Original Research Article

<https://doi.org/10.20546/ijcmas.2019.801.120>

Combining Ability Analysis for Oil and Seed Parameters in Linseed (*Linum usitatissimum* L.).

Anu Rastogi* and Sudhir Shukla

Department of Genetics and Plant Breeding,
CSIR-National Botanical Research Institute, Lucknow, U.P., India

*Corresponding author

ABSTRACT

Keywords

Linseed, Oil, Acid
value, Fatty acids,
Colour value

Article Info

Accepted:
10 December 2018
Available Online:
10 January 2019

The present study deals with the scope of development of linseed lines for edible purposes by estimating its oil, seed and oil quality characteristics. For this study 30 lines and three testers were crossed in line x tester mating design to get high yielding crosses. Seed colour ranged between greyed orange (165A/166A) or brown group (200D) while majority of crosses in F₂ belonged with brown group (200D) except few ones having greyed orange group (165A). Among the testers, Heera was found good general combiner for true density Ex-7959 for porosity and phenol content and Neelam for Iodine value, linolenic acid and linoleic acid. Parents EC-115161 and EC-115178 were good general combiner for oil in F₁ generation while CRISTA for in F₂ generation. Parent EC-112689 was found good general combiner for oil content in both generations. The crosses EC-104739 x Neelam, EC-110288 x Neelam, EC-112689 x Neelam, EC-115178 x Heera and Ex-339-6 x Heera in F₁ and crosses EC-41750 x Heera, EC-41752 x Ex-7959, EC-1041492 x Neelam, ES-1474 x Heera and Ezox Heera in F₂ generation and cross Ex-28-3 x Ex-7959 in both generations were good specific combiners for oil percentage.

Introduction

Oils are an essential part of our diet by supplying concentrate source of energy, improving flavor to food and helps in absorption of vitamins in body (Fellows *et al.*, 1998 and Okorie and Nwachukwu, 2014). It can be extracted from a variety of plant seeds such as soybean, cotton, sesame, sunflower, safflower, palm, corn and canola makes them primary oilseed crops. The tremendous research work on these major oilseed crops on various aspects have been done for the

development of high oil yielding varieties and are still continuing in India. In spite of sincere efforts, these crops are still unable to meet out the demand and supply ratio of edible oil. So, seeing the growing population rate and their ever increasing demand of oil, there is an urgent need to seek other secondary oil yielding crops having similar edible oil characteristics and nutritional qualities to fulfill this demand. Linseed is one of the oilseed crop, which can be a future edible oil seed crop having physical, chemical, and processing properties similar to other oilseed

crops with balanced proportion of essential fatty acids except linoleic/ α -linolenic acid composition. The commercial demand of linseed is currently dominated by the industrial uses of its oil in varnishes, paints and additives (Dash *et al.*, 2017 and Kaur *et al.*, 2018). The oil is amber in colour and is extracted from the cotyledons and inner coats of seeds. The oil ranges from 33 to 45% in different varieties having high content of PUFA triglycerides (upto 73%) including 6-9% saturated fat, 16-20% monosaturated fat, 16-22% linoleic acid and 60-69% linolenic acid with vitamins A, B, D, E, minerals, carbohydrates, soluble and insoluble fibers, phytoestrogenic lignans (secoisolariciresinol diglycoside-SDG), proteins, an array of antioxidants and amino acids (Kouba *et al.*, 2003; Basbag *et al.*, 2009; Chauhan *et al.*, 2009; Khan *et al.*, 2010; Herchi *et al.*, 2009 and Goyal *et al.*, 2014).

The whole plant has commercial use directly or indirectly as a food ingredient, industrial purposes and medicinal purposes worldwide (Kumari and Rao, 2008; Bozan and Tamelli, 2008; Bayrak *et al.*, 2010; Gonarkar and Jain, 2013; Biradakar *et al.*, 2016; Singh *et al.*, 2016; Dash *et al.*, 2017 and Kaur *et al.*, 2018). Beside the oil valuable properties, after oil extraction the remaining oil cakes have high protein which are used for baby food, breakfast food, energy rich foods for disaster victims and young stock, manure, fodder, cosmetics, perfumes, insecticides and pharmaceutical products (Biswas *et al.*, 2001; Warrand *et al.*, 2005 and Kaur *et al.*, 2018). The seeds are brown to yellow, flat and oval with pointed tip measuring about 2.5 x 5.0 x 1.5 mm and have a pleasant nutty taste, crispy and chewy texture (Gonarkar and Jain, 2013). Generally, oily seeds have greater dimension than fiber seeds (Coskuner and Karababa, 2007). Dried flax seeds are used in cookery as well as for preparation of various medicines for breast and prostate cancers, intestinal and

urinary problems, hypercholesterolaemia, thrombosis, platelet adhesiveness and chest problems (Loria, 1993; Guan *et al.*, 1998; Chen *et al.*, 2006; Thompson *et al.*, 2005; Science daily, 2007 and Coskuner and Karababa, 2007). Linseed contains highest arginine and tryptophan when compared with sunflower which is essential amino acids to reducing the healing time of injuries and protein biosynthesis has an amino acid profile comparable to soybean flour and contains no gluten (Hongzhi *et al.*, 2004 and Hussain *et al.*, 2008).

High α -linolenic acid content in linseed oil causes sensitivity to oxidation leading to rapid rancidity and reduces its shelf life making it non-edible (Jaswir *et al.*, 2005 and Hall *et al.*, 2016). The edible linseed oil with increase keeping and desirable nutritional quality can be obtained by reducing α -linolenic acid <5% to maintain the required ratio of linoleic and α -linolenic acids (5:1 to 10:1) in its oil (Nykter and Kymalainen, 2006 and Ebrahimi *et al.*, 2014). The development of such lines having low α -linolenic acid/high linoleic acid can serve linseed as an edible oilseed crop, which can substantially substitute other edible oilseed crops. This can be certainly a significant contribution to Indian vegetable oil industry and also can be healthy oil to the society. Simultaneously, its seed meal can also serve as an ideal meal for poultry industry. So present study is undertaken with the objective of screening linseed lines having edible oil properties by combining ability analysis using line x tester mating design.

Materials and Methods

The present study was conducted in the field of Genetics and Plant Breeding, CSIR-National Botanical Research Institute, Lucknow situated 26°40'E longitudes and 80°45' latitudes and at an altitude of 129m above sea level. For the present study 30

distinct lines and three testers were combined according to line x tester mating design, as a result 90 F₁s were developed. The seeds of F₁ crosses were sown and selfed to get 90 F₂. The final trial was conducted comprising of 33 parents, 90 F₁s and 90 F₂s with two rows of three replications. The rows were 3 meter in length and 30 cm apart. In each row plant to plant distance was maintained at 10 cm by thinning and recommended cultural practices and fertilizers were applied during whole crop season (Reddy and Pati, 1995).

The plants were selected randomly and the seeds of each plant were grinded and subjected to oil extraction through soxhlet method using hexane. The whole seeds were used for estimation of bulk density (g/cm³), true density (g/cm³) and porosity (%). The identification of colour of seeds were done using colour card of Royal Botanical society, Kew, England and the colour value of oil was determined using Lovibond Tintometer. The oil was taken separately for oil parameters analysis i.e. refractive index, specific gravity, acid value, linolenic acid (%), linoleic acid (%) and iodine value. The remaining oil cakes were used for protein (%), free amino acids (g/Kg), carbohydrate (%) and phenol (%). The description of estimation procedure of different parameters are described below:

Bulk density

It is the mass of particles of the material divided by the total volume they occupy. The total volume includes particle volume, inter-particle void volume and internal pore volume or is the ratio of mass sample of the seeds to its total volume and determined by filling a 1000ml measuring cylinder with seeds at height up to 15cm and weighted.

$$P = \frac{M_s}{V_t}$$

True density

It is the ratio of mass of the sample to its seed volume and was determined using water displacement method. 50ml of water was poured in a 100ml graduated measuring cylinder and 5g seeds were immersed in that water. The amount of displaced water was recorded from the graduated scale of the cylinder. The ratio of weight of seeds to the volume of displaced water gave the true density.

Porosity

Porosity is the fraction of the space in bulk grain which is not occupied by the grain. The porosity of bulk seed was calculated from the values of true density and bulk density using the relationship as follows:

$$\varepsilon = (p_t - p_b / p_t) \times 100$$

Where,

p_t = True density

p_b = Bulk density

Protein

The soluble protein of defatted powder was determined by using Bradford method. Sample (air-dried defatted powder +800 µl buffer extract) was placed in a test tube and centrifuged for 10 min. The 5µl of sample was placed in ELISA plate and added 200µl of Bradford reagent. The buffer was prepared by adding 20mM HEPES (pH 8.0), glycerol 10%, 1mM EDTA, 100mM PMSF, 0.5mM DTT and 1mM benzamidine. The absorbance of the sample was measured at 590 nm using spectrophotometer. Total protein was calculated as

Total protein content (%) =

$$\frac{O.D. (s) - O.D. (b) \times 18.3 \times 100}{\text{Volume of sample}}$$

Volume of sample

Where,

O.D. (s) = OD of sample in buffer

O.D. (b) = OD of blank

18.3= Standard factor

Free amino acid

The total free amino acids of defatted powder were determined spectrophotometrically following the procedure of Hamilton and Van Slyke (1943). Sample (100mg defatted powder + 1.0ml buffer extract) was placed in a test tube and centrifuged. The supernatant was taken in test tube and added a mixture of 1.0ml ninhydrin and 1.0ml of pyridine solution. The test tube was heated for 30 min on a boiling water bath. The content of tubes was diluted with 50 ml water and absorbance of the solution was measured at 570 nm using spectrophotometer. Total free amino acids were calculated as

Total free amino acids (g/kg) =

Abs. of sample x Vol. of sample x Dilution factor

Weight of the sample

Carbohydrate

The total carbohydrate content of defatted powder was determined spectrophotometrically by Phenol-Sulphuric acid method. Air-dried defatted powder (100mg) was suspended in 5.0ml water with heating for 5 minutes and filtered through Whatmann filter paper. The residue was re-suspended in 1% HCL to remove all the traces of soluble sugar and filtered sample (100µl) was placed in a beaker. The sample was diluted to 900µl by de-ionized water and then added 1ml of 5% phenol solution and 5ml sulphuric acid. The absorbance of each sample was monitored at 625 nm using spectrophotometer and calculated as

Carbohydrate (%) =

0.2857 x Abs. of sample x Dilution factor x 100

Weight of seeds

Phenolcontent

100g seeds were extracted with ethanol 80% (1000ml) on shaker for 24 hours at room temperature. The extract was filtered and evaporated to dryness in a rotary evaporator to yield ethanolic extract (yield: 19.3%). The Folin-Ciocalteu reagent (0.2ml), H₂O (2 ml) and 15% Na₂CO₃ solution (1 ml) was mixed in the ethanolic extracts (100 µl) and kept for 2 hours at room temperature. The absorbance of the mixture was then measured at 765 nm through spectrophotometer (Make: Shimadzu UV-1601). The mean of three readings was used and the total phenolic content was expressed as milligrams of gallic acid equivalents/1 g extract. The coefficient of determination was $r^2 = 0.9958$ (Aslan *et al.*, 2007).

Oil percentage

Total oil extracted from crushed seeds in culture tubes using soxhlet extraction method and calculated by using following formula:

Oil % =

(Weight of culture tubes + weight of oil) -
Weight of culture tubes X 100

Weight of seeds

Refractive index

It was measured by Refractometer by measuring the speed of light in oil. The appropriate temperature correction factors were specified using the following equation:

$R=R' + K (T'-T)$

Where,

R= Reading of the refractometer reduced to the specified temperature, T°C.

R'= reading at T'°C.

K= Constant 0.000385 for oils.

T'= temperature at which reading R' is taken.

T= specified temperature.

Specific gravity

Specific gravity is the ratio of density (mass of a unit volume) of a substance to the density of a given reference material. Specific gravity usually means relative density with respect to water. The term "relative density" is often preferred in modern scientific usage. If relative density of a substance is less than one then it is less dense than the reference; if greater than one then it is denser than the reference.

Relative density (RD) = ρ Substance / ρ Reference

Where,

RD= Relative density

ρ Substance= Density of the substance being measured

ρ Reference= Density of the reference

Specific gravity was measured by using Pycnometer (specific gravity bottle). The empty bottle was weighted followed by filled bottle with water. Further the bottle was weighted filled with oil avoiding air bubbles, insert the stopper, holed it for few minutes and weight it. Finally, it was calculate by the formula

Specific gravity = A-B/C-B

Where,

A= Weight in g of the specific gravity bottle with oil.

B= Weight in g of the specific gravity bottle.

C= Weight in g of the specific gravity bottle with water.

Acid value

The acid value was done to estimate the total free fatty acids present in the sample. 2.5g of appropriate sample of the material was dissolved in 20ml ethyl alcohol, previously neutrilized by phenolphthalein with KOH solution. The sample was titrated with KOH 0.1N solution until the solution remains faintly pink after 10 sec. of shaking. Finally, note the volume of KOH consumed and put that value in following formula

Acid Value = $56.10 \times V \times N / \text{wt. of oil}$

Where,

V = Volume of KOH consumed

N = Normality of KOH solution

wt. = Weight in g of material taken

Fatty acid analysis

The analysis was done using modified method of Schaffer and Holm (1950) and Indrayan *et al.*, (2005).

Linolenic acid

It was calculated as per formula

Linolenic acid (Y%) =

α (268m μ) x 100

53.20

Linoleic acid

It was calculated as per formula

Linoleic acid (%) =

α (234m μ) – (Y/100 x 60.90) x 100

86.00

Where,
53.20 is the specific absorption coefficient of pure linolenic acid at 268m μ , 60.90 is the specific absorption coefficient of linolenic acid at 234m μ and 86.00 is the specific absorption coefficient of pure linoleic acid at 234m μ .

Iodine value

The iodine value is iodine monochloride which is absorbed by sample to be tested and expressed in term of iodine. It is helpful to understand the concentration of unsaturated fatty acid present in testing sample and estimated by titration method using Wijs solution. It was calculated by the following formula

Iodine value =

$$\frac{(B-S) \times 0.0126 \times 100}{\text{Weight of sample}}$$

Where,

B = Blank test reading of burette

S = Titration of sample reading

W = Weight of the sample

Statistical analysis

The recorded data was subjected to combining ability analysis for selection of good general and specific combiners using INDOSTAT software, Hyderabad.

