 122.33* | 122.67* | 5.30* | 7.10* | 8.43* | 8.63* | 36.33 | 36.50 |
| $1F_2$ | 6.53 | 8.40* | 129.33 | 124.0* | 5.80* | 6.37* | 8.07* | 7.50* | 36.07 | 36.50 |
| $2F_2$ | 8.17 | 8.20* | 128.33 | 137.0 | 4.63 | 5.13 | 7.37* | 6.67* | 36.10 | 36.00 |
| $3F_2$ | 7.63 | 7.20 | 129.00 | 132.0 | 3.30 | 4.27 | 7.73 | 6.33* | 36.37 | 37.50* |
| $4F_2$ | 7.50 | 8.47* | 128.33 | 131.67 | 3.27 | 4.70 | 7.20 | 7.10* | 35.67 | 36.50 |
| $5F_2$ | 7.03 | 8.13* | 126.67* | 125.33* | 3.30 | 4.07 | 6.97 | 7.43* | 35.50 | 37.50* |
| $6F_2$ | 6.83 | 7.27 | 123.00* | 122.0* | 3.20 | 3.33 | 7.43 | 6.60* | 36.19 | 36.67* |
| $1BC_1$ | 8.30 | 8.60* | 124.00* | 125.67* | 8.07* | 8.03* | 8.13* | 8.00* | 36.00 | 36.50 |
| $2BC_1$ | 8.13 | 7.80 | 125.67* | 124.33* | 8.13* | 7.00* | 8.40* | 7.77* | 37.50* | 38.50* |
| $3BC_1$ | 7.93 | 7.00 | 126.00* | 129.67 | 7.00* | 6.50* | 7.37 | 8.27* | 36.00 | 40.00* |
| $4BC_1$ | 8.07 | 8.50* | 125.00* | 124.67* | 8.37* | 7.87* | 8.17* | 8.70* | 37.50* | 37.50* |
| $5BC_1$ | 7.93 | 8.40* | 123.33* | 128.0* | 4.93 | 7.33* | 8.23* | 8.30* | 35.00 | 35.50 |
| $6BC_1$ | 8.03 | 8.40* | 121.00* | 123.0* | 4.77 | 4.90 | 7.50 | 7.70* | 37.0 | 38.00* |
| $1BC_2$ | 6.53 | 7.33 | 135.33 | 135.33 | 5.43 | 6.07 | 7.53 | 7.43* | 36.50 | 38.50* |
| $2BC_2$ | 7.17 | 7.67 | 134.33 | 134.33 | 4.77 | 5.80 | 7.50 | 7.40* | 34.00 | 38.00* |
| $3BC_2$ | 7.63 | 6.00 | 131.33 | 132.67 | 4.50 | 4.93 | 7.30 | 7.20* | 39.00* | 36.50 |
| $4BC_2$ | 7.63 | 8.10 | 132.00 | 131.0 | 3.80 | 5.40 | 6.87 | 7.43* | 40.00* | 38.83* |
| $5BC_2$ | 6.80 | 7.33 | 127.00* | 128.0* | 4.97 | 4.50 | 6.20 | 7.40* | 38.00* | 38.50* |
| $6BC_2$ | 7.93 | 8.87 | 122.67* | 122.67* | 5.37 | 4.63 | 7.00 | 7.07* | 35.50 | 35.50 |
| L-54 | 7.50 | 7.00 | 133.00 | 133.0 | 3.97 | 4.60 | 6.53 | 4.47 | 36.50 | 35.50 |
| Gross mean | 7.71 | 7.94 | 127.85 | 129.01 | 5.57 | 6.11 | 7.69 | 7.72 | 36.44 | 41.27 |
| S.E.± | 0.33 | 0.36 | 1.85 | 1.691 | 0.43 | 0.63 | 0.46 | 0.46 | 0.34 | 21.57 |
| C.D. (P=0.05) | 0.94 | 1.02 | 5.25 | 4.78 | 1.23 | 1.80 | 1.31 | 1.32 | 0.98 | 61.07 |

