CHAPTER II
REVIEW OF LITERATURE

A brief account of the research work done on the relevant aspects of the present study has been reported in this chapter under the following heads:-

1. To estimate components of genetic variance
2. To estimate variances of general and specific combining ability
3. To estimate general and specific combining ability effects
4. To estimate economic heterosis in $F_1$, hybrids and inbreeding depreciation incurred in $F_2$
5. To estimate the heritability and excepted genetic gain in respect of Atributes under study
6. To work out association among the characters under study at genotypic level.

A. GENE ACTION AND COMBINING ABILITY:

Variance is the measure of the variability and heritable variations, in particular are of great importance as they offer a working bench for operating selection by the breeder to meet his breeding objectives. The genetic improvement mostly depends on the nature, magnitude and inter-relationship of heritable and non-heritable variations for economic characteristics. The studies on the quantitative characters in plants started with the work of Johannson (1909), Nilsson Ehle (1909) and East (1916).
Fisher (1918) was the first to recognize three major components of genetic variance viz., (i) Additive component arising from average effect of genes, (ii) dominance component arising from Intra-Allelic interactions and (iii) epistatic part associated with non-allelic interactions.

According to Wright (1921, 1935) the hereditary component of variation are composed of additive and non-additive type (dominance and epistasis). He also suggested that only the additive effect contributed towards the genetic advancement in the selection.

Mather (1949) proposed that the variance observed in a character could be described due to non-heritable, heritable but fixable and heritable but not fixable.

Robinson et al. (1949) suggested that additive genetic variance measures relationship between parents and their offsprings.

Comstock and Robinson (1948) outlined the procedure for estimating the degree of dominance using the data of biparental pogenies. They defined 'a' (Degree of dominance) as a mean of dominance over all the loci. Dominance is complete if 'a' is equal to 1.0, values more than 1.0 indicate over dominance and less than 1.0 are associated with partial dominance.

Mather (1949) developed a formula $\sqrt{H/D}$, for determining the degree of dominance. Robinson et al. (1949) and
Gardner (1963) recognised that the estimates of degree of dominance in over dominance range for yield could be obtained as a result of repulsion phase linkage even-though none of the genes involved are more than completely and partially dominant to their alleles. Gardner and Lonngquist (1959), Robinson and Moll (1963), Moll et al. (1964) and William et al. (1965), have provided experimental evidence regarding indication of linkage bias in their results.

Comstock and Robinson (1952) suggested that non allelic interactions might inflate the Average degree of dominance by 10 to 25 percent.

Anderson and Kempthorne (1954) Cockerham (1954) and Hayman and Mather (1955) proposed genetic models permitting the estimation of different types of gene effects i.e., additive, dominance and epistasis.

Cockerham (1954), Kempthorne (1955) and Horner and Kempthorne (1955) further partitioned epistatic variance into (1) additive X additive (i), (2) additive X dominance (j) and (3) dominance X dominance (i) components.

Hayman (1958b) reported that additive and dominance gene effects not be unequally measured when significant epistasis was present. Jinks (1955) and Gamble (1962) reported that among all these gene effects, epistasis was correlated with yield.
Rosbaco (1959), while studying $F_1$, $F_2$ and $F_3$ populations of a flax cross, found intermediate inheritance for seed size and height with tendency towards dominance in case of tallness.

Joshi et al. (1961) studied the genetics of time taken from sowing to first flowering in a diallel of $3 \times 3$ cross technique and observed additive gene effects to be fairly high and significant, whereas the value of dominance were much lower, higher significant.

Jeswani et al. (1962) studied the genetic variance in progenies of crosses derived by crossing two linseed and two flax types in respect of yield factors. These results were analysed by (i) partitioning of variance in to $D$, $H$, $E_1$ and $E_2$ (ii) estimation of interaction components and (iii) parents offspring regression between the mean and second degree statistics. It was stated that interaction played a significant role in the inheritance of tiller number and 1000 - Seed Weight, complementary epistasis was operating in a majority of the cases except plant height, where duplicate epistasis was pronounced. Dominance was indicated in case of plant height, whereas balanced dominance was operating for other characters.