Results and Discussion

The estimates, magnitude and direction of general combining ability effects in both F₁ and F₂ generations of all 33 parents (3 testers and 30 lines) for all 14 traits are mentioned in table 1 and 3. The negative values were desirable for the traits porosity, refractive index, specific gravity, acid value, linolenic

acid and iodine value and positive values for rest of the traits. The range of gca effect for all the traits are mentioned in table 1. For oil percentage the only tester Neelam had significant maximum positive value in F₁ generation while none of the tester parent had significant positive value in F₂ generation. Among lines parent Ex-313-23 followed by EC-110288 and EC-115161 in F₁ and parent CRISTA followed by Ex-5-36E and Ex-28-3 in F₂ generation had significant maximum positive values. For bulk density none of the tester had significant positive value in both generations. Among lines parent EC-41752 followed by EC-1041492 and Ex-3 had significant maximum positive value in F₁ while parent Ex-3 followed by Ezox Natural and Ex-339-6 had non-significant maximum value in F₂ generation. For true density Heera had significant value for both generations. Among lines, parent EC-41752 followed by EC-41750 and EC-1041492 in F₁ generation and parent FR-3 followed by parents EC-99056, EC-41752, EC-104739, CRISTA, EC-225125, ES-1474, ES-1531 and FRW-9 in F₂ generation had significant positive high value. For Porosity Ex-7959 had high significant negative value in both generations. The line ES-14600 followed by EC-98994 and ES-1474 in F₁ and line EC-115161 followed by EC-112689 and Ex-313-23 in F₂ had significant maximum negative value. For protein none of the tester had significant value in F₁ while Heera followed by Neelam had significant maximum positive value in F₂ generation. Among lines parent ES-1463 followed by EC-41752 and Ezox Natural in F₁ and parent T-397 followed by ES-1496 and EC-110288 in F₂ had significant maximum positive value. Similarly for free amino none of the tester and line had significant positive value in both generations. The parent EC-115162 followed by EC-112689, Mukta, EC-115161, EC-115178 and EC-225125 in F₁ and parent T-397 followed by ES-1496 and EC-110288 in F₂ generation had maximum

positive value. For carbohydrate Ex-7959 had highest significant maximum positive value in F_1 while Heera in F_2 generation. Among line, parents EC-115161 followed by ES-1463 and Ex-28-3 in F_1 and parent EC-225125 followed by EC-99029 and EC-115186 in F_2 generation had significant maximum positive value. For phenol Ex-7959 had significant maximum positive value in both generations. Among lines, parent Ex-5-36E followed by parent CRISTA and Ex-28-3 in F_1 and parents Ex-5-36E followed by T-397 and CRISTA in F_2 generation had significant maximum positive values. For refractive index none of the tester and line had significant negative value in both generations. The parent EC-104739 in F_1 and parent Ex-5-36E followed by FR-3 and CRISTA in F_2 generation had maximum negative value. For specific gravity none of the tester had significant negative value. Among lines, parent FR-3 followed by Ezox Natural in F_1 and parent Ex-339-6 in F_2 generation had significant maximum negative value. Similarly for acid value none of the tester had significant negative value in F_1 generation while Heera had significant maximum negative value in F_2 generation. Among lines, parent EC-104739 followed by ES-14600 in F_1 and parent EC-112689 followed by EC-104739 and T-397 in F_2 generation had significant maximum negative value. For linolenic acid tester Neelam had significant negative value in F_2 generation. Among lines, the parent Ex-5-36E followed by CRISTA and EC-41750 in F_1 and parent EC-110288 followed by EC-98994 and Ex-5-36E in F_2 generation had significant maximum negative value. In linoleic Acid, Neelam had significant maximum positive value in both generations followed by Ex-7959 in F_2 generation. Among lines, parent EC-112689 had significant maximum positive value followed by parents EC-104739 and FRW-9 in F_1 and parent EC-115178 followed by parents ES-1474 and EC-112689 in F_2 generation. For iodine value Neelam had significant maximum negative

value in both generations. Among lines, parent Ex-28-3 followed by CRISTA and Ex-5-36E in F_1 and parent EC-110288 followed by EC-98994 and Ex-5-36E in F_2 generation had significant maximum negative value.

The values of specific combining ability effects and their per se performance of 90 crosses for all 14 traits are presented in table 2 and 4. For the traits viz. porosity, refractive index, specific gravity, acid value, linolenic acid and iodine value the negative values were considered desirable while for rest of the traits positive values were considered desirable. Based on per se performance five crosses possessed high value for three traits in F_1 , six crosses for three traits and four crosses for four traits in F_2 generation. The range of sca value for each trait are presented in table 2. For oil percentage 29 crosses possessed significant positive values in F_1 and 27 crosses in F_2 generation. The crosses having maximum significant positive values were Ex-3 x Ex-7959, ES-1463 x Neelam and EC-110288 x Neelam in F_1 and EC-115162 x Neelam, EC-115161 x Ex-7959 and ES-1474 x Heera in F_2 generation. For bulk density 34 crosses possessed significant positive values in F_1 and 47 crosses in F_2 generation. The cross ES-1463 x Neelam followed by crosses EC-115186 x Ex-7959 and EC-115178 x Heera in F_1 and cross T-397 x Heera followed by crosses EC-115186 x Neelam and ES-1496 x Ex-7959 in F_2 generation showed significant maximum positive values.

For true density 32 crosses in F_1 and 38 crosses in F_2 generation had significant positive values. Three desirable crosses in descending order of magnitude were ES-1463 x Neelam, EC-115186 x Ex-7959 and Ex-313-23 x Ex-7959 in F_1 and EC-115186 x Neelam, EC-110288 x Heera, EC-115178 x Heera, Ex-3 x Heera and Ex-5-36E x Heera in F_2 generation. Likewise for porosity 42 crosses in F_1 and 45 crosses in F_2 generation showed

significant negative values. The cross EC-115186 x Neelam followed by crosses Ex-28-3 x Heera and EC-104739 x Ex-7959 in F_1 generation and cross EC-41752 x Heera followed by Ex-28-3 x Neelam and Ex-3 x Ex-7959 in F_2 generation had significant maximum negative values. For protein 28 crosses in F_1 and 45 crosses in F_2 generation had significant positive values. The cross Ezox Natural x Heera followed by crosses EC-104739 x Heera and EC-1041492 x Ex-7959 in F_1 and cross ES-1531 x Neelam followed by crosses EC-115161 x Heera and EC-41752 x Ex-7959 in F_2 generation had significant maximum positive values. For free amino acid 19 crosses had significant positive values in F_1 and 32 crosses in F_2 generation. Few desirable crosses in descending order of magnitude were EC-99056 x Ex-7959, FRW-9 x Heera, ES-1474 x Neelam and EC-104739 x Neelam in F_1 and EC-115161 x Heera, EC-98994 x Heera, EC-41752 x Ex-7959 and EC-99056 x Ex-7959 in F_2 generation. For carbohydrate 44 crosses had significant positive values in F_1 and 43 crosses in F_2 generation. Based on the magnitude, cross ES-1531 x Heera followed by crosses FRW-9 x Heera and CRISTA x Neelam in F_1 and cross EC-110288 x Neelam followed by crosses ES-1496 x Ex-7959 and FRW-9 x Heera in F_2 generation exhibited significant maximum positive values. For phenol 42 crosses showed significant positive value in F_1 and 44 crosses in F_2 generation. The cross EC-115162 x Neelam followed by crosses EC-110288 x Heera and EC-112689 x Heera in F_1 generation and cross EC-41750 x Ex-7959 followed by EC-110288 x Heera and EC-99056 x Ex-7959 in F_2 generation had significant maximum positive values. For refractive index only two crosses in F_1 and 22 crosses in F_2 generation had significant negative values. Based on the magnitude, cross EC-98994 x Neelam followed by cross EC-98994 x Heera in F_1 and cross EC-1126898 x Neelam followed by crosses ES-1474 x Heera and EC-115178 x Heera in F_2

generation exhibited maximum significant negative values. Similarly for specific gravity 18 crosses in F_1 and only two crosses in F_2 generation had significant negative values. Three desirable crosses in descending order of magnitude were EC-104739 x Neelam, Ex-5-36E x Heera and EC-99029 x Ex-7959 in F_1 and crosses EC-112689 x Ex-7959 and Ex-339-6 x Neelam in F_2 generation. For acid value only one cross had significant negative value in F_1 and 43 crosses in F_2 generation. Based on magnitude, cross EC-98994 x Ex-7959 in F_1 and cross ES-1463 x Heera followed by crosses Ex-28-3 x Neelam and ES-1496 x Neelam in F_2 generation had significant maximum negative values. For linolenic acid 27 crosses in F_1 and 45 crosses in F_2 generation possessed significant negative values. The cross EC-41750 x Ex-7959 followed by crosses EC-115186 x Ex-7959 and Ex-5-36E x Ex-7959 in F_1 generation and cross T-397 x Neelam followed by crosses ES-14600 x Neelam and CRISTA x Heera in F_2 generation possessed significant maximum negative values. Likewise for linoleic acid 44 crosses in F_1 and 42 crosses in F_2 generation had significant positive values. The cross Ex-3 x Ex-7959 followed by crosses Mukta x Heera and EC-115178 x Ex-7959 in F_1 and Ezox Natural x Heera followed by crosses Ex-28-3 x Ex-7969 and EC-1041492 x Neelam in F_2 generation had significant maximum positive values. For the iodine value 46 crosses in F_1 and 45 crosses in F_2 generation had significant negative values. The cross Ex-28-3 x Neelam followed by crosses Ezox Natural x Heera and Mukta x Ex-7959 in F_1 and cross EC-41750 x Ex-7959 followed by crosses ES-115186 x Ex-7959 and FRW-9 x Neelam in F_2 had significant maximum negative values.

Among the parents, seed colour varies between greyed orange (165A) or brown group (200D). The grading of colour was done using colour card of Royal Botanical Society, Kew. The texture of seeds and colour of oil of

each parents are described in table 5. Among the F_1 crosses, seed colour vary between greyed orange (165A/166A) or brown group (200D) while seeds of majority of crosses in F_2 belonged with brown group (200D) except few ones having seed colour of greyed orange group (165A). The texture of seeds and colour of oil of each crosses in both generations are described in table 6 and 7.

There is always a need to improve the oil yield and its edible characteristic in secondary oilseed crops. The yield is a polygenic controlled trait and depends on large number of other related traits. Selection on the basis of yield alone is usually not effective, whereas selection along with its component characters could be more effective and reliable. There are several instances the importance of both additive and non-additive types of gene action for yield components was reported (Mistry *et al.*, 2016 and Devi *et al.*, 2018).

Linseed oil has less shelf life due to its rapid oxidation property (Kozłowska *et al.*, 2008; Singh *et al.*, 2011 and Faintuch *et al.*, 2011). Despite this, its physical and chemical properties is nearby similar to existing oilseed crops which proven the use of linseed oil for edible purposes. Various edible forms of flax are available in the food market as whole flaxseeds, milled flax, roasted flax etc. Linseed seeds are found in two colours (1) brown; and (2) yellow or golden and both have similar nutritional characteristics (Morris, 2007; Gonarkar and Jain, 2013 and Kaur *et al.*, 2018). It is evident by the literature that seed colour is also helpful to get an idea for fatty acid profile that can also be used as morphological marker.

Yield is a quantitative trait which is pretentious by genotype $\times$ environment ($G \times E$) hence combining ability would depend on the set of germplasm and environment where they are tested. The selection of best performing lines is main objective in the crop

breeding programme (Fasahat *et al.*, 2016 and Patel and Patidar, 2018). Combining ability is defined as ability of parents to combine in hybridization process to transfer the desirable genes or characters to their progenies. Two concepts of combining ability i.e. general combining ability (GCA) and specific combining ability (SCA) have had important influence on inbred line evaluation and population development in crop breeding. GCA is an effective tool used in selection of parents based on performance of their progenies, usually in the F_1 but it has also been used in F_2 and later generations (F_n). The high GCA estimate indicates higher heritability and less environmental effects. Additive variances are fixable in nature while non-additive are non-fixable and due to dominance and epistatic gene action. The dominance variances diminish by half with each generation of selfing and thus un-exploitable in pure lines. Epistatic variance also declines on selfing. In GCA determination, SCA usually acts as a masking effect. By selecting genetically broad testers or increasing number of testers, SCA impact can be decreases. Parental choice only on the basis of SCA effect has limited value in breeding programs. Therefore, SCA effect should be used in combination with a high performance *per se* hybrid, favourable SCA estimates, and involving at least one parent with high GCA (Fasahat *et al.*, 2016). Observations of performance of different cross patterns on the basis of SCA have been used to get result on gene action perform. High SCA effects in crosses where both parents are good general combiners (i.e., good GCA $\times$ good GCA) may be due to additive $\times$ additive gene action. The high SCA effects derived from crosses including good $\times$ poor general combiner parents may be credited to favourable additive effects of the good general combiner parent and epistatic effects of poor general combiner, which fulfils the favourable plant trait (Kumar *et al.*, 2011).

Table.1 General combining ability effects in F₁ and F₂ generations for different traits

S.No.	Parents	OIL		BD		TD		PO		PR	
		F ₁	F ₂	F ₁	F ₁	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
Testers											
1	Heera	-1.251	-0.594	0.056	-0.010	0.079 *	0.644 **	0.671 **	3.409 **	0.345	0.519 **
2	Ex-7959	-0.469	0.573	-0.006	0.002	-0.017	-0.667 **	-0.811 **	-3.724 **	-0.555	-0.959 **
3	Neelam	1.721 *	0.022	-0.050	0.008	-0.062	0.022 *	0.139	0.315 **	0.210	0.440 **
	gi-gj (tester)	0.337	0.450	0.015	0.026	0.015	0.005	0.044	0.005	0.146	0.005
Lines											
1	EC-41750	-7.098 **	0.493	0.109 *	-0.112	0.431 **	0.078 **	-3.738 **	0.680 **	2.228 **	-6.945 **
2	EC-41752	-1.739	4.000 *	0.579 **	-0.057	0.568 **	1.411 **	-1.019 **	8.164 **	3.155 **	-0.133 **
3	EC-98994	-4.215 **	0.650	0.059	0.001	0.048	-0.256 **	-10.349 **	-0.453 **	1.618 **	1.117 **
4	T-397	-5.577 **	-3.267 *	-0.265 **	-0.004	-0.276 **	0.078 **	17.123 **	-0.401 **	-0.890	7.129 **
5	EC-99029	-0.887	1.973	-0.200 **	0.034	-0.212 **	-0.811 **	-6.908 **	-4.789 **	-2.101 **	-0.640 **
6	EC-99056	-0.027	-6.305 **	-0.083	0.045	-0.094	1.411 **	-0.494 **	7.335 **	1.203 *	-4.388 **
7	EC-104739	2.032	-8.279 **	-0.629 **	0.017	-0.640 **	1.411 **	-1.567 **	7.589 **	0.042	-0.269 **
8	CRISTA	-2.392 *	11.540 **	-0.262 **	-0.125	-0.273 **	1.411 **	0.718 **	8.926 **	-1.012 *	-3.100 **
9	EC-110288	8.696 **	-8.683 **	-0.163 **	-0.020	-0.174 **	-0.533 **	-0.364 *	-4.282 **	0.993 *	4.357 **
10	EC-112689	5.895 **	3.201 *	0.071	0.013	0.060	-1.367 **	-3.285 **	-8.647 **	0.325	0.892 **
11	EC-115161	8.207 **	-1.559	0.095	0.012	0.084	-1.367 **	-3.647 **	-8.720 **	-1.481 **	-0.728 **
12	EC-115162	3.558 **	1.140	-0.416 **	-0.055	-0.428 **	-0.256 **	2.596 **	0.113 **	-0.802	1.888 **
13	EC-115178	8.154 **	-8.684 **	-0.488 **	0.027	-0.499 **	0.022	9.445 **	-0.477 **	-0.588	-0.094 **
14	EC-115186	2.689 *	0.935	-0.471 **	0.024	-0.482 **	0.022	3.934 **	-0.387 **	-1.652 **	-1.450 **
15	EC-225125	-7.229 **	0.320	0.234 **	0.045	0.223 **	0.578 **	-5.203 **	3.167 **	-5.551 **	-1.275 **
16	EC-1041492	-7.174 **	-1.345	0.400 **	-0.172 *	0.389 **	-0.256 **	1.276 **	5.177 **	-2.225 **	0.668 **
17	Mukta	5.048 **	2.428	0.049	0.010	0.038	-0.811 **	-4.720 **	-4.578 **	-1.217 *	-1.685 **
18	ES-1463	0.014	-6.915 **	0.103 *	-0.264 **	0.092	-0.811 **	-4.655 **	-1.584 **	4.975 **	0.882 **
19	ES-1474	-4.718 **	6.165 *	-0.106 *	0.086	-0.117 *	0.578 **	-7.863 **	2.878 **	2.965 **	-1.538 **
20	ES-1496	2.672 *	-5.137 **	-0.139 **	-0.007	-0.151 **	-0.256 **	-0.806 **	-0.370 **	0.910	5.099 **
21	ES-1531	-11.649 **	-4.860 **	0.102 **	-0.038	0.091	0.578 **	4.851 **	4.000 **	-1.364 **	-1.021 **
22	ES-14600	3.136 **	-7.745 **	-0.128 *	0.060	-0.139 **	-0.811 **	-12.562 **	-5.051 **	1.779 **	3.108 **
23	Ex-3	2.548 *	-2.109	0.399 **	0.166	0.388 **	0.022	-7.242 **	-2.089 **	0.662	-1.099 **
24	Ex-5-36E	-2.649 *	11.255 **	0.191 **	-0.040	0.180 **	0.022	3.542 **	0.114 **	-5.165 **	3.332 **
25	Ex-28-3	-0.494	11.091 **	0.253 **	0.097	0.242 **	-0.811 **	2.707 **	-5.621 **	-0.256	-0.142 **
26	Ex-313-23	10.034 **	-0.462	0.233 **	0.007	0.222 **	-1.367 **	-5.280 **	-8.547 **	-0.666	-4.066 **
27	Ex-339-6	-0.836	1.355	0.111 *	0.137	0.100 *	-0.478 **	-3.768 **	-5.944 **	0.274	0.267 **
28	Ezox Natural	-4.215 **	3.835 *	0.073	0.147	0.062	-0.256 **	12.392 **	-1.907 **	2.989 **	-1.167 **
29	FR-3	-0.550	0.635	0.095	-0.027	0.084	2.244 **	13.199 **	12.003 **	-1.281 **	-0.455 **
30	FRW-9	-1.233	4.338 *	0.193 **	-0.007	0.182 **	0.578 **	11.689 **	3.704 **	2.130 **	1.458 **
	gi-gj (line)	1.066	1.421	0.047	0.081	0.047	0.050	0.141	0.015	0.462	0.014