* indicate significance of value at P=0.05

**Table 3 : Mean Performance of parents and crosses for seventeen traits at ($E_1$) location**

| Parents \ Location | Palmitic acid content (%) | Stearic acid content (%) | Oleic acid content (%) | Linoleic acid content (%) | Linolenic acid content (%) |
|---|---|---|---|---|---|
| | Ranchi | Ranchi | Ranchi | Ranchi | Ranchi |
| Meera | 12.55* | 5.34 | 17.73 | 16.19* | 48.64* |
| Shekhar | 11.57* | 5.51 | 22.49* | 12.78 | 42.62* |
| T-397 | 13.07* | 5.70 | 18.19 | 13.42 | 49.17* |
| KL-221 | 7.17 | 11.47* | 30.86* | 14.62 | 44.90* |
| JLS-9 | 7.18 | 11.95* | 12.73 | 17.66* | 48.91* |
| **Crosses** | | | | | |
| $1F_1$ | 13.92* | 4.99 | 12.63 | 10.39 | 50.61 |
| $2F_1$ | 6.18 | 9.29* | 25.70* | 10.77 | 49.53* |
| $3F_1$ | 7.20 | 9.35* | 22.33* | 17.82* | 34.77* |
| $4F_1$ | 6.82 | 6.06 | 23.94* | 14.92* | 50.90 |
| $5F_1$ | 6.70 | 4.22 | 21.51* | 15.96* | 45.70* |
| $6F_1$ | 9.31* | 12.90* | 11.63 | 18.41* | 48.86* |
| $1F_2$ | 7.61 | 4.10 | 11.81 | 10.39 | 48.11* |
| $2F_2$ | 6.78 | 5.57 | 23.44* | 12.81 | 41.91* |
| $3F_2$ | 7.83 | 7.65* | 14.99 | 16.98* | 24.78* |
| $4F_2$ | 5.17 | 4.60 | 20.51* | 14.21 | 50.47 |
| $5F_2$ | 5.34 | 4.88 | 24.03* | 10.77 | 51.78 |
| $6F_2$ | 6.67 | 5.47 | 14.24 | 13.59 | 55.05 |
| $1BC_1$ | 10.14* | 18.20* | 24.58* | 13.82 | 50.55 |
| $2BC_1$ | 6.25 | 14.11* | 23.60* | 13.41 | 40.90* |
| $3BC_1$ | 16.90* | 10.21* | 23.74* | 23.70* | 51.99 |
| $4BC_1$ | 10.20* | 6.70 | 22.80* | 14.47 | 49.39* |
| $5BC_1$ | 11.14* | 5.91 | 14.18 | 14.65* | 52.36 |
| $6BC_1$ | 6.80 | 5.50 | 20.93* | 16.61* | 44.34* |
| $1BC_2$ | 12.07* | 11.15* | 12.36 | 21.15* | 49.84* |
| $2BC_2$ | 13.95* | 12.20* | 16.05 | 18.01* | 52.68 |
| $3BC_2$ | 15.76* | 16.73* | 27.28* | 26.48* | 50.89 |
| $4BC_2$ | 6.70 | 4.30 | 23.57* | 13.20 | 56.33 |
| $5BC_2$ | 7.05 | 11.31* | 30.04* | 14.54* | 48.03* |
| $6BC_2$ | 8.03 | 4.20 | 26.98* | 16.57* | 59.55* |
| LC-54 | 8.40 | 7.30 | 19.40 | 14.19 | 50.65 |
| Gross mean | 9.16 | 8.39 | 19.60 | 15.41 | 48.14 |
| S.E.± | 0.06 | 0.05 | 0.06 | 0.11 | 0.24 |
| C.D. (P=0.05) | 0.18 | 0.16 | 0.18 | 0.33 | 0.68 |

* indicate significance of value at P=0.05

GCV and PCV for all characters (excluded five fatty acids) for parents and crosses at Chianki location ($E_2$) (Table 5 and 6) revealed high PCV for most of the characters such as, wilt disease reaction, capsule per plant, rust disease reaction, plant height, seed yield per plant, days to 50 per cent flowering, number of primary branches per plant and days to maturity. The moderate PCV was observed for only one character *i.e.* tests weight while rest of the traits showed low PCV. GCV revealed almost similar trend as that of PCV estimate except three character days to 50 per cent flowering, days to maturity and test weight. Almost all the characters like, plant height, number of primary branches per plant, number of capsules per plant, wilt disease reaction, rust disease reaction, seed yield per plant at both the locations and all the fatty acids at Ranchi location showed high