Kasim (1964) observed non-additive genetic variance in flax for number of boll per unit area, Number of seeds per boll and seed size.
Murty and Anand (1966) concluded from the study of $F_1$ crosses of 10 X 10 diallel that predominantly additive gene action was observed for flowering time, plant height, height at Branching and length of early and Late tillers, while non-additive gene action was relatively important for number of fruit bearing branches, number of capsules and seed number.

Chaudhary et al. (1972) while partitioning $F_2$ variance into D and H components and estimation of generation means, found that epistasis played a significant role in the inheritance of all the characters studied. High additive genetic variance and expected genetic gain were found in case of capsule number, seeds per capsule, 1000-seed weight and grain yield per plant.

Anand et al. (1972) estimated the genetic covariance for full-sib and half-sib analysis in linseed. The reported additive gene action to be predominant for flowering time and height at branching, while non-additive action was predominant for plant height, tiller number, capsule number and seed number per five capsules.

Badwal and Bains (1974), through the genetic Analysis in Linum, reported considerable epistatic variation and predominance of additive genetic variability together with a low but significant deviation for all the characters studied. Directional dominance towards dominant alleles was
observed for days to flower, while for other traits it was ambidirectional dominance.

Kausal et al. in a 10 X 10 diallel cross of linseed reported predominance of non-additive gene action for oil content.

Singh (1976) through diallel analysis, observed major role of non-additive gene action for plant height, branch number, capsule number, no. of seed per capsule and yield per plant, where as additive gene action was observed for days to flower, tiller number, capsule length, days to maturity and 1000 seed weight. Equal role of both additive and non-additive gene action was observed for oil content in \( F_1 \) generation.

Rai (1976) studied combining ability and various genetic parameters for days to flower and maturity in linseed. The additive portion of genetic variance appeared to be substantial. However dominance and epistatic components were also significant. The average degree of dominance revealed partial dominance operating in expression of these characters.

Mishra (1977) reported additive genetic variance for days to flower; plant height and seeds per capsule and non-additive variance for branch number, capsule number, days to maturity, 1000-seed weight, yield per plant, length of reproductive phase, oil content and Iodine value.
Singh (1977) observed additive gene action for plant height, tiller number, branch number, days to maturity and 1000-seed weight and non-additive gene action for capsule number, seeds per capsule, yield per plant and oil content.

Singh and Singh (1979) through diallel analysis in linseed, observed major role of non-additive gene action for plant height, number of seeds per capsule and yield per plant, whereas additive gene action was observed for days to flower, number of tillers, capsule length, capsule diameter, days to maturity and 1000-seed weight. Equal role of both additive and non-additive gene action was observed for oil content in $F_1$ and only non-additive gene action in the $F_2$.

Patil and Chopde (1981) indicated that both additive and non-additive gene action was involved for the inheritance of seed yield in linseed.

Sindhu et al. (1983) through diallel analysis in linseed, studied the gene action in $F_1$ and $F_2$ generations by graphical and analytical methods and observed preponderance of additive gene action for oil content suggested the scope of practising directional selection for this traits.

Singh and Srivastava (1983) observed additive gene action in linseed for plant height, number of tillers per plant, number of branches per plant, days to maturity and 1000-seed weight in both $F_1$ and $F_2$ generation. Non-additive gene action played a major role in the inheritance of number
cf capsule per plant, number of seeds per capsule, yield per plant and oil content in $F_1$ and $F_2$ generation.

Sharma, S.K. (1986) yield and some of its components were studied in the $F_1$ and $F_2$ of a diallel cross of 10 varieties of linseed. Non-additive effects were significant for all characters and additive effects were significant for all except capsules per plant and seed yield in the $F_1$. Additive gene action predominated for height and 100 seed weight but dominance components were more important for the other characters.

Tak, G.M.; Gupta, V.P. (1989) reported that both additive and non-additive gene effects were observed for the traits, with dominance and dominance X dominance effects predominating in most cases. Reciprocal recurrent selection is recommended for improving yield in linseed.