Table.1 Continued

S.No.	Parents	FAA		CAR		PHE		RF		SG	
		F ₁	F ₂	F ₁	F ₁	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
Testers											
1	Heera	0.001	0.001	-0.617 **	0.296 **	-0.138 **	-0.184 **	0.001	0.001	0.001	0.005
2	Ex-7959	-0.001	-0.001	0.768 **	-0.228 **	0.101 **	0.390 **	0.001	0.004	-0.002	-0.004
3	Neelam	0.001	0.001	-0.151 **	-0.069 **	0.037 **	-0.206 **	-0.001	-0.004	0.001	-0.002
	gi-gj (tester)	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.003	0.012
Lines											
1	EC-41750	0.003	-0.006	-1.496 **	-5.571 **	-0.599 **	0.750 **	0.001	0.013	0.009	0.008
2	EC-41752	0.003	0.000	-6.807 **	3.190 **	0.495 **	-0.275 **	0.001	0.030 *	0.010	-0.003
3	EC-98994	-0.001	0.001	-3.774 **	-3.343 **	-0.647 **	0.340 **	0.027	0.015	0.005	-0.015
4	T-397	-0.003	0.007	-5.267 **	-0.143 **	-0.096 **	1.349 **	0.000	0.020	-0.005	0.007
5	EC-99029	-0.001	-0.001	0.027	9.190 **	-0.595 **	0.344 **	0.001	0.018	-0.013	-0.016
6	EC-99056	-0.003	-0.004	-1.430 **	6.466 **	1.092 **	0.397 **	-0.003	0.023	0.011	0.036
7	EC-104739	-0.002	0.000	5.126 **	-8.257 **	-1.520 **	-1.129 **	-0.010	0.004	-0.001	0.033
8	CRISTA	-0.001	-0.003	-1.040 **	-2.467 **	1.410 **	0.937 **	-0.003	-0.021	-0.003	-0.007
9	EC-110288	-0.001	0.004	-2.828 **	-1.400 **	0.394 **	-0.085 **	-0.002	0.029	0.006	0.022
10	EC-112689	0.005	0.001	-2.716 **	-4.105 **	-0.683 **	-0.652 **	-0.004	-0.014	0.006	-0.071
11	EC-115161	0.004	-0.001	7.426 **	0.067 **	0.037 **	-0.621 **	-0.002	0.003	0.013	0.011
12	EC-115162	0.006	0.002	5.420 **	-1.752 **	-0.767 **	-1.506 **	-0.003	0.003	0.012	0.023
13	EC-115178	0.004	0.000	2.801 **	-1.248 **	-0.398 **	-0.906 **	-0.005	0.018	0.013	0.068
14	EC-115186	0.001	-0.002	-3.447 **	6.543 **	-0.844 **	0.314 **	-0.003	0.003	0.010	-0.026
15	EC-225125	0.004	-0.001	4.829 **	11.914 **	-0.478 **	0.166 **	-0.003	-0.005	-0.008	-0.024
16	EC-1041492	-0.003	0.001	-1.701 **	2.276 **	-0.009	0.554 **	0.002	0.005	0.001	0.034
17	Mukta	0.005	-0.002	-2.319 **	-0.829 **	-1.336 **	-0.180 **	-0.001	-0.002	0.014	-0.043
18	ES-1463	0.000	0.001	7.159 **	-6.066 **	0.486 **	-0.289 **	-0.001	0.004	0.012	0.032
19	ES-1474	0.002	-0.002	3.109 **	0.305 **	-0.814 **	-0.854 **	0.000	-0.014	0.011	-0.023
20	ES-1496	0.003	0.005	-2.138 **	2.228 **	-0.207 **	-0.095 **	0.000	0.005	0.000	0.007
21	ES-1531	-0.001	-0.001	0.553 **	0.419 **	-0.643 **	-0.981 **	0.000	-0.016	-0.015	0.058
22	ES-14600	-0.002	0.003	0.350 **	0.571 **	-0.449 **	-0.845 **	0.000	-0.010	-0.003	0.032
23	Ex-3	-0.002	-0.001	-5.412 **	-1.657 **	0.464 **	0.141 **	0.001	-0.015	-0.001	0.024
24	Ex-5-36E	-0.002	0.003	4.431 **	-3.524 **	2.027 **	1.387 **	0.000	-0.024	0.006	-0.009
25	Ex-28-3	-0.002	0.000	5.876 **	-3.905 **	1.405 **	0.474 **	0.001	-0.012	0.001	-0.027
26	Ex-313-23	-0.005	-0.004	-0.162 **	-8.495 **	-0.206 **	-0.036 **	0.000	-0.004	0.003	-0.011
27	Ex-339-6	-0.004	0.000	-4.537 **	2.171 **	0.867 **	0.514 **	0.000	-0.008	-0.016	-0.112 **
28	Ezox Natural	-0.003	-0.001	-0.236 **	4.390 **	0.732 **	0.075 **	0.001	-0.006	-0.035 **	-0.022
29	FR-3	0.000	0.001	1.308 **	0.457 **	0.328 **	0.462 **	0.001	-0.023	-0.040 **	0.007
30	FRW-9	-0.002 **	0.001	-3.104 **	2.571 **	0.553 **	0.249 **	0.000	-0.018	-0.007	0.007
	gi-gj (line)	0.015	0.015	0.015	0.014	0.015	0.003	0.015	0.015	0.011	0.065

Table.1 Continued

S. No.	Parents	AV		LN		LL		IV	
		F ₁	F ₂	F ₁	F ₁	F ₂	F ₂	F ₂	F ₂
Testers									
1	Heera	-0.092	-0.074**	-0.848	1.038**	-0.397 **	-1.208 **	1.965 **	0.755 **
2	Ex-7959	0.034	0.031*	0.092	0.480**	-0.638 **	0.286 **	1.831 **	-0.210 **
3	Neelam	0.058	0.043*	0.756	-1.519**	1.036 **	0.922 **	-3.796 **	-0.546 **
	gi-gj (tester)	0.029	0.007	0.347	0.003	0.023	0.077	0.083	0.020
Lines									
1	EC-41750	-0.171	-0.093**	-6.889 **	12.912**	-3.135 **	3.171 **	-1.522 **	-1.088 **
2	EC-41752	-0.038	0.064**	-2.993 *	-1.895**	-0.188 *	-4.566 **	3.581 **	0.573 **
3	EC-98994	0.163	0.044*	1.845	-12.033**	-0.425 **	-7.682 **	0.399 *	-6.958 **
4	T-397	0.049	-0.397**	-1.503	-2.427**	1.550 **	3.637 **	2.138 **	-0.760 **
5	EC-99029	0.129	0.182**	-3.141 **	1.120**	-2.939 **	0.734 **	-2.839 **	-4.465 **
6	EC-99056	-0.031	0.152**	1.874	5.175**	4.695 **	2.356 **	8.264 **	3.204 **
7	EC-104739	0.206**	-0.400**	3.881 **	9.745**	6.195 **	6.497 **	7.551 **	0.205 **
8	CRISTA	0.085	-0.145**	-10.854**	-3.240**	-7.633 **	-3.419 **	-6.817 **	2.544 **
9	EC-110288	-0.010	-0.201**	0.177	-15.219**	2.332 **	-12.240 **	-1.024 **	-7.641 **
10	EC-112689	-0.050	-0.507**	3.658 **	-4.804**	6.544 **	6.577 **	5.551 **	-1.577 **
11	EC-115161	0.013	-0.132**	1.264	2.743**	3.161 **	-2.457 **	4.304 **	4.806 **
12	EC-115162	0.034	-0.113**	4.139 **	8.836**	4.901 **	3.452 **	7.514 **	8.299 **
13	EC-115178	-0.065	0.165**	-0.880	3.874**	-4.372 **	6.743 **	2.297 **	5.161 **
14	EC-115186	-0.103	-0.209**	-3.036 **	2.164**	0.307 **	-1.251 **	-0.449 *	-2.477 **
15	EC-225125	0.222**	0.120**	4.541 **	3.716**	1.409 **	-0.073	4.981 **	7.538 **
16	EC-1041492	0.185	0.469**	-2.765 **	-1.257**	2.600 **	2.373 **	6.070 **	-3.857 **
17	Mukta	0.052	-0.223**	-2.034	-1.813**	2.947 **	-3.171 **	10.124 **	1.861 **
18	ES-1463	0.068	0.838**	3.597 **	-1.633**	-1.244 **	2.461 **	4.468 **	-1.465 **
19	ES-1474	-0.060	-0.207**	0.777	3.954**	-3.190 **	6.639 **	-3.199 **	0.866 **
20	ES-1496	0.054	0.534**	-3.139 **	-1.646**	-4.253 **	-4.204 **	-5.358 **	5.483 **
21	ES-1531	-0.005	-0.092**	2.215	7.266**	-2.116 **	2.971 **	0.975 **	-2.515 **
22	ES-14600	-0.194*	0.040	2.610 *	-3.646**	1.730 **	-7.704 **	7.434 **	-4.930 **
23	Ex-3	-0.099	-0.072**	-1.252	5.090**	-2.662 **	-5.348 **	4.370 **	1.156 **
24	Ex-5-36E	-0.088	0.209**	-12.655 **	-10.143**	-5.013 **	-7.282 **	-6.326 **	-6.148 **
25	Ex-28-3	-0.089	0.101**	7.337 **	-6.293**	-0.150 **	4.973 **	-9.419 **	-3.494 **
26	Ex-313-23	-0.019	0.014	4.306 **	0.457**	-3.223 **	-0.472 *	6.674 **	-0.146 *
27	Ex-339-6	0.011	0.486**	4.067 **	6.684**	-1.063 **	4.429 **	6.230 **	7.873 **
28	Ezox Natural	0.265**	-0.115**	0.478	-9.134**	-1.935 **	-3.950 **	2.101 **	-5.135 **
29	FR-3	-0.065	-0.166**	4.286 **	-0.828**	0.0700	2.645 **	-4.376 **	-0.462 **
30	FRW-9	-0.037	-0.347**	0.087	2.272**	5.100 **	4.163 **	-3.696 **	3.545 **
	gi-gj (line)	0.094	0.021	1.098	0.011	0.074	0.244	0.262	0.066

OIL= Oil (%), BD= Bulk density (g/cm³), TD= True density (g/cm³), PO= Porosity (%), PR= Protein (%), FAA= Free amino acids (g/Kg), CAR= Carbohydrate (%), PHE= Phenol (%), RF= Refractive index, SG= Specific gravity, AV= Acid value, LN= Linolenic acid (%), LL= Linoleic acid (%) and IV= Iodine value.

Table.2 Specific combining ability effects in F₁ and F₂ generations for different traits in linseed