**Table 4: Mean performance of parents and crosses for seventeen traits at ($E_1$) and ($E_2$) location**

| Location / Parents | Wilt-disease reaction (%) | | Rust-disease reaction (%) | |
|---|---|---|---|---|
| | Ranchi | Chianki | Ranchi | Chianki |
| Meera | 36.67 | 29.33 | 35.00 | 28.33 |
| Shekhar | 31.67* | 27.67 | 28.33 | 25.00 |
| T-397 | 33.33 | 28.33 | 32.67 | 22.33 |
| KL-221 | 35.67 | 27.33 | 37.33 | 23.33 |
| JLS-9 | 32.67 | 27.67 | 34.33 | 22.67 |
| **Crosses** | | | | |
| $1F_1$ | 09.67* | 7.67* | 10.33* | 10.00* |
| $2F_1$ | 11.67* | 9.67* | 13.00* | 15.33* |
| $3F_1$ | 29.33* | 24.33* | 24.67 | 17.33* |
| $4F_1$ | 09.00* | 7.0* | 09.00* | 10.67* |
| $5F_1$ | 34.33 | 29.33 | 26.00 | 21.33 |
| $6F_1$ | 35.00 | 30.0 | 27.33 | 21.33 |
| $1F_2$ | 40.00 | 35.0 | 31.67 | 24.33 |
| $2F_2$ | 43.33 | 38.33 | 33.33 | 24.67 |
| $3F_2$ | 50.00 | 48.3 | 36.00 | 30.0 |
| $4F_2$ | 54.00 | 49.0 | 40.00 | 31.67 |
| $5F_2$ | 53.67 | 48.67 | 36.67 | 31.33 |
| $6F_2$ | 52.33 | 52.33 | 40.67 | 32.67 |
| $1BC_1$ | 10.00* | 8.33* | 9.33* | 12.00* |
| $2BC_1$ | 10.33* | 9.33* | 10.00* | 12.33* |
| $3BC_1$ | 22.67* | 17.67* | 23.67 | 17.67* |
| $4BC_1$ | 10.67* | 9.0* | 9.67* | 12.0* |
| $5BC_1$ | 39.33 | 34.93 | 32.33 | 26.33 |
| $6BC_1$ | 38.00 | 33.33 | 31.67 | 27.33 |
| $1BC_2$ | 37.67 | 32.67 | 29.00 | 28.0 |
| $2BC_2$ | 40.67 | 35.67 | 39.33 | 22.33 |
| $3BC_2$ | 42.67 | 37.67 | 40.67 | 25.33 |
| $4BC_2$ | 32.67 | 27.67 | 31.00 | 26.67 |
| $5BC_2$ | 37.33 | 32.33 | 35.00 | 20.67 |
| $6BC_2$ | 49.67 | 45.0 | 32.67 | 27.33 |
| LC-54 | 38.33 | 33.33 | 20.67 | 24.67 |
| Gross mean | 33.41 | 29.21 | 28.04 | 22.53 |
| S.E.± | 2.26 | 2.43 | 2.03 | 1.52 |
| C.D.(P=0.05) | 6.41 | 6.90 | 5.75 | 4.31 |

* indicate significance of value at P=0.05

PCV and GCV, showing presence of variability among the treatments for all the yield and yield attributing traits. PCV was higher than GCV for all the characters at both the locations. Low difference between PCV and GCV for these traits indicated that there was less influence of environment for expression of their traits. The findings of Tadesse *et al*. (2010); Belete *et al*. (2013); Reddy *et al*. (2013); Yared *et al*. (2013); Ahmad *et al*. (2014); Sahu *et al*. (2014) and Tyagi *et al*. (2014) also supports the results.

Heritability estimates (expressed in %) in broad sense and GA were estimated for each of the seventeen characters both among the parents and crosses at Ranchi location and presented in Table 5. Heritability estimate ranged from 21.99 (test weight) to 99.96 (oleic acid). High heritability was observed for palmitic acid , linolenic acid, wilt disease reaction, rust disease reaction, seed yield per plant, oil content, number of capsules per plant, number of primary branches per plant and days to maturity. Moderate heritability was observed for number of capsule per plant and days to maturity while rest of the characters showed low heritability. The genetic advance ranged from 0.39 (number of seeds per capsule) to 26.92 (wilt disease reaction). The characters wilt disease reaction (26.92) and number of capsules per plant, showed high genetic advance while characters rust disease reaction, linolenic acid content and oleic acid content showed moderate genetic advance values and rest of the characters showed low genetic advance values. In the present investigation high heritability at Chianki location was observed for wilt disease reaction, oil content, rust disease reaction, days to maturity, primary branches per plant and number of capsules per plant. Moderate heritability was observed for seed yield per plant and test weight while rest of the characters showed low heritability. The genetic advance for characters studied were ranged from 55 (seeds per capsule) to 25.20 wilt disease reaction. High genetic advance was observed for wilt disease reaction and number of capsules per plant. Moderate genetic advance was observed for linolenic acid content, rust disease reaction and oleic acid content while rest of the characters showed low genetic advance.