The fact that certain lines gave more desirable hybrids than others, was established by the work of East, Shull and Jones in the early part of this century. Sprague and Tatum (1942), however, gave clear picture of combining ability viz. general and specific combining abilities. The general combining ability (GCA) refers to the average performance of a line or lines in a series of hybrid combinations, while specific combining ability (SCA) was designated to cover those cases in which certain combinations do relatively better or worse as would be expected on the basis of average performance of the line.
involved. Further, they concluded that GCA is primarily due to additive effects of genes, while SCA is a consequence of Intra-allelic (dominance) and inter-allelic (epistasis) interactions.

Henderson (1952) also defined GCA as the average merit of large number of progenies of an individual or line when mated with a random sample, whereas SCA was defined as the deviation of an average of indefinitely large number of progenies of two individuals or lines from the values expected on the basis of known general combining ability of these two lines or individuals.

Griffing (1956a) pointed out that general combining ability involved both additive as well as additive X additive interaction. Subsequently he suggested the method of estimating general and specific combining ability in a diallel cross with or without reciprocals. He partitioned $P^2$ combinations into the following four possible experimental methods in diallel crossing technique may vary from one another

(i) parents, one set of $F_1$ S and their reciprocals (all $P^2$ combinations).

(ii) parents and one set of $F_1$ S excluding reciprocals $\frac{P(P+1)}{2}$ combinations.

(iii) one set of $F_1$ S and their reciprocals excluding parents ($P^2-P$ combinations).
(iv) a set of $F_1$'s but neither parents nor reciprocals included $\binom{P(P-1)}{2}$ combinations.

According to Griffing (1956b) total genetic variance along the single cross progeny is equal to twice the GCA component of variance ($6^2_g \times 2$) plus the specific combining ability component of variance ($6^2_s$). He further suggested that the related importance of GCA and SCA in determining progeny performance should be assessed by estimating the components of variance and expressing them in the ratio, $\frac{26^2_g}{26^2_g + 6^2_s}$. The closer this ratio is to unity, the greater would be the predictability based on GCA alone. When the analysis is based on a model with fixed effect, one would use, equivalent components of mean squares.

Kempthorne (1957) precisely gave the explanation of general and specific combining ability variance in terms of covariance of half-sib (H.S.) and full-sib (F.S.) in random mating population, where, $6^2_{GCA} = COV(H.S.)$ and $6^2_{SCA} = COV(F.S.) - 2 COV(H.S.)$.

Moll et al. (1960) suggested that the results about the magnitude of gene action based on combining ability variance were not much reliable due to serious bias from genotype environmental interactions.

In linseed not much work has been done on this aspect. However the available literature is being reviewed below:
Dalal and Gill (1965), while studying general combining ability in intervarietal crosses and observed significant inherent differences were found between various progenies for plant height, tiller per plant, capsule per plant, seeds per capsule, 1000-seed weight and grain yield per plant.

Murty et al. (1967) compared the estimates of combining ability obtained from diallel and partial diallel sets for characters flowering time, plant height, height and branching, number of fruit bearing branches, number of capsules per plant and number of seeds per five capsules over two years. The magnitude of variation due to general and specific combining ability were reported significant for all the mentioned characters for both the years.

Badwal and Gupta (1970a) reported that specific combining ability was more important for seed yield in linseed, but for the characters like days to flowering, plant height, tiller number, capsule number, primary branches, seeds per capsule and seed size, the general combining ability was more pronounced. Most of the combinations with high SCA effects involved at least one high general combining parents, one cross involving average X low combination also gave high SCA effects. They concluded that genetic diversity among the parents played an important role in combining ability.
Rai and Das (1974) observed that variation due to GCA and SCA was significant for plant height, Number of effective tillers, Number of capsule per plant, seeds per capsule and seed index in lin seed. However, GCA variance was larger in magnitude than that due to SCA.

Chandra (1978) found in 6 x 6 diallel for nine character that the general combining ability variance were particularly important with regard to plant height, tiller number, while specific combining ability variance predominantly influenced capsules number, seed number, seed number, flowering date in F₁ generation. The general and specific combining ability external equal influence of seed yield and 1000-seed weight.

Patil and Chopde (1981) in combining ability studies for yield and its component traits viz., number of tillers per plant, number of capsules per plant, 1000-seed weight and days to 50 percent flowering further observed that general combining ability mean squares were several time greater than specific combining ability mean squares for all the traits.

Patil and Chopde (1983) ecogeographically and genetically diverse ten lin seed cultivars were crossed