S.No	Crosses	OIL		BD		TD		PO		PR	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
1	EC-41750 x Heera	4.344*	9.754**	-0.107	-0.047**	0.538**	0.022	-0.053	-2.838**	0.089	5.249**
2	EC-41750 x Ex-7959	4.018*	-2.313	-0.328**	0.314**	-0.651**	0.333**	4.763**	0.568**	-1.353	1.106**
3	EC-41750 x Neelam	-8.362**	-7.442**	0.435**	-0.267**	0.113	-0.356**	-4.711**	2.269**	1.263	-6.355**
4	EC-41752 x Heera	-7.980**	-7.252**	-0.325**	0.080**	-0.347**	-2.311**	19.439**	-12.135**	-0.647	-7.859*
5	EC-41752 x Ex-7959	12.903**	14.706**	0.332**	-0.042**	0.343**	1.500**	-11.526**	8.132**	0.282	7.118**
6	EC-41752 x Neelam	-4.922**	-7.453**	-0.007	-0.037**	0.004	0.811**	-7.912**	4.003**	0.365	0.741**
7	EC-98994 x Heera	-9.839**	-1.077	0.637**	-0.049**	0.615**	-0.644**	-1.879**	-2.818**	2.427**	6.879**
8	EC-98994 x Ex-7959	0.945	0.256	-0.022	-0.060**	-0.011	0.667**	8.255**	4.308**	-2.426**	-0.309**
9	EC-98994 x Neelam	8.894**	0.822**	-0.615**	0.109**	-0.604**	-0.022**	-6.376**	-1.491**	-0.001	-6.569**
10	T-397 x Heera	-4.430**	4.119*	0.557**	0.386**	0.534**	-0.978**	3.488**	-7.170**	-4.566**	1.716**
11	T-397 x Ex-7959	1.353	7.017**	-0.227**	-0.114**	-0.216**	1.333**	-12.855**	4.840**	0.448	3.751**
12	T-397 x Neelam	3.078	-11.137**	-0.330**	-0.273**	-0.319**	-0.356**	9.367**	2.331**	4.118**	-5.467**
13	EC-99029 x Heera	0.784	-6.886**	0.305**	0.002**	0.283**	-0.089**	2.220**	0.681**	-2.712**	-0.470**
14	EC-99029 x Ex-7959	3.967*	6.827**	-0.564**	-0.133**	-0.553**	-0.444**	-6.426**	-2.987**	0.824	2.706**
15	EC-99029 x Neelam	-4.751*	0.058	0.259**	0.131**	0.270**	0.533**	4.206**	2.305**	1.888**	-2.236**
16	EC-99056 x Heera	8.695**	-7.112**	-0.214**	-0.072**	-0.237**	0.189*	0.244	1.340**	-0.233	-2.227**
17	EC-99056 x Ex-7959	0.038	13.756**	0.146*	-0.020**	0.157	-1.000**	1.005**	-4.323**	1.224	5.752**
18	EC-99056 x Neelam	-8.732**	-6.643**	0.068	0.091**	0.080	0.811**	-1.250**	2.983**	-0.991	-3.524**
19	EC-104739 x Heera	15.406**	2.091	-0.388**	0.109**	-0.410**	0.189*	-10.349**	-0.133**	6.829**	3.346**
20	EC-104739 x Ex-7959	-10.361**	1.149	0.136	-0.036**	0.147	-1.000**	-15.945**	-4.130**	-1.392	-0.007**
21	EC-104739 x Neelam	-5.046**	-3.240	0.252**	-0.072**	0.263**	0.811**	26.293**	4.263**	-5.437**	-3.339**
22	CRISTA x Heera	-1.745	-12.141**	-0.114	0.017**	-0.136	0.811**	0.123	0.399**	-6.157**	4.595**
23	CRISTA x Ex-7959	3.087	-1.280	-0.472**	-0.201**	-0.461**	-1.000**	6.531**	-2.408**	3.952**	-3.999**
24	CRISTA x Neelam	-1.341	13.241**	0.586**	0.184**	0.598**	0.811**	-6.653**	2.008**	2.205**	-0.596**
25	EC-110288 x Heera	-9.256**	7.048**	-0.067	0.026**	-0.090	2.133**	-0.475*	12.695**	0.226	2.555**
26	EC-110288 x Ex-7959	-10.090**	-12.367**	-0.060	-0.063**	-0.049	-0.722**	1.492**	-3.686**	-2.329**	-5.180**
27	EC-110288 x Neelam	19.346**	5.319**	0.128	0.037**	0.139	1.411**	-1.017**	-9.009**	2.103**	2.634**
28	EC-112689 x Heera	-4.830**	-0.429	-0.146*	-0.074**	-0.168	-1.200	0.406**	-6.570**	1.891*	1.774**
29	EC-112689 x Ex-7959	-9.893**	2.119	-0.384**	-0.049**	-0.373**	0.111	5.494**	0.111**	1.326	-1.754**
30	EC-112689 x Neelam	14.723**	-1.690	0.529**	0.123**	0.540**	1.089**	-5.899**	6.460**	-3.217**	-0.020**
31	EC-115161 x Heera	6.566**	-3.339	0.320**	0.005**	0.298**	-1.200	-5.119**	-7.438**	1.075	7.933**
32	EC-115161 x Ex-7959	-7.256**	16.444**	-0.346**	-0.004**	-0.335**	0.111	5.022**	-0.345**	3.659**	4.756**
33	EC-115161 x Neelam	0.691	-13.105**	0.026	-0.001**	0.037	1.089**	0.097	7.782**	-4.734**	-12.689**
34	EC-115162 x Heera	5.779**	-14.977**	-0.318**	-0.238**	-0.340**	-0.644**	2.445**	-0.931**	0.939	-2.501**
35	EC-115162 x Ex-7959	-2.749	-6.394**	0.112	0.077**	0.123	0.667**	-0.488*	2.935**	2.644**	1.906**
36	EC-115162 x Neelam	-3.030	21.372**	0.206**	0.161**	0.217**	-0.022	-1.956**	-2.004**	-3.582**	0.594**
37	EC-115178 x Heera	13.284**	3.851*	0.652**	0.261**	0.630**	1.578**	-15.305**	6.640**	-0.096	-0.929**
38	EC-115178 x Ex-7959	-1.333	-3.116	0.199**	-0.065**	0.210**	-1.278**	-7.581**	-7.667**	-3.544**	-3.784**
39	EC-115178 x Neelam	-11.951**	-0.735	-0.851**	-0.165**	-0.840**	-0.300**	22.887**	1.027**	3.640**	4.713**
40	EC-115186 x Heera	16.596**	0.258	-0.835**	-0.324**	-0.858**	-0.922**	7.940**	-0.361**	1.495	1.569**
41	EC-115186 x Ex-7959	-2.949	-7.454**	0.670**	-0.051**	0.681**	1.278**	16.721**	-8.249**	0.155	1.408**
42	EC-115186 x Neelam	-13.647**	7.197**	0.166*	0.375**	0.177	2.200**	-24.661**	8.609**	-1.650*	-2.978**
43	EC-225125 x Heera	0.339	-4.757**	0.185**	-0.060**	0.163	1.022**	-3.668**	5.409**	-0.0184	-3.350**
44	EC-225125 x Ex-7959	3.730*	2.661	-0.614**	-0.058**	-0.603**	-0.167**	8.245**	0.228**	-1.260	3.224**
45	EC-225125 x Neelam	-4.068*	2.097	0.429**	0.118**	0.440**	-0.856**	-4.576**	-5.637**	1.444	0.126**

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S.No	Crosses	OIL		BD		TD		PO		PR	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
46	EC-1041492 x Heera	-4.060*	-4.227	-0.174**	0.048**	-0.196*	-0.644**	4.740**	-7.682**	-2.192**	-2.745**
47	EC-1041492 x Ex-7959	-1.825	-3.584	0.130	-0.113**	0.141	0.667**	3.817**	12.596**	6.064**	-1.969**
48	EC-1041492 x Neelam	5.886**	7.812**	0.044	0.065**	0.055	-0.022	-8.557**	-4.914**	-3.873**	4.713**
49	Mukta x Heera	-4.417*	-0.491	-0.011	0.118**	-0.033	-0.089	0.507*	-0.450**	-0.096	-0.187**
50	Mukta x Ex-7959	-7.022**	-1.143	-0.240**	-0.032**	-0.228**	1.222**	5.476**	8.063**	-5.755**	3.487**
51	Mukta x Neelam	11.439**	1.903	0.250**	-0.086**	0.261**	-1.133**	-5.983**	-7.613**	5.851**	-3.300**
52	ES-1463 x Heera	-7.418**	-7.602**	-0.827**	0.346**	-0.849**	-0.089	9.472**	-2.977**	-0.623	-5.507**
53	ES-1463 x Ex-7959	-12.207**	12.486**	0.057	-0.167**	0.069	-0.444**	1.207**	-2.204**	2.634**	0.686**
54	ES-1463 x Neelam	19.625**	-4.883*	0.770**	-0.179**	0.781**	0.533**	-10.679**	5.181**	-2.011**	4.820**
55	ES-1474 x Heera	-6.534**	14.873**	0.372**	0.076**	0.350**	1.022**	0.800**	4.291**	1.388*	3.004**
56	ES-1474 x Ex-7959	0.764	-5.469*	-0.143*	0.080**	-0.132	-0.167**	9.235**	-1.266**	-1.255*	-2.222**
57	ES-1474 x Neelam	5.769**	-9.403**	-0.228**	-0.156**	-0.217*	-0.856**	-10.036**	-3.025**	-0.132	-0.782**
58	ES-1496 x Heera	7.510**	5.484*	0.019	-0.421**	-0.003	-0.644**	-1.598**	0.899**	-2.385**	-3.662**
59	ES-1496 x Ex-7959	6.524**	-0.138	0.360**	0.366**	0.371**	0.667**	-3.362**	0.048**	1.238*	-1.715**
60	ES-1496 x Neelam	-14.034**	-5.347**	-0.379**	0.055**	-0.368**	-0.022	4.959**	-0.947**	1.146*	5.377**
61	ES-1531 x Heera	3.728*	6.498**	-0.944**	0.039**	-0.966**	1.022**	1.502**	4.448**	1.207*	-5.038**
62	ES-1531 x Ex-7959	-0.812	-3.355	0.544**	0.099**	0.555**	-0.167**	-14.273**	-1.351**	-3.968**	-5.785**
63	ES-1531 x Neelam	-2.917	-3.144	0.400**	-0.139**	0.411**	-0.856**	12.771**	-3.097**	2.762**	10.823**
64	ES-14600 x Heera	2.504	-1.417	0.335**	0.042**	0.313**	-0.089	1.169**	0.279**	-2.126**	-4.628**
65	ES-14600 x Ex-7959	-8.056**	-9.999**	0.574**	-0.159**	0.585**	-0.444**	5.639**	-2.730**	-1.841**	0.920**
66	ES-14600 x Neelam	5.552**	11.417**	-0.909**	0.117**	-0.898**	0.533**	-6.808**	2.450**	3.967**	3.708**
67	Ex-3 x Heera	-9.310**	-6.364*	-0.034	0.078**	-0.056	1.578**	-1.013**	8.593**	-1.784**	-0.509**
68	Ex-3 x Ex-7959	22.790**	-7.666**	-0.089	0.045**	-0.078	-1.278**	1.995**	-9.415**	-0.021	-1.403**
69	Ex-3 x Neelam	-13.480**	14.030**	0.123	-0.123**	0.134	-0.300**	-0.981**	0.822**	1.805**	1.912**
70	Ex-5-36E x Heera	-1.392	4.338	0.275**	0.080**	0.253**	1.578**	-13.006**	8.030**	0.016	-0.549**
71	Ex-5-36E x Ex-7959	-6.258**	9.891**	0.026	0.083**	0.037	0.389**	17.096**	2.724**	0.829	-0.710**
72	Ex-5-36E x Neelam	7.650**	-14.228**	-0.301**	0.163**	-0.290**	-1.967**	-4.090**	-10.574**	-0.845	1.258**
73	Ex-28-3 x Heera	-6.006**	4.956**	0.624**	-0.157**	0.602**	-0.089	-17.097**	2.483**	2.456**	-2.754**
74	Ex-28-3 x Ex-7959	11.973**	-10.491**	-0.043	0.053**	-0.032	1.222**	17.930**	7.386**	3.342**	1.887**
75	Ex-28-3 x Neelam	-5.967**	5.535**	-0.581**	0.104**	0.570**	-1.133**	-0.833**	-9.870**	-5.798**	0.868**
76	Ex-313-23 x Heera	-0.810	0.914	0.081	-0.406**	0.059	-1.200**	-2.277**	-2.630**	-3.686**	2.340**
77	Ex-313-23 x Ex-7959	4.112	-5.288**	0.647**	0.222**	0.658**	0.111	-6.909**	-3.177**	0.136	-3.355**
78	Ex-313-23 x Neelam	-3.302	4.373	-0.728**	0.183**	-0.717**	1.089**	9.186**	5.807**	3.733**	1.014**
79	Ex-339-6 x Heera	5.586**	0.553	0.228**	0.173**	0.205**	0.578**	-4.136**	-0.904**	2.044**	2.194**
80	Ex-339-6 x Ex-7959	3.312*	7.376**	-0.271**	-0.046**	-0.260**	-0.778**	4.159**	-4.112**	1.275*	-0.339**
81	Ex-339-6 x Neelam	-8.898**	-7.928**	0.044	-0.127**	0.055**	0.200**	-0.022	5.017**	-3.319**	1.855**
82	Ezox Natural x Heera	0.529	14.753**	-0.295**	-0.175**	-0.317**	-0.644**	9.722**	-1.558**	7.102**	1.696**
83	Ezox Natural x Ex-7959	-1.745	-4.674	0.325**	-0.023**	0.336**	0.667**	-14.705**	3.932**	-2.656**	-0.749**
84	Ezox Natural x Neelam	1.215	-10.078**	-0.030	0.198**	-0.019	-0.022	8.983**	-2.374**	-4.446**	-0.948**
85	FR-3 x Heera	-9.856**	0.983	0.364**	0.118**	0.341**	-0.644	3.475**	-4.269**	-2.316**	-3.467**
86	FR-3 x Ex-7959	4.748*	-2.484	-0.448**	0.070**	-0.437**	0.667**	-10.530**	3.149**	-1.358*	0.325**
87	FR-3 x Neelam	5.107**	1.502	0.084	-0.188**	0.095	0.022	7.055**	1.121**	3.674**	3.142**
88	FRW-9 x Heera	-3.767*	-2.401	-0.155*	0.017**	-0.177**	1.022**	8.283**	4.674**	0.802	1.530**
89	FRW-9 x Ex-7959	-1.707	-7.203**	-0.006	0.060**	0.005	-0.167	-15.482**	-0.973**	-0.875	-5.746**
90	FRW-9 x Neelam	5.474**	9.603**	0.161*	0.008**	0.172**	-0.856**	7.198**	-3.702**	0.073	4.215**
	Sij-skl	1.846	2.463	0.069	0.0006	0.086	0.086	0.238	0.0004	0.801	0.0001

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S.No	Crosses	FAA		CAR		PHE		RF		SG	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
1	EC-41750 x Heera	0.002	0.004**	-1.021**	6.980**	0.058**	-1.608**	-0.005	-0.026**	-0.006	0.029
2	EC-41750 x Ex-7959	-0.002	0.001	-5.605**	2.161**	0.168**	3.261**	0.001	0.006	0.006	-0.014
3	EC-41750 x Neelam	-0.001	-0.004**	6.626**	-9.140**	-0.226**	-1.653**	0.005	0.020**	0.001	-0.015
4	EC-41752 x Heera	0.004**	-0.008**	-4.398**	0.789**	-0.869**	-0.753**	0.005	0.004	-0.022**	-0.020
5	EC-41752 x Ex-7959	-0.003*	0.007**	1.535**	4.227**	1.226**	0.899**	-0.006	-0.11**	0.003	-0.026
6	EC-41752 x Neelam	0.001	0.001	2.863**	-5.017**	-0.357**	-0.146**	0.001	0.007	0.019**	0.047
7	EC-98994 x Heera	0.001	0.007**	-4.265**	4.980**	-0.964**	0.652**	-0.025**	0.015**	0.003	0.006
8	EC-98994 x Ex-7959	-0.003*	0.001	5.243**	-3.353**	2.091**	0.137**	0.053**	-0.001	-0.007	0.005
9	EC-98994 x Neelam	0.003*	-0.007**	-0.978**	-1.627**	-1.127**	-0.790**	-0.028**	-0.014**	0.004	-0.10
10	T-397 x Heera	0.005**	0.002**	-1.109**	-9.420**	0.789**	1.279**	0.001	-0.007	0.001	-0.027
11	T-397 x Ex-7959	-0.001	0.004**	-1.146**	-5.096**	0.902**	1.049**	-0.002	0.005	-0.015**	-0.007
12	T-397 x Neelam	-0.003*	-0.005**	1.255**	14.515**	-1.692**	-2.328**	0.003	0.002	0.014**	0.033
13	EC-99029 x Heera	0.003*	0.001	-1.403**	-2.639**	0.572**	0.216**	0.002	-0.004	0.028**	-0.009
14	EC-99029 x Ex-7959	-0.005**	0.003**	6.812**	-1.287**	1.437**	0.840**	-0.003	-0.005	-0.030**	0.001
15	EC-99029 x Neelam	0.002	-0.002**	-5.409**	3.926**	-2.009**	-1.056**	0.002	0.008	0.001	0.009
16	EC-99056 x Heera	-0.005**	-0.002**	0.054**	-11.543**	-0.246**	-0.226**	0.005	0.001	0.005	0.011
17	EC-99056 x Ex-7959	0.009**	0.006**	-7.042**	10.894**	-0.158**	1.876**	-0.008	-0.006	0.001	-0.045
18	EC-99056 x Neelam	-0.004**	-0.004**	6.988**	0.649**	0.404**	-1.650**	0.003	0.006	-0.007	0.034
19	EC-104739 x Heera	-0.001	0.004**	1.596**	-3.934**	-0.585**	-0.092**	0.001	0.004	0.011	0.019
20	EC-104739 x Ex-7959	-0.005**	0.001	-9.028**	7.732**	-0.574**	-0.817**	-0.011	-0.004	0.032**	-0.053
21	EC-104739 x Neelam	0.006**	-0.004**	7.432**	-3.798**	1.159**	0.909**	0.011	0.001	-0.043**	0.034
22	CRISTA x Heera	-0.003*	0.005**	-3.107**	-2.810**	0.647**	-0.736**	0.002	0.035**	-0.027**	-0.004
23	CRISTA x Ex-7959	-0.001	-0.004**	-8.232**	-0.230**	0.282**	-0.106**	0.004	-0.013**	0.015*	-0.033
24	CRISTA x Neelam	0.003*	-0.001	11.339**	3.040**	-0.929**	0.842**	-0.005	-0.022**	0.012	0.037
25	EC-110288 x Heera	-0.003**	0.003**	-1.060**	-4.534**	2.449**	2.197**	0.004	-0.012**	0.004	-0.033
26	EC-110288 x Ex-7959	0.004**	-0.005**	-1.185**	1.447**	-2.532**	-2.079**	0.002	0.008	0.004	0.001
27	EC-110288 x Neelam	-0.002	0.003**	2.245**	30.87**	0.083**	-0.118**	-0.006	0.004	-0.008	0.032
28	EC-112689 x Heera	0.001	0.002**	-6.430**	2.028**	2.354**	0.310**	0.005	0.030**	0.005	0.056
29	EC-112689 x Ex-7959	-0.003**	-0.002**	3.155**	-0.277**	-2.184**	-0.698**	0.001	0.029**	-0.009	-0.218**
30	EC-112689 x Neelam	0.002	0.001	3.275**	-1.750**	-0.169**	0.387**	-0.005	-0.060**	0.004	0.162**
31	EC-115161 x Heera	0.001	0.008**	1.028**	5.542**	-0.240**	-0.243**	-0.002	0.005	0.005	0.049
32	EC-115161 x Ex-7959	0.001	0.005**	4.788**	9.065**	0.710**	0.518**	-0.001	-0.019**	-0.002	-0.040
33	EC-115161 x Neelam	-0.002	-0.013**	-5.813**	-14.607**	-0.470**	-0.275**	0.003	0.014**	-0.003	-0.009
34	EC-115162 x Heera	0.002	-0.002**	1.249**	-0.610**	-1.873**	0.540**	-0.006	0.001	0.001	-0.004
35	EC-115162 x Ex-7959	0.003*	0.002**	4.511**	3.999**	-0.778**	0.110**	0.003	0.016**	-0.003	0.063
36	EC-115162 x Neelam	-0.005**	0.001	-3.262**	-3.388**	2.651**	-0.650**	0.004	-0.017**	0.002	-0.058
37	EC-115178 x Heera	-0.003*	-0.001	4.593**	-2.315**	0.657**	0.654**	0.001	-0.030**	0.005	0.015
38	EC-115178 x Ex-7959	0.002	-0.004**	-2.356**	-4.191**	-1.403**	-0.693**	-0.005	0.004	-0.001	0.015
39	EC-115178 x Neelam	0.001	0.005**	-2.237**	6.506**	0.747**	0.039**	0.006	0.025**	-0.003	-0.030
40	EC-115186 x Heera	0.005**	0.002**	7.108**	1.209**	1.342**	1.091**	0.004	-0.002	0.003	0.001
41	EC-115186 x Ex-7959	-0.002	0.001	-6.284**	-0.725**	-1.330**	-2.090**	-0.009	0.001	-0.008	0.011
42	EC-115186 x Neelam	-0.003*	-0.003**	-0.824**	-0.484**	-0.011**	0.999**	0.005	0.002	0.004	-0.012
43	EC-225125 x Heera	-0.004**	-0.003**	-4.838**	1.323**	-1.387**	0.762**	0.006	0.015**	-0.024**	0.007
44	EC-225125 x Ex-7959	0.004**	0.003**	8.874**	-1.410**	1.803**	-0.248**	0.001	0.005	0.019**	0.012
45	EC-225125 x Neelam	0.001	0.001	-4.035**	0.088**	-0.416**	-0.514**	-0.007	-0.020**	0.005	-0.020