In the present investigation high heritability coupled with high to moderate genetic advance was found for traits like; wilt disease reaction, oleic acid content and linolenic acid content at both the locations. High heritability with high genetic advance was recorded for rust disease reaction at location Ranchi ($E_1$) and high heritability with high genetic advance was observed for number of capsules per plant at location Chianki ($E_2$). The findings

**Table 5: Estimates of variability, heritability and genetic advance at ($E_1$) and ($E_2$) location**

| Location / Characters | PCV. | | GCV. | | Heritability (%) | | Genetic advance | | Genetic advance as per cent of mean | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki | Ranchi | Chianki |
| Days to 50% flowering | 33.07 | 34.70 | 9.70 | 7.73 | 29.33 | 22.27 | 3.02 | 2.34 | 4.00 | 3.11 |
| Plant height (cm.) | 76.72 | 91.26 | 24.90 | 42.14 | 32.46 | 46.18 | 4.47 | 7.01 | 76.58 | 11.75 |
| No. of primary branches/ plant | 38.67 | 32.66 | 29.00 | 23.41 | 74.99 | 71.70 | 2.09 | 1.78 | 43.89 | 39.97 |
| No. of capsules/ plant | 336.48 | 274.82 | 235.71 | 193.92 | 70.05 | 70.57 | 22.47 | 21.04 | 31.50 | 27.58 |
| No. of seeds/ capsule | 8.53 | 6.93 | 2.17 | 2.59 | 25.41 | 37.34 | 0.39 | 0.55 | 5.86 | 7.54 |
| Capsule diameter (mm.) | 8.53 | 9.43 | 4.19 | 4.45 | 49.11 | 47.23 | 0.82 | 0.84 | 10.62 | 10.57 |
| Days to maturity | 21.84 | 23.75 | 13.77 | 17.10 | 63.05 | 72.00 | 6.87 | 8.20 | 5.37 | 6.35 |
| Seed yield/ plant (g.) | 63.12 | 47.65 | 52.85 | 27.81 | 83.72 | 58.37 | 3.23 | 2.05 | 57.96 | 33.53 |
| Test weight (g.) | 10.78 | 17.78 | 2.37 | 9.22 | 21.99 | 51.85 | 0.41 | 1.25 | 5.32 | 3.23 |
| Oil content (%) | 4.28 | 4.55 | 3.29 | 4.09 | 76.90 | 89.90 | 1.97 | 2.54 | 5.40 | 6.15 |
| Palmitic acid content (%) | 114.12 | - | 113.98 | - | 99.88 | - | 6.67 | - | 72.74 | - |
| Stearic acid content (%) | 190.24 | - | 190.12 | - | 99.94 | - | 8.22 | - | 97.91 | - |
| Oleic acid contents (%) | 150.36 | - | 150.29 | - | 99.96 | - | 11.42 | - | 55.77 | - |
| Linoleic acid content (%) | 87.13 | - | 86.86 | - | 99.69 | - | 7.52 | - | 48.77 | - |
| Linolenic acid contents (%) | 88.80 | - | 88.44 | - | 99.60 | - | 13.41 | - | 27.85 | - |
| Wilt-disease reaction( %) | 599.54 | 628.57 | 553.47 | 567.46 | 92.32 | 90.28 | 26.92 | 25.20 | 80.57 | 86.26 |
| Rust-disease reaction (%) | 408.14 | 207.52 | 364.02 | 176.62 | 89.19 | 85.11 | 19.65 | 11.99 | 70.06 | 53.21 |

of Nakhlawy (2006); Tadesse *et al.* (2010); Kumar *et al.* (2012); Belete *et al.* (2013); Reddy *et al.* (2013); Sahu *et al*. (2014) and Tyagi *et al*. (2014) were in agreement with the finding of this experiment.