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S.No	Crosses	FAA		CAR		PHE		RF		SG	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
46	EC-1041492 x Heera	0.001	-0.003**	0.901**	0.190**	-0.781**	-0.926**	0.001	0.005	0.028**	0.019
47	EC-1041492 x Ex-7959	0.001	-0.002**	-3.967**	0.428**	-1.144**	0.053**	-0.001	-0.014**	-0.023**	0.023
48	EC-1041492 x Neelam	-0.003**	0.005**	3.067**	-0.617**	1.926**	0.873**	0.001	0.009*	-0.004	-0.042
49	Mukta x Heera	0.001	0.001	-10.364**	2.666**	-0.382**	0.164**	0.001	-0.001	-0.006	0.020
50	Mukta x Ex-7959	0.001	0.004**	5.081**	-3.524**	1.356**	1.364**	-0.002	-0.007	0.012	-0.009
51	Mukta x Neelam	0.001	-0.003**	5.284**	0.859**	-0.974**	-1.528**	0.002	0.008	-0.006	-0.011
52	ES-1463 x Heera	-0.002*	-0.005**	-4.379**	0.875**	-0.126**	-0.229**	0.002	0.012**	-0.013*	0.024
53	ES-1463 x Ex-7959	0.005**	0.001	-0.685**	-9.458**	-0.558**	-0.812**	-0.003	-0.003	0.016*	-0.041
54	ES-1463 x Neelam	-0.003**	0.005**	5.064**	8.582**	0.684**	1.041**	0.001	-0.009*	-0.003	0.018
55	ES-1474 x Heera	-0.007**	0.003**	3.290**	-1.182**	0.222**	-0.596**	0.002	-0.036**	0.008	-0.033
56	ES-1474 x Ex-7959	0.001	-0.002**	0.396**	2.113**	1.345**	0.339**	-0.002	0.016**	-0.010*	0.020
57	ES-1474 x Neelam	0.006**	-0.001	-3.686**	-0.931**	-1.567**	0.256**	-0.001	0.020**	0.002	0.013
58	ES-1496 x Heera	-0.003**	-0.004**	2.827**	-2.220**	-0.838**	1.112**	0.001	0.001	0.013*	-0.062
59	ES-1496 x Ex-7959	0.003**	-0.002**	-7.253**	18.446**	1.045**	-0.351**	-0.001	-0.001	0.001	0.046
60	ES-1496 x Neelam	0.001	0.005**	4.426**	-16.226**	-0.207**	-0.761**	0.001	0.001	-0.014*	0.016
61	ES-1531 x Heera	0.001	-0.005**	14.536**	6.475**	-1.772**	-1.024**	0.001	-0.020**	0.001	-0.045
62	ES-1531 x Ex-7959	0.001	-0.006**	-4.609**	-16.257**	0.323**	-0.558**	-0.002	0.008	0.010	0.048
63	ES-1531 x Neelam	-0.002*	0.011**	-9.927**	9.782**	1.449**	1.582**	0.001	0.012**	-0.011	-0.003
64	ES-14600 x Heera	0.001	-0.005**	-1.827**	-8.277**	0.400**	0.157**	0.001	-0.006	0.031**	0.028
65	ES-14600 x Ex-7959	0.001	0.001	1.012**	11.132**	-1.655**	-1.230**	0.001	0.009*	-0.013*	0.024
66	ES-14600 x Neelam	-0.002*	0.004**	0.815**	-2.855**	1.255**	1.073**	0.001	-0.003	-0.018**	-0.051
67	Ex-3 x Heera	-0.006**	0.001	0.396**	0.437**	-1.074**	-0.244**	0.001	0.019**	0.008	-0.011
68	Ex-3 x Ex-7959	0.001	-0.001	0.369**	-0.982**	-0.259**	-0.835**	-0.001	-0.010**	-0.018**	0.005
69	Ex-3 x Neelam	0.005**	0.002**	-0.765**	0.545**	1.333**	1.078**	0.001	-0.009*	0.010	0.006
70	Ex-5-36E x Heera	0.003**	-0.001	-11.402**	1.589**	0.022**	0.017**	0.001	-0.011**	-0.031**	-0.034
71	Ex-5-36E x Ex-7959	-0.002*	-0.001	1.385**	-2.001**	-0.051**	-0.203**	-0.001	0.005	0.023**	-0.030
72	Ex-5-36E x Neelam	-0.001	0.001	10.017**	0.411**	0.029**	0.185**	0.001	0.006	0.008	0.063
73	Ex-28-3 x Heera	0.001	-0.003**	-3.315**	-2.687**	-0.705**	-0.042**	0.001	0.001	0.002	-0.021
74	Ex-28-3 x Ex-7959	0.001	0.002**	2.911**	-1.506**	0.429**	-0.909**	-0.001	0.016**	-0.001	0.031
75	Ex-28-3 x Neelam	0.001	0.001	0.223**	4.192**	0.276**	0.951**	0.001	-0.016**	-0.001	-0.010
76	Ex-313-23 x Heera	0.001	0.003**	-2.476**	-7.696**	2.338**	0.231**	-0.001	0.001	-0.012	-0.005
77	Ex-313-23 x Ex-7959	-0.005**	-0.003**	10.091**	-5.258**	-2.237**	-1.178**	-0.001	-0.007	0.009	-0.002
78	Ex-313-23 x Neelam	0.005**	0.001	-7.614**	12.954**	-0.101**	0.947**	0.002	0.008	0.003	0.007
79	Ex-339-6 x Heera	-0.001	0.002**	9.338**	-5.934**	1.108**	-0.366**	0.001	-0.001	-0.005	0.094
80	Ex-339-6 x Ex-7959	0.001	0.001	-3.587**	0.732**	-0.478**	1.023**	-0.001	0.001	-0.024**	0.098
81	Ex-339-6 x Neelam	0.001	-0.002**	-5.751**	5.202**	-0.631**	-0.658**	0.001	0.001	0.029**	-0.191**
82	Ezox Natural x Heera	0.001	0.002**	4.688**	-1.182**	-0.238**	-0.312**	-0.001	-0.006	-0.006	-0.021
83	Ezox Natural x Ex-7959	0.001	-0.001	-3.090**	4.199**	1.244**	1.109**	0.001	-0.009*	0.012	0.010
84	Ezox Natural x Neelam	0.001	-0.001	-1.598**	-3.017**	-1.005**	-0.797**	0.001	0.015**	-0.006	0.011
85	FR-3 x Heera	0.003**	-0.004**	-1.540**	14.951**	-0.278**	-1.172**	0.0001	0.012**	0.013*	-0.023
86	FR-3 x Ex-7959	0.001	0.001	10.053**	-14.638**	-0.207**	-0.146**	0.0001	-0.021**	0.013*	0.046
87	FR-3 x Neelam	-0.004**	0.003**	-8.514**	-0.312**	0.485**	1.318**	0.0001	0.009*	-0.026**	-0.023
88	FRW-9 x Heera	0.007**	0.001	12.649**	16.951**	-0.598**	-0.815**	0.001	0.005	-0.022**	-0.026
89	FRW-9 x Ex-7959	-0.006**	-0.006**	-2.147**	-6.382**	1.190**	0.376**	-0.002	0.005*	-0.014*	0.062
90	FRW-9 x Neelam	-0.001	0.004**	-10.502**	-10.569**	-0.592**	0.439**	0.001	-0.009*	0.036**	-0.035
	Sij-skl	0.001	0.0005	0.008	0.0007	0.001	0.005	0.009	0.004	0.006	0.061

Continued....

S.No	Crosses	AV		LN		LL		IV	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
1	EC-41750 x Heera	-0.186	-0.019	0.870	4.448**	-2.813**	-0.816	-5.632**	10.129**
2	EC-41750 x Ex-7959	0.037	0.500**	-10.546**	4.703**	-1.161**	2.834**	-2.498**	0.091
3	EC-41750 x Neelam	0.152	-0.480**	9.677**	-9.151**	3.974**	-2.018**	8.130**	-10.220**
4	EC-41752 x Heera	-0.198	-0.179**	8.657**	5.7979**	5.242**	1.754**	5.375**	-4.535**
5	EC-41752 x Ex-7959	0.041	-0.600**	-0.518	-4.370**	2.906**	-0.217	-3.601**	0.783**
6	EC-41752 x Neelam	0.157	0.827**	-8.139**	-1.427**	-8.147**	-1.538**	-1.774**	3.752**
7	EC-98994 x Heera	0.280	-0.239**	-0.612	-12.606**	-1.802**	-3.356**	-4.167**	-3.128**
8	EC-98994 x Ex-7959	-0.374*	-0.200	-4.058*	-14.179**	-2.856**	-4.387**	-3.032**	0.957**
9	EC-98994 x Neelam	0.094	0.259**	4.670**	26.785**	4.659**	7.743**	7.199**	2.170**
10	T-397 x Heera	-0.232	-0.009	-0.064	6.329**	3.345**	-6.449**	2.968**	-1.202**
11	T-397 x Ex-7959	-0.112	0.208**	4.323*	10.466**	7.152**	-3.961**	-1.771**	5.123**
12	T-397 x Neelam	0.344*	-0.199**	-4.259*	-46.795**	-10.498**	10.410**	-1.197**	-3.921**
13	EC-99029 x Heera	0.178	0.653**	-1.473	-1.208**	0.007	-0.249	-4.928**	-3.144**
14	EC-99029 x Ex-7959	0.124	-0.482**	5.834**	8.780**	4.533**	5.865**	0.482	0.464**
15	EC-99029 x Neelam	-0.302	-0.171**	-4.361*	-7.527**	-4.540**	-5.616**	4.447**	2.680**
16	EC-99056 x Heera	-0.034	0.268**	-2.607	-2.710**	0.258*	1.307**	-1.169*	-3.160**
17	EC-99056 x Ex-7959	0.103	0.064	7.955**	2.759**	-1.402**	3.081**	-1.174*	-0.328**
18	EC-99056 x Neelam	-0.069	-0.332**	-5.348**	-0.049**	1.144**	-4.388**	2.343**	3.488**
19	EC-104739 x Heera	0.077	-0.150**	-0.670	1.710**	3.416**	2.845**	1.405**	3.836**
20	EC-104739 x Ex-7959	0.190	-0.261**	0.556	2.226**	-1.602**	-7.433**	-2.461**	-4.323**
21	EC-104739 x Neelam	-0.266	0.411**	0.113	-3.936**	-1.814**	4.588**	1.056*	0.487**
22	CRISTA x Heera	-0.131	-0.356**	-7.134**	-17.309**	-1.865**	-6.648**	-3.951**	2.337**
23	CRISTA x Ex-7959	0.002	-0.290**	-5.498**	11.599**	-1.320**	6.619**	-2.527**	-6.531**
24	CRISTA x Neelam	0.129	0.647**	12.633**	5.709**	3.185**	0.030	6.478**	4.195**
25	EC-110288 x Heera	0.222	0.306**	-2.114	-1.467**	-0.687**	4.385**	-4.021**	-4.491**
26	EC-110288 x Ex-7959	-0.042	-0.383**	4.324*	13.702**	-3.425**	5.301**	-2.663**	7.501**
27	EC-110288 x Neelam	-0.180	0.077	-2.210	-12.235**	4.112**	-9.686**	6.684**	-3.010**
28	EC-112689 x Heera	-0.11	-0.109**	-2.834	-1.552**	-0.560**	-8.518**	-2.039**	1.635**
29	EC-112689 x Ex-7959	0.189	-0.166**	2.494	18.381**	1.334**	3.158**	0.872	7.443**
30	EC-112689 x Neelam	-0.177	0.275**	0.340	-16.829**	-0.773**	5.359**	1.166*	-9.078**
31	EC-115161 x Heera	0.237	0.233**	-4.867*	0.802**	-0.228*	3.929**	-2.199**	0.081**
32	EC-115161 x Ex-7959	-0.172	-0.469**	2.194	-4.518**	3.616**	-1.444**	-0.214	-2.977**
33	EC-115161 x Neelam	-0.065	0.237**	2.673	3.716**	-3.388**	-2.485**	2.413**	2.896**
34	EC-115162 x Heera	-0.114	0.883**	3.445	-13.441**	1.963**	-8.497**	-5.669**	-3.438**
35	EC-115162 x Ex-7959	0.095	-0.560**	0.786	6.252**	1.884**	3.547**	3.576**	0.704**
36	EC-115162 x Neelam	0.018	-0.323**	-4.231*	7.189**	-3.847**	4.950**	2.093**	2.734**
37	EC-115178 x Heera	-0.076	-0.102*	2.139	2.265**	-2.376**	-1.531**	-3.451**	2.750**
38	EC-115178 x Ex-7959	-0.182	-0.203**	-7.871**	0.554**	7.796**	-2.616**	-1.650**	1.195**
39	EC-115178 x Neelam	0.258	0.305**	5.732**	-2.819**	-5.419**	4.147**	5.102**	-3.945**
40	EC-115186 x Heera	-0.217	-0.252**	6.020**	-0.960**	3.987**	2.443**	-1.705**	-2.479**
41	EC-115186 x Ex-7959	0.219	0.206**	-10.409**	-12.387**	-6.842**	-6.966**	-4.794**	3.833**
42	EC-115186 x Neelam	-0.002	0.046	4.388*	13.347**	2.855**	4.523**	6.500**	-1.354**
43	EC-225125 x Heera	-0.086	-0.557**	-1.618	10.016**	4.802**	8.129**	-4.736**	-1.610**
44	EC-225125 x Ex-7959	-0.156	-0.563**	-2.055	-0.267**	4.396**	-1.899**	-0.667	2.452**
45	EC-225125 x Neelam	0.242	1.119**	3.673	-9.749**	-9.198**	-6.230**	5.403**	-0.842**

Continued....

S.No	Crosses	AV		LN		LL		IV	
		F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂
46	EC-1041492 x Heera	0.043	0.111**	-5.193**	-5.175**	6.023**	-14.696**	-1.558**	-3.279**
47	EC-1041492 x Ex-7959	0.003	0.758**	0.670	10.266**	-8.804**	1.293**	-4.980**	-0.264*
48	EC-1041492 x Neelam	-0.046	-0.869**	4.524*	-5.091**	2.781**	13.400**	6.537**	3.542**
49	Mukta x Heera	0.075	0.211**	-4.732*	-10.555**	7.807**	-1.553**	-0.309	-6.970**
50	Mukta x Ex-7959	-0.242	0.083*	-4.201*	2.283**	-9.871**	3.324**	-9.144**	-0.855**
51	Mukta x Neelam	0.167	-0.294**	8.933**	8.272**	2.065**	-1.771**	9.453**	7.825**
52	ES-1463 x Heera	-0.080	-1.061**	1.005	2.074**	-6.393**	9.131**	5.378	10.372**
53	ES-1463 x Ex-7959	0.319	0.472**	1.944	-10.262**	4.029**	-10.227**	-1.518**	-3.176**
54	ES-1463 x Neelam	-0.239	0.589**	-2.949	8.188**	2.364**	1.096*	-3.860**	-7.196**
55	ES-1474 x Heera	0.060	-0.340**	0.770	-6.850**	3.283**	-7.783**	-1.955**	-5.972**
56	ES-1474 x Ex-7959	-0.269	-0.004	-0.875	5.806**	-3.793**	0.719*	-0.851	4.493**
57	ES-1474 x Neelam	0.209	0.344**	0.106	1.044**	0.510**	7.065**	2.806**	1.479**
58	ES-1496 x Heera	-0.119	0.088*	-3.773*	5.548**	-2.780**	1.393**	-1.743**	2.388**
59	ES-1496 x Ex-7959	0.313	0.542**	2.101	9.161**	2.147**	8.391**	-2.275**	1.396**
60	ES-1496 x Neelam	-0.194	-0.630**	1.672	-14.710**	0.634**	-9.784**	4.019**	-3.784**
61	ES-1531 x Heera	0.098	-0.176**	1.954	-5.390**	2.160**	-0.198	-5.743**	-4.564**
62	ES-1531 x Ex-7959	-0.210	0.012	3.019	-12.343**	3.674**	-10.535**	-1.609**	-4.643**
63	ES-1531 x Neelam	0.112	0.164**	-4.973**	17.732**	-5.834**	10.734**	7.352**	9.207**
64	ES-14600 x Heera	-0.119	-0.492**	4.200*	28.635**	3.052**	4.532**	2.411**	10.945**
65	ES-14600 x Ex-7959	-0.180	0.364**	-1.063	-10.073**	-2.153**	-1.043*	-3.584**	-5.220**
66	ES-14600 x Neelam	0.299	0.129**	-3.137	-18.562**	-0.899**	-3.489**	1.173*	-5.724**
67	Ex-3 x Heera	-0.050	0.140**	-4.933*	-11.613**	-3.886**	2.060**	-4.568**	-9.219**
68	Ex-3 x Ex-7959	0.245	-0.100*	-0.021	-0.630**	9.155**	1.042*	-9.670**	5.210**
69	Ex-3 x Neelam	-0.196	-0.041	4.954*	12.542**	-5.269**	-3.102**	14.237**	4.009**
70	Ex-5-36E x Heera	0.283	0.952**	12.828**	5.705**	-0.843**	3.211**	-2.959**	1.182**
71	Ex-5-36E x Ex-7959	-0.147	-0.591**	-8.662**	-7.068**	-1.504**	-2.686**	-3.974**	-7.023**
72	Ex-5-36E x Neelam	-0.136	-0.362**	-4.166*	1.363**	2.347**	-0.525	6.933**	5.840**
73	Ex-28-3 x Heera	0.219	-0.161**	3.331	-5.194**	-4.408**	-9.452**	60.801**	-1.572**
74	Ex-28-3 x Ex-7959	-0.189	0.961**	2.914	-0.899**	-6.373**	16.436**	62.452**	-0.614**
75	Ex-28-3 x Neelam	-0.030	-0.800**	-6.245**	6.093**	10.781**	-6.983**	-123.254**	2.186**
76	Ex-313-23 x Heera	0.101	0.576**	-6.643**	16.020**	-3.375**	10.310**	-10.162**	5.184**
77	Ex-313-23 x Ex-7959	-0.005	-0.306**	12.043**	-8.804**	-0.092	-4.737**	0.176	-1.495**
78	Ex-313-23 x Neelam	-0.096	-0.270**	-5.400**	-7.216**	3.468**	-5.293**	9.986**	-3.689**
79	Ex-339-6 x Heera	0.011	-0.417**	10.263**	5.511**	1.806**	2.663**	4.949**	-0.839**
80	Ex-339-6 x Ex-7959	0.170	0.916**	-5.043**	-6.926**	-4.571**	2.497**	-5.197**	2.490**
81	Ex-339-6 x Neelam	-0.181	-0.499**	-5.220**	1.415**	2.765**	-5.160**	0.247	-1.651**
82	Ezox Natural x Heera	-0.321	0.090*	-3.630	8.721**	-9.124**	20.770**	-10.255**	11.526**
83	Ezox Natural x Ex-7959	0.121	-0.013	6.186**	-11.448**	5.599**	-8.643**	7.879**	-6.873**
84	Ezox Natural x Neelam	0.200	-0.077	-2.555	2.727**	3.525**	-12.127**	2.376**	-4.653**
85	FR-3 x Heera	0.070	0.261**	4.028*	-7.355**	-0.853**	-4.737**	2.221**	-7.136**
86	FR-3 x Ex-7959	0.138	-0.171**	-6.624**	-2.463**	-0.804**	-7.319**	-3.591**	-2.641**
87	FR-3 x Neelam	-0.208	-0.090*	2.236	9.818**	1.657**	12.056**	1.370**	9.778**
88	FRW-9 x Heera	0.024	-0.152**	-6.612**	0.103**	-5.156**	-4.100**	-2.589**	4.372**
89	FRW-9 x Ex-7959	-0.028	0.145**	9.742**	-0.300**	-1.646**	10.005**	-1.991**	2.827**
90	FRW-9 x Neelam	0.004	0.007	-3.131	0.197	6.802**	-5.905**	4.580**	-7.200**
	Sij-skl	0.162	0.039	1.903	0.0004	0.128	0.423	0.452	0.110

OIL= Oil (%), BD= Bulk density (g/cm³), TD= True density (g/cm³), PO= Porosity (%), PR= Protein (%), FAA= Free amino acids (g/Kg), CAR= Carbohydrate (%), PHE= Phenol (%), RF= Refractive index, SG= Specific gravity, AV= Acid value, LN= Linolenic acid (%), LL= Linoleic acid (%) and IV= Iodine value.

Table.3 Ranking of parents (lines and testers) on the basis of per se performance and gca effect for all traits in both generations

Traits		<i>per se</i> performance	Good General combiners	
			F ₁ generation	F ₂ generation
Oil percentage	Testers	Heera, Neelam, Ex-7959	Neelam	None
	Lines	EC-41752, ES-1496, EC-104739, EC-115161, Ex-313-23	Ex-313-23, EC-110288, EC-115161, EC-115178, EC-112689	CRISTA, Ex-5-36E, Ex-28-3, ES-1474, FRW-9, EC-41752, EC-112689, Ezox Natural
Bulk density	Testers	Neelam, Heera, Ex-7959	None	None
	Lines	Ex-313-23, Ex-5-36E, EC-98994, EC-112689, FRW-9	EC-41752, EC-1041492, Ex-3, Ex-28-3, EC-225125	Ex-3, Ezox Natural, Ex-339-6, Ex-28-3, ES-1474
True density	Testers	Neelam, Heera, Ex-7959	Heera	Heera
	Lines	EC-1041492, EC-225125, Ex-3, Ex-313-23, Ex-339-6	EC-41752, EC-41750, EC-1041492, Ex-3, Ex-28-3	FR-3, EC-99056, EC-104739, EC-99056, EC-41752
Porosity	Testers	Heera, Ex-7959, Neelam	Ex-7959	Ex-7959
	Lines	ES-1496, Ex-28-3, EC-98994, FR-3, ES-14600	ES-14600, EC-98994, ES-1474, EC-99029, Ex-313-23	EC-115161, EC-112689, Ex-313-23, Ex-339-6, Ex-28-3
Protein	Testers	Ex-7959, Neelam, Heera	None	Heera, Neelam
	Lines	T-397, EC-99029, EC-115186, Ex-339-6, EC-112689	ES-1463, EC-41752, Ezox Natural, ES-1474, EC-41750	T-397, ES-1496, Ex-110288, Ex-5-36E, ES-14600
Free amino acids	Testers	Ex-7959, Heera, Neelam	None	None
	Lines	ES-1463, Ex-28-3, Mukta, EC-104739, FRW-9	EC-115162, EC-112689, Mukta, EC-225125, EC-115178, EC-115161	T-397, ES-1496, EC-110288, Ex-5-36E, ES-14600, EC-115162
Carbohydrate	Testers	Ex-7959, Heera, Neelam	Ex-7959	Heera
	Lines	ES-1531, EC-41752, Ex-3, EC-98994, EC-112689	EC-115161, ES-1463, Ex-28-3, EC-115162, EC-104739	EC-225125, EC-99029, EC-115186, EC-99056, Ezox Natural
Phenol	Testers	Heera, Neelam, Ex-7959	Ex-7959	Ex-7959
	Lines	Ex-3, EC-115178, EC-1041492, EC-99029, ES-1531	Ex-5-36E, CRISTA, Ex-28-3, EC-99056, Ex-339-6	Ex-5-36E, T-397, CRISTA, EC-41750, EC-1041492
Refractive index	Testers	Neelam, Ex-7959, Heera	None	None
	Lines	Mukta, ES-14600, EC-41752, EC-41750, T-397, Ex-313-23	EC-104739, EC-115178, EC-112689, CRISTA, EC-99056	Ex-5-36E, FR-3, CRISTA, FRW-9, ES-1531
Specific gravity	Testers	Ex-7959, Heera, Neelam	None	None
	Lines	Ex-28-3, Ezox Natural, EC-112689, CRISTA, EC-115186	FR-3, Ezox Natural, Ex-339-6, EC-99029, EC-225125	Ex-339-6, EC-112689, Mukta, EC-115186, EC-225125
Acid value	Testers	Heera, Ex-7959, Neelam	None	Heera
	Lines	Ezox Natural, EC-1041492, Ex-28-3, ES-1496, Ex-5-36E	EC-104739, ES-14600, EC-41750, EC-115186, Ex-3	EC-112689, EC-104739, T-397, FRW-9, Mukta
Linolenic acid	Testers	Ex-7959, Neelam, Heera	Neelam	Neelam
	Lines	ES-1463, ES-14600, Mukta, EC-1041492, Ex-313-23	Ex-5-36E, CRISTA, EC-41750, EC-99029, ES-1496	EC-110288, EC-98994, Ex-5-36E, Ezox Natural, Ex-28-3
Linoleic acid	Testers	Neelam, Heera, Ex-7959	Neelam	Neelam
	Lines	ES-1496, EC-110288, EC-98994, EC-115178, FR-3	EC-112689, EC-104739, FRW-9, EC-115162, EC-99056	EC-115178, ES-1474, EC-112689, EC-104739, Ex-28-3
Iodine value	Testers	Heera, Ex-7959, Neelam	Neelam	Neelam
	Lines	Mukta, EC-99029, EC-1041492, EC-99056, Ex-5-36E, FR-3	Ex-28-3, CRISTA, Ex-5-36E, ES-1496, FR-3	EC-110288, EC-98994, Ex-5-36E, Ezox Natural, Ex-28-3

Table.4 Grading of crosses on the basis of per se performance and sca effect in both generations for all traits in linseed

Traits	<i>per se</i> performance		Good Specific combiners		
	F ₁ generation	F ₂ generation	F ₁ generation	F ₂ generation	In both generations
OIL	EC-110288 x Neelam, Ex-3 x Ex-7959, EC-112689 x Neelam, ES-1463 x Neelam, EC-115178 x Heera	CRISTA x Neelam, EC-115162 x Neelam, Ex-5-36E x Ex-7959, ES-1474 x Heera, EC-41752 x Ex-7959	Ex-3 x Ex-7959, ES-1463 x Neelam, EC-110288 x Neelam, EC-115186 x Heera, EC-104739 x Heera	EC-115162 x Neelam, EC-115161 x Ex-7959, ES-1474 x Heera, Ezox Natural x Heera, EC-41752 x Ex-7959	-
BD	Ex-28-3 x Heera, EC-41752 x Ex-7959, Ex-313-23 x Ex-7959, ES-1463 x Neelam, EC-98994 x Heera	EC-115186 x Neelam, T-397 x Heera, ES-1496 x Ex-7959, Ezox Natural x Neelam, Ex-339-6 x Heera	ES-1463 x Neelam, EC-115186 x Ex-7959, EC-115178 x Heera, EC-98994 x Heera, Ex-28-3 x Heera	T-397 x Heera, EC-115186 x Neelam, ES-1496 x Ex-7959, ES-1463 x Heera, EC-41750 x Ex-7959	-
TD	EC-41750 x Heera, Ex-28-3 x Heera, EC-41752 x Ex-7959, Ex-313-23 x Ex-7959, ES-1463 x Neelam	EC-41752 x Ex-7959, EC-41752 x Neelam, EC-99056 x Heera, EC-99056 x Neelam, EC-104739 x Heera, EC-104739 x Neelam, CRISTA x Heera, CRISTA x Neelam, EC-110288 x Heera, EC-115186 x Neelam, EC-225125 x Heera, ES-1474 x Heera, ES-1531 x Heera, Ex-3 x Heera, Ex-5-36E x Heera, FR-3 x Heera, FR-3 x Ex-7959, FR-3 x Neelam, FRW-9 x Heera	ES-1463 x Neelam, EC-115186 x Ex-7959, Ex-313-23 x Ex-7959, EC-115178 x Heera, Ex-28-3 x Heera	EC-115186 x Neelam, EC-110288 x Heera, EC-115178 x Heera, Ex-3 x Heera, Ex-5-36E x Heera	EC-115178 x Heera
PO	EC-115186 x Neelam, ES-14600 x Neelam, EC-104739 x Ex-7959, ES-1474 x Neelam, EC-98994 x Neelam	Ex-313-23 x Ex-7959, Ex-3 x Ex-7959, Ex-28-3 x Neelam, Ex-339-6 x Ex-7959, EC-110288 x Neelam	EC-115186 x Neelam, Ex-28-3 x Heera, EC-104739 x Ex-7959, FRW-9 x Ex-7959, EC-115178 x Heera,	EC-41752 x Heera, Ex-5-36E x Neelam, Ex-28-3 x Neelam, Ex-3 x Ex-7959, EC-110288 x Neelam	-
PR	Ezox Natural x Heera, EC-104739 x Heera, ES-1463 x Ex-7959, ES-14600 x Neelam, Mukta x Neelam	ES-1496 x Neelam, ES-1531 x Neelam, T-397 x Ex-7959, T-397 x Heera, EC-98994 x Heera	Ezox Natural x Heera, EC-104739 x Heera, EC-1041492 x Ex-7959, Mukta x Neelam, T-397 x Neelam	ES-1531 x Neelam, EC-115161 x Heera, EC-41752 x Ex-7959, EC-98994 x Heera, EC-99056 x Ex-7959	-
FAA	EC-115162 x Heera, EC-115162 x Ex-7959, EC-41752 x Heera, EC-112689 x Heera, EC-115186 x Heera, EC-225125 x Ex-7959, ES-1474 x Neelam	ES-1496 x Neelam, ES-1531 x Neelam, T-397 x Ex-7959, T-397 x Heera, EC-98994 x Heera, EC-110288 x Heera, EC-110288 x Neelam, EC-115161 x Heera, ES-14600 x Neelam, EC-41752 x Ex-7959	EC-99056 x Ex-7959, FRW-9 x Heera, ES-1474 x Neelam, EC-104739 x Neelam, T-397 x Heera, EC-115186 x Heera, Ex-3 x Heera	EC-115161 x Heera, EC-98994 x Heera, EC-41752 x Ex-7959, EC-99056 x Ex-7959, CRISTA x Heera, EC-115161 x Ex-7959, EC-115178 x Neelam, EC-1041492 x Neelam, ES-1463 x Neelam, ES-1496 x Neelam	EC-99056 x Ex-7959
CAR	ES-1531 x Heera, EC-225125 x Ex-7959, Ex-5-36E x Neelam, EC-115161 x Ex-7959, EC-104739 x Neelam	ES-1496 x Ex-7959, FRW-9 x Heera, EC-99056 x Ex-7959, FR-3 x Heera, T-397 x Neelam	ES-1531 x Heera, FRW-9 x Heera, CRISTA x Neelam, Ex-313-23 x Ex-7959, FR-3 x Ex-7959	EC-110288 x Neelam, ES-1496 x Ex-7959, FRW-9 x Heera, FR-3 x Heera, T-397 x Neelam	FRW-9 x Heera