**Conclusion :**

Phenotypic co-efficient of variability was higher than genotypic co-efficient of variability for all the characters like, plant height, number of primary branches per plant, number of capsules per plant, wilt disease reaction, rust disease reaction, seed yield per plant showed high PCV and GCV at both the locations including all the fatty acids at only Ranchi location showing presence of variability among the treatments for yield and yield attributing traits.

High heritability coupled with high genetic advance was observed for number of capsules per plant at location Chianki whereas high heritability with high genetic advance was recorded for rust disease reaction at location Ranchi. High heritability coupled with high to moderate genetic advance was found for traits like wilt disease reaction, oleic acid content and linolenic acid content and rest characters exhibited low heritability and low genetic advance at both the locations.

## LITERATURE CITED

**Ahmad, R.,** Danish, Ibrar, D. M., Mirza, Y., Mahmood, T., Khan, M.A., Iqbal, M.S. and Ahmad, M. (2014). Genetic variability, heritability and genetic advance in some genotypes of linseed (*Linum usitatissimum* L.). *J. Agric. Res.*, **52** (1): 43.

Anonymous, (2013). Annual Progress Report, All India Co-ordinated Research Project on Linseed. Project Coordinating Unit (Linseed), C.S.A. University of Agriculture and Technology, Kanpur (U.P.) INDIA.

Anonymous (2014). Economic survey of Himachal Pradesh. Economics and Statistical, pp. 69-70, Department. Government of Himachal Pradesh, (H.P.) INDIA.

Anonymous (2014). Annual progress report, all india co-ordinated research project on linseed. Project co-ordinating, linseed unit, C.S.A. University of Agriculture and Technology, Kanpur (U.P.) INDIA.

**Belete, S. Yared,** Wolde, Y. and Misteru, T. (2013). Genetic variation of different crosses of linseed (*Linum usitatissimum* L.) genotypes for some agro-morphological traits. *Asian J.Crop Sci.*, **5** (4): 436.

**Kumar, S.,** Kerkhi, S.A., Gangwar, L.K., Chand, Pooran and Kumar, M. (2012). Improvement in the genetic architecture through study of variability, heritability and genetic advance in linseed crop (*Linum usitatissimum* L.). *Internat. J. Res. Engg. IT & Soc. Sci.*, **2**(9) : 58-62.

**Nakhlawy, F.S.EL.** (2006). Gene effects controlling the inheritance of yield, oil content and fatty acid composition of flax (*Linum usitatissimum* L.) *JKAU: Met., Env. & Arid Land Agric. Sci.*, **17** (1) : 47-57.

**Reddy, M. P.,** Reddy, Rajasekhar and Maheshwari, J.J. (2013). Screening of linseed genotypes for resistance against Budfly, *Alternaria* and Powdery mildew and genetic parameters for yield components in linseed (*Linum usitatissimum* L.). *Internat. J. Curr. Microbiol. App. Sci.*, **2** (9) : 267-276.

**Sahu, G.,** Mishra, S.P., Mishra, V.K., Sahu T. and Solanki, R.S. (2014). Studies on genetic variability in linseed (*Linum usitatissimum* L.). Genotypes under rainfed condition. *J. Ecol., Envir. Conser.*, **20** (3) : 983-987.

**Tadesse, T.,** Parven, A. Singh, H. and Weyessa, B. (2010). Estimates of variability and heritability in linseed germplasm. *Internat. J. Sustain. Crop Prod.*, **5**(3): 8-16.

**Tyagi ,A.,** Kumar, M., Kumar, S., Mishra, S.K., Kerkhi, S. A. and Chand, Pooran (2014). Estimates of genetic variability, heritability and genetic advance in linseed (*Linum usitatissinum* L.) germplasm. *Prog. Agric*., **14** (1): 37-48.

**Walsh, R.J.** (1965). Linseed oil protection for New York State Thruway bridges. *Civil Engg.*, **15** (2) : 39-41.

**Yared, S.B.,** Wolde, Y. and Misteru, T. (2013). Genetic variation of different crosses of linseed (*Linum usitatissimum* L.) genotypes for some agro-morphological traits. *Asian J. Crop Sci*., **5** (4): 436.