PHE	EC-110288 x Heera, Ex-5-36E x Neelam, Ex-5-36E x Ex-7959, Ezox Natural x Ex-7959, Ex-313-23 x Heera, EC-1041492 x Neelam	EC-41750 x Ex-7959, T-397 x Ex-7959, EC-99056 x Ex-7959, T-397 x Heera, EC-110288 x Heera, Ex-339-6 x Ex-7959	EC-115162 x Neelam, EC-110288 x Heera, EC-112689 x Heera, Ex-313-23 x Heera, EC-98994 x Ex-7959	EC-41750 x Ex-7959, EC-110288 x Heera, EC-99056 x Ex-7959, EC-115186 x Heera, EC-104739 x Heera	EC-110288 x Heera
RF	EC-104739 x Ex-7959, EC-99056 x Ex-7959, EC-115162 x Heera, EC-115186 x Ex-7959, EC-225125 x Neelam, EC-115178 x Ex-7959, EC-104739 x Heera, CRISTA x Neelam, EC-110288 x Neelam, EC-112689 x Neelam	EC-112689 x Neelam, ES-1474 x Heera, CRISTA x Neelam, FR-3 x Ex-7959, ES-1531 x Heera	EC-98994 x Neelam, EC-98994 x Heera, EC-104739 x Ex-7959, EC-115186 x Ex-7959, EC-99056 x Ex-7959	EC-112689 x Neelam, ES-1474 x Heera, EC-115178 x Heera, EC-41752 x Heera, CRISTA x Neelam	-
SG	FR-3 x Neelam, EC-99029 x Ex-7959,, EC-104739 x Neelam, Ex-339-6 x Ex-7959, Ezox Natural x Heera, Ezox Natural x Neelam	Mukta x Ex-7959, Mukta x Neelam, ES-1474 x Heera, ES-1496 x Heera, EC-225125 x Neelam, CRISTA x Ex-7959	EC-104739 x Neelam, Ex-5-36E x Heera, EC-99029 x Ex-7959, FR-3 x Neelam, Ex-339-6 x Ex-7959, EC-225125 x Heera	EC-112689 x Ex-7959, Ex-339-6 x Neelam, ES-1496 x Heera, EC-115162 x Neelam, EC-104739 x Ex-7959	-
AV	EC-41750 x Heera,, EC-104739 x Neelam, EC-115186 x Heera, ES-14600 x Heera, ES-14600 x Ex-7959	EC-112689 x Heera, Ex-28-3 x Neelam, EC-112689 x Ex-7959, EC-115162 x Ex-7959, EC-104739 x Ex-7959, EC-104739 x Heera	EC-98994 x Ex-7959, Ezox Natural x Heera, ES-1474 x Ex-7959, EC-99029 x Neelam, Mukta x Ex-7959	ES-1463 x Heera, Ex-28-3 x Neelam, ES-1496 x Neelam, EC-41752 x Ex-7959, Ex-5-36E x Ex-7959	-
LN	Ex-5-36E x Ex-7959, CRISTA x Heera, EC-41750 x Ex-7959, CRISTA x Ex-7959, Ex-5-36E x Neelam	EC-110288 x Neelam, EC-98994 x Ex-7959, ES-14600 x Neelam, EC-98994 x Heera, EC-112689 x Neelam	EC-41750 x Ex-7959, EC-115186 x Ex-7959, Ex-5-36E x Ex-7959, EC-112689 x Neelam, Ex-313-23 x Heera	T-397 x Neelam, ES-14600 x Neelam, CRISTA x Heera, EC-112689 x Neelam, ES-1496 x Neelam	EC-112689 x Neelam
LL	FRW-9 x Neelam, Ex-28-3 x Neelam, Mukta x Heera, EC-104739 x Heera, EC-1041492 x Heera	Ex-28-3 x Ex-7959, FR-3 x Neelam, EC-1041492 x Neelam, Ezox Natural x Heera, T-397 x Neelam, ES-1474 x Neelam, ES-1531 x Neelam	Ex-28-3 x Neelam, Ex-3 x Ex-7959, Mukta x Heera, EC-115178 x Ex-7959, T-397 x Ex-7959	Ezox Natural x Heera, Ex-28-3 x Ex-7959, EC-1041492 x Neelam, FR-3 x Neelam, ES-1531 x Neelam	-
IV	CRISTA x Heera, Ex-5-36E x Ex-7959, CRISTA x Ex-7959, Ex-5-36E x Heera, FR-3 x Neelam	Ex-5-36E x Ex-7959, EC-41750 x Neelam, EC-110288 x Heera, EC-112689 x Neelam, ES-14600 x Neelam, EC-110288 x Neelam	Ex-28-3 x Neelam, Ezox Natural x Heera, Ex-313-23 x Heera, Ex-3 x Ex-7959, Mukta x Ex-7959	EC-41750 x Ex-7959, Ex-3 x Heera, EC-112689 x Neelam, FRW-9 x Neelam, ES-1463 x Neelam	-

OIL= Oil (%), BD= Bulk density (g/cm^3), TD= True density (g/cm^3), PO= Porosity (%), PR= Protein (%), FAA= Free amino acids (g/Kg), CAR= Carbohydrate (%), PHE= Phenol (%), RF= Refractive index, SG= Specific gravity, AV= Acid value, LN= Linolenic acid (%), LL= Linoleic acid (%) and IV= Iodine value.

Table.5 Colour and texture of seeds along with colour value of oil of 33 parents in linseed

S.No.	Parents	Colour of seeds	Colour Code (Kew)	Texture of seeds	Colour value of oil
Testers					
1	Heera	Greyed orange	165A	Medium & shiny	20+2
2	Ex-7959	Greyed orange	166A	Large & shiny	20.3+2
3	Neelam	Greyed orange	165A	Very small & shiny	30+2
Lines					
1	EC-41750	Greyed orange	165A	Medium & shiny	26.7+2
2	EC-41752	Greyed orange	165A	Medium & shiny	21.3+2
3	EC-98994	Greyed orange	165A	Medium & shiny	21.8+2
4	T-397	Greyed orange	165A	Medium & shiny	22.4+2
5	EC-99029	Brown	200D	Small & non-shiny	22.4+2
6	EC-99056	Greyed orange	166A	Medium & shiny	20.8+2
7	EC-104739	Greyed orange	166A	Medium & shiny	30.1+2
8	CRISTA	Greyed orange	165A	Small & shiny	22.4+2
9	EC-110288	Greyed orange	165A	Small & shiny	60+2
10	EC-112689	Brown	200D	Medium & non-shiny	22.4+2
11	EC-115161	Greyed orange	165A	Medium & shiny	30+2
12	EC-115162	Greyed orange	165A	Small & non-shiny	22.2+2
13	EC-115178	Greyed orange	166A	Small & non-shiny	22.4+2
14	EC-115186	Greyed orange	166A	Small & non-shiny	22.3+2
15	EC-225125	Greyed orange	165A	Medium & non-shiny	21.2+2
16	EC-1041492	Greyed orange	166A	Small & shiny	22.3+2
17	Mukta	Greyed orange	165A	Medium & shiny	22.3+2
18	ES-1463	Greyed orange	165B	Medium & shiny	22.8+2
19	ES-1474	Greyed orange	165B	Small & non-shiny	61+2
20	ES-1496	Greyed orange	165A	Small & shiny	35+2.1
21	ES-1531	Greyed orange	165A	Small & shiny	45.3+3
22	ES-14600	Greyed orange	165A	Small & shiny	70+2
23	Ex-3	Greyed orange	165A	Medium & non-shiny	30+2
24	Ex-5-36E	Greyed orange	165A	Medium & non-shiny	11.9+2
25	Ex-28-3	Greyed orange	165A	Small & non-shiny	22.3+2
26	Ex-313-23	Greyed orange	165A	Small & non-shiny	60+2
27	Ex-339-6	Greyed orange	165A	Medium & non-shiny	22.5+2
28	Ezox Natural	Greyed orange	165A	Medium & non-shiny	61.7+3
29	FR-3	Brown	200D	Small & non-shiny	22.1+2
30	FRW-9	Greyed orange	177A	Medium & non-shiny	35+2.1

Table.6 Colour and texture of seeds along with colour value of oil of 90 crosses in F1 generation in linseed

S.No.	Crosses	Colour of seeds	Colour code (Kew)	Texture of seeds	Colour value of oil
1	EC-41750 x Heera	Brown	200D	Large & non shiny	19 + 2
2	EC-41750 x Ex-7959	Brown	200D	Large & non shiny	48.5 + 2
3	EC-41750 x Neelam	Brown	200D	Medium & non-shiny	24 + 2
4	EC-41752 x Heera	Greyed orange	165A	Medium & non-shiny	10 + 0.3
5	EC-41752 x Ex-7959	Greyed orange	165A	Medium & shiny	31 + 2
6	EC-41752 x Neelam	Greyed orange	165A	Medium & shiny	27 + 2
7	EC-98994 x Heera	Greyed orange	165A	Medium & non-shiny	30.9 + 2
8	EC-98994 x Ex-7959	Greyed orange	165A	Large & shiny	45.5 + 2
9	EC-98994 x Neelam	Greyed orange	165A	Large & shiny	31.5 + 2
10	T-397 x Heera	Greyed orange	165A	Medium & non-shiny	40 + 2
11	T-397 x Ex-7959	Greyed orange	165A	Large & shiny	40 + 2
12	T-397 x Neelam	Greyed orange	165A	Large & shiny	40 + 2
13	EC-99029 x Heera	Greyed orange	165A	Medium & non-shiny	26 + 2
14	EC-99029 x Ex-7959	Greyed orange	165A	Large & non shiny	43.5 + 2
15	EC-99029 x Neelam	Brown	200D	Large & shiny	21 + 2
16	EC-99056 x Heera	Greyed orange	165A	Large & shiny	30 + 2
17	EC-99056 x Ex-7959	Greyed orange	165A	Small & non-shiny	30 + 2
18	EC-99056 x Neelam	Greyed orange	165A	Medium & shiny	50.5 + 2
19	EC-104739 x Heera	Greyed orange	165A	Medium & shiny	35 + 2
20	EC-104739 x Ex-7959	Greyed orange	166A	Large & shiny	30 + 2
21	EC-104739 x Neelam	Greyed orange	165A	Small & non-shiny	30 + 2
22	CRISTA x Heera	Greyed orange	166A	Medium & non-shiny	35 + 2
23	CRISTA x Ex-7959	Greyed orange	165A	Medium & shiny	38.5 + 2
24	CRISTA x Neelam	Greyed orange	166A	Medium & shiny	27.5 +
25	EC-110288 x Heera	Brown	200D	Large & non shiny	36 + 2
26	EC-110288 x Ex-7959	Greyed orange	165A	Medium & non-shiny	35 + 2
27	EC-110288 x Neelam	Greyed orange	165A	Medium & shiny	25 + 2
28	EC-112689 x Heera	Greyed orange	166A	Large & shiny	32.5 + 2
29	EC-112689 x Ex-7959	Greyed orange	165A	Large & non shiny	38 + 2
30	EC-112689 x Neelam	Greyed orange	165A	Medium & shiny	47.5 + 2
31	EC-115161 x Heera	Greyed orange	166A	Medium & shiny	45 + 2
32	EC-115161 x Ex-7959	Greyed orange	165A	Large & shiny	30 + 2
33	EC-115161 x Neelam	Brown	200D	Large & shiny	20 + 2
34	EC-115162 x Heera	Greyed orange	165A	Medium & shiny	18.5 + 2
35	EC-115162 x Ex-7959	Greyed orange	165A	Large & shiny	31 + 2
36	EC-115162 x Neelam	Greyed orange	165A	Large & shiny	30 + 2
37	EC-115178 x Heera	Greyed orange	165A	Large & shiny	25 + 2
38	EC-115178 x Ex-7959	Greyed orange	165A	Large & shiny	30 + 2
39	EC-115178 x Neelam	Brown	200D	Small & non-shiny	27.5 + 2
40	EC-115186 x Heera	Greyed orange	166A	Small & non-shiny	28 + 2
41	EC-115186 x Ex-7959	Greyed orange	166A	Medium & shiny	27 + 1
42	EC-115186 x Neelam	Greyed orange	165A	Medium & shiny	39.5 + 2
43	EC-225125 x Heera	Greyed orange	165A	Medium & shiny	31 + 2
44	EC-225125 x Ex-7959	Greyed orange	165A	Medium & shiny	29.5 + 2
45	EC-225125 x Neelam	Greyed orange	165A	Large & shiny	33 + 2

Continued.....

S.No	Crosses	Colour of seeds	Colour Code (Kew)	Texture of seeds	Colour value
46	EC-1041492 x Heera	Greyed orange	165A	Medium & shiny	29 + 1
47	EC-1041492 x Ex-7959	Greyed orange	166A	Medium & non-shiny	40 + 2
48	EC-1041492 x Neelam	Greyed orange	166A	Medium & shiny	20.5 + 0.4
49	Mukta x Heera	Brown	200D	Large & shiny	47.5 + 2
50	Mukta x Ex-7959	Greyed orange	165A	Large & shiny	20 + 2
51	Mukta x Neelam	Greyed orange	165A	Large & shiny	29 + 2
52	ES-1463 x Heera	Greyed orange	165A	Medium & shiny	32.5 + 2
53	ES-1463 x Ex-7959	Greyed orange	165A	Small & shiny	48 + 2
54	ES-1463 x Neelam	Greyed orange	166A	Medium & shiny	18 + 2
55	ES-1474 x Heera	Greyed orange	165A	Large & shiny	30 + 1
56	ES-1474 x Ex-7959	Greyed orange	165A	Large & shiny	50 + 2
57	ES-1474 x Neelam	Greyed orange	165A	Medium & shiny	35 + 2
58	ES-1496 x Heera	Greyed orange	165A	Medium & shiny	29 + 1
59	ES-1496 x Ex-7959	Greyed orange	165A	Large & shiny	28 + 2
60	ES-1496 x Neelam	Greyed orange	165A	Medium & shiny	44 + 2
61	ES-1531 x Heera	Greyed orange	165A	Medium & shiny	46.5 + 2
62	ES-1531 x Ex-7959	Greyed orange	165A	Large & shiny	34.5 + 2
63	ES-1531 x Neelam	Brown	200D	Medium & shiny	21 + 2
64	ES-14600 x Heera	Brown	200D	Medium & shiny	46 + 2
65	ES-14600 x Ex-7959	Brown	200D	Medium & shiny	45 + 2
66	ES-14600 x Neelam	Greyed orange	165A	Medium & non-shiny	18.5 + 2
67	Ex-3 x Heera	Brown	200D	Small & non-shiny	31 + 2
68	Ex-3 x Ex-7959	Greyed orange	165A	Large & non shiny	48.5 + 2
69	Ex-3 x Neelam	Greyed orange	166A	Large & shiny	25.8 + 2
70	Ex-5-36E x Heera	Greyed orange	165A	Large & shiny	35 + 2
71	Ex-5-36E x Ex-7959	Greyed orange	165A	Large & shiny	56 + 2
72	Ex-5-36E x Neelam	Greyed orange	165A	Medium & shiny	45 + 2
73	Ex-28-3 x Heera	Brown	200D	Medium & shiny	33.5 + 2
74	Ex-28-3 x Ex-7959	Greyed orange	165A	Medium & shiny	50.5 + 2
75	Ex-28-3 x Neelam	Greyed orange	165A	Medium & shiny	31 + 2
76	Ex-313-23 x Heera	Greyed orange	165A	Large & shiny	20.8 + 2
77	Ex-313-23 x Ex-7959	Greyed orange	165A	Medium & shiny	38 + 2
78	Ex-313-23 x Neelam	Greyed orange	165A	Medium & shiny	16.5 + 0.5
79	Ex-339-6 x Heera	Greyed orange	166A	Medium & non-shiny	29.5 + 2
80	Ex-339-6 x Ex-7959	Greyed orange	165A	Large & shiny	40 + 2
81	Ex-339-6 x Neelam	Brown	200D	Medium & non-shiny	31 + 2
82	Ezox Natural x Heera	Greyed orange	165A	Medium & shiny	30 + 2
83	Ezox Natural x Ex-7959	Brown	200D	Large & shiny	44 + 2
84	Ezox Natural x Neelam	Greyed orange	165A	Medium & shiny	47 + 2
85	FR-3 x Heera	Greyed orange	165A	Medium & shiny	56 + 2
86	FR-3 x Ex-7959	Greyed orange	165A	Medium & shiny	37.8 + 2
87	FR-3 x Neelam	Greyed orange	165A	Small & non-shiny	47.5 + 2
88	FRW-9 x Heera	Greyed orange	165A	Medium & shiny	38 + 2
89	FRW-9 x Ex-7959	Greyed orange	165A	Large & shiny	40 + 2
90	FRW-9 x Neelam	Brown	200D	Medium & shiny	47 + 2

Table.7 Colour and texture of seeds along with colour value of oil of 90 crosses in F2 generation in linseed

S.No.	Crosses	Colour of seeds	Colour Code (Kew)	Texture of seeds	Colour value
1	EC-41750 x Heera	Brown	200D	Small & non-shiny	40+2
2	EC-41750 x Ex-7959	Brown	200D	Small & non-shiny	30+2
3	EC-41750 x Neelam	Brown	200D	Medium & shiny	40+2
4	EC-41752 x Heera	Brown	200D	Large & non shiny	50+2
5	EC-41752 x Ex-7959	Brown	200D	Large & non shiny	50+2
6	EC-41752 x Neelam	Brown	200D	Medium & shiny	60+2
7	EC-98994 x Heera	Brown	200D	Medium & shiny	50+2
8	EC-98994 x Ex-7959	Brown	200D	Medium & non-shiny	35+2
9	EC-98994 x Neelam	Brown	200D	Large & non shiny	15+1
10	T-397 x Heera	Brown	200D	Medium & shiny	60+2
11	T-397 x Ex-7959	Brown	200D	Medium & shiny	60+2
12	T-397 x Neelam	Brown	200D	Medium & shiny	40+2
13	EC-99029 x Heera	Brown	200D	Medium & shiny	85+2
14	EC-99029 x Ex-7959	Brown	200D	Medium & shiny	40+2
15	EC-99029 x Neelam	Brown	200D	Medium & non-shiny	40+2
16	EC-99056 x Heera	Greyed orange	165A	Large & non shiny	25+2
17	EC-99056 x Ex-7959	Brown	200D	Large & non shiny	30+2
18	EC-99056 x Neelam	Brown	200D	Medium & shiny	30+2
19	EC-104739 x Heera	Brown	200D	Large & non shiny	30+2
20	EC-104739 x Ex-7959	Brown	200D	Large & shiny	30+2
21	EC-104739 x Neelam	Greyed orange	165A	Large & non shiny	15+1
22	CRISTA x Heera	Brown	200D	Small & non-shiny	40+2
23	CRISTA x Ex-7959	Brown	200D	Medium & non-shiny	30+2
24	CRISTA x Neelam	Brown	200D	Medium & shiny	15+2
25	EC-110288 x Heera	Brown	200D	Large & non shiny	40+2
26	EC-110288 x Ex-7959	Brown	200D	Small & non-shiny	30+2
27	EC-110288 x Neelam	Brown	200D	Small & non-shiny	40+2
28	EC-112689 x Heera	Brown	200D	Large & shiny	50+2
29	EC-112689 x Ex-7959	Brown	200D	Medium & shiny	30+2
30	EC-112689 x Neelam	Brown	200D	Medium & shiny	50+2
31	EC-115161 x Heera	Brown	200D	Medium & shiny	25+1
32	EC-115161 x Ex-7959	Brown	200D	Large & shiny	65+2
33	EC-115161 x Neelam	Brown	200D	Large & shiny	30+2
34	EC-115162 x Heera	Brown	200D	Medium & shiny	30+2
35	EC-115162 x Ex-7959	Brown	200D	Medium & non-shiny	50+2
36	EC-115162 x Neelam	Brown	200D	Large & shiny	55+2
37	EC-115178 x Heera	Brown	200D	Large & shiny	30+1
38	EC-115178 x Ex-7959	Brown	200D	Large & shiny	25+1
39	EC-115178 x Neelam	Brown	200D	Small & non-shiny	20+2
40	EC-115186 x Heera	Brown	200D	Small & non-shiny	30+2
41	EC-115186 x Ex-7959	Brown	200D	Medium & shiny	15+1
42	EC-115186 x Neelam	Brown	200D	Medium & shiny	30+2
43	EC-225125 x Heera	Brown	200D	Medium & shiny	40+2
44	EC-225125 x Ex-7959	Brown	200D	Small & non-shiny	50+2
45	EC-225125 x Neelam	Brown	200D	Large & shiny	15+1

Continued.....

S.No	Crosses	Colour of seeds	Colour Code (Kew)	Texture of seeds	Colour value
46	EC-1041492 x Heera	Brown	200D	Medium & shiny	25+1
47	EC-1041492 x Ex-7959	Brown	200D	Medium & non-shiny	15+1
48	EC-1041492 x Neelam	Brown	200D	Medium & shiny	30+2
49	Mukta x Heera	Brown	200D	Large & shiny	30+2
50	Mukta x Ex-7959	Brown	200D	Large & shiny	30+2
51	Mukta x Neelam	Brown	200D	Large & shiny	30+2
52	ES-1463 x Heera	Brown	200D	Medium & shiny	40+2
53	ES-1463 x Ex-7959	Brown	200D	Medium & non-shiny	30+2
54	ES-1463 x Neelam	Brown	200D	Medium & shiny	30+2
55	ES-1474 x Heera	Brown	200D	Large & shiny	15+1
56	ES-1474 x Ex-7959	Brown	200D	Medium & shiny	70+2
57	ES-1474 x Neelam	Brown	200D	Medium & shiny	50+2
58	ES-1496 x Heera	Brown	200D	Medium & shiny	30+2
59	ES-1496 x Ex-7959	Brown	200D	Large & shiny	40+2
60	ES-1496 x Neelam	Brown	200D	Medium & shiny	40+2
61	ES-1531 x Heera	Brown	200D	Medium & shiny	15+1
62	ES-1531 x Ex-7959	Brown	200D	Large & shiny	25+1
63	ES-1531 x Neelam	Brown	200D	Medium & shiny	15+1
64	ES-14600 x Heera	Brown	200D	Medium & shiny	40+2
65	ES-14600 x Ex-7959	Brown	200D	Medium & shiny	30+2
66	ES-14600 x Neelam	Brown	200D	Medium & non-shiny	55+2
67	Ex-3 x Heera	Brown	200D	Small & non-shiny	50+2
68	Ex-3 x Ex-7959	Brown	200D	Large & shiny	25+2
69	Ex-3 x Neelam	Brown	200D	Large & shiny	15+1
70	Ex-5-36E x Heera	Brown	200D	Large & shiny	16+1
71	Ex-5-36E x Ex-7959	Brown	200D	Large & shiny	15+1
72	Ex-5-36E x Neelam	Brown	200D	Medium & shiny	15+1
73	Ex-28-3 x Heera	Brown	200D	Medium & non-shiny	15+1
74	Ex-28-3 x Ex-7959	Brown	200D	Medium & shiny	50+2
75	Ex-28-3 x Neelam	Brown	200D	Medium & shiny	15+1
76	Ex-313-23 x Heera	Brown	200D	Large & shiny	50+2
77	Ex-313-23 x Ex-7959	Brown	200D	Medium & shiny	50+2
78	Ex-313-23 x Neelam	Brown	200D	Medium & non-shiny	60+2
79	Ex-339-6 x Heera	Brown	200D	Medium & non-shiny	30+2
80	Ex-339-6 x Ex-7959	Brown	200D	Large & non shiny	50+2
81	Ex-339-6 x Neelam	Greyed orange	165A	Medium & non-shiny	40+2
82	Ezox Natural x Heera	Brown	200D	Medium & non-shiny	40+2
83	Ezox Natural x Ex-7959	Brown	200D	Large & non shiny	30+2
84	Ezox Natural x Neelam	Brown	200D	Medium & shiny	30+2
85	FR-3 x Heera	Brown	200D	Medium & shiny	70+2
86	FR-3 x Ex-7959	Brown	200D	Medium & shiny	15+1
87	FR-3 x Neelam	Brown	200D	Small & non-shiny	30+2
88	FRW-9 x Heera	Brown	200D	Medium & shiny	65+2
89	FRW-9 x Ex-7959	Brown	200D	Medium & shiny	15+1
90	FRW-9 x Neelam	Brown	200D	Medium & shiny	15+1

High SCA effects manifested by low $\times$ low crosses may be attributed to dominance $\times$ dominance type of non-allelic gene interaction producing over dominance thus being non-fixable. If both the GCA and SCA values are not significant, epistatic gene effects may play a remarkable role in determining these characters (Talukder *et al.*, 2016).

Considering the GCA effects of parents, none of the parent was found to be good general combiner for all the traits to utilize them for edible purposes. Among the testers based on the *per se* performance and gca effect in both generations, Heera was found good general combiner for true density; tester parent Ex-7959 for porosity and phenol content and Neelam for iodine value, linolenic acid and linoleic acid. Among lines based on *per se* performance and gca effect in both generations Ex-5-36E was good general combiner for iodine value. While considering the *per se* performance of parents alone, EC-1041492 was good general combiner for true density, phenol, acid value, iodine value and linolenic acid; Ex-28-3 for porosity, free amino acids, specific gravity and acid value; Ex-339-6 for true density, oil percentage and refractive index; Ex-313-23 for bulk density, true density, refractive index and linolenic acid; Mukta for free amino acids, refractive index, iodine value and linolenic acid and Ezox Natural for specific gravity and acid value. On the basis of gca effect of parent over both generations, parent Ex-5-36E was good general combiner phenol, iodine value and linolenic acid; Ex-313-23 for porosity; EC-112689 for linoleic acid; EC-104739 for acid value and linoleic acid and Ex-28-3 for bulk density and iodine value. Parent EC-112689 was found good general combiner for oil content in both generations. Similarly, parents EC-115161 and EC-115178 were good general combiner for oil in F_1 generation while CRISTA for in F_2 generation. It is

therefore suggested that intermating in randomly selected progenies from early segregating generations (biparental mating) obtained as a result of crossing between parents will release the concealed genetic variability through breakage of undesirable linkages involved in various traits, may produce population for selection of elite lines in advance generations (Bhateria *et al.*, 2006).

The specific combining ability is defined as any deviation in the performance of parents in producing good cross combinations (Hallauer and Miranda, 1981 and Yamanura *et al.*, 2009). Falconer (1981) suggested that high SCA variances showed non-additive gene action or dominance and epistatic gene effects. A perusal of results indicated that none of the cross combinations was superior for all the traits. In the present study good cross combinations was obtained not only between high $\times$ high general combiners but also as a result of low $\times$ low and low $\times$ high combinations interaction. The good combinations from high $\times$ low general combiners might be due to the favourable additive effects of good general combiner parent and epistatic effect of poor general combiner and low $\times$ low general combiners might be due to the presence of epistatic or dominant gene actions producing over dominance (Bhateria *et al.*, 2006). Cross combination EC-112689 $\times$ Neelam was found good specific combiner for oil based on *per se* performance in F_1 generation.. However, cross Ex-3 $\times$ Ex-7959 for porosity, oil percentage, iodine value and linoleic acid; cross EC-115186 $\times$ Ex for refractive index and linolenic acid, and cross Ezox Natural $\times$ Heera for protein, acid value and iodine value were good specific combiner in F_1 generation. Crosses EC-98994 $\times$ Ex, EC-110288 $\times$ Neelam, ES-1463 $\times$ Neelam and Mukta $\times$ Ex-7959 were good specific combiners in F_1 generation. Similarly, cross EC-41750 $\times$ Ex-7959 for phenol and iodine value; EC-41752

x Ex-7959 also for porosity, free amino acids, oil percentage and acid value and cross EC-1041492 x Neelam for free amino acids and linoleic acid in F₂ generation were good specific combiners. Beside this, cross EC-115178 x Heera was good specific combiner for true density in both generation, bulk density and porosity in F₁ generation and refractive index in F₂ generation, cross EC-99056 x Ex-7959 for free amino acids and phenol in both generations in F₁ generation and for protein in F₂ generation, cross FR-3 x Heera for test weight and carbohydrate content in F₂ generation, cross EC-112689 x Neelam for linolenic acid in both generations and for refractive index and iodine value in F₂ generation and cross ES-1463 x Neelam for bulk density, true density and oil percentage in F₁ generation and free amino acids and iodine value in F₂ generation were good specific combiners. The cross FRW-9 x Heera for carbohydrate and cross EC-110288 x Heera for phenol were good specific combiner in both generations. Finally the crosses EC-104739 x Neelam, EC-110288 x Neelam, EC-112689 x Neelam, EC-115178 x Heera and Ex-339-6 x Heera in F₁ and crosses EC-41750 x Heera, EC-41752 x Ex-7959, EC-1041492 x Neelam, ES-1474 x Heera and Ezox Heera in F₂ generation and cross Ex-28-3 x Ex-7959 in both generations were good specific combiners for oil percentage and improvement of these crosses can be done using biparental mating or reciprocal recurrent selection followed by pedigree selection (Bhateria *et al.*, 2006 and Ilker *et al.*, 2000).

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How to cite this article:

Anu Rastogi and Sudhir Shukla. 2019. Combining Ability Analysis for Oil and Seed Parameters in Linseed (*Linum usitatissimum* L.). *Int.J.Curr.Microbiol.App.Sci*. 8(01): 1118-1148. doi: <https://doi.org/10.20546/ijcmas.2019.801.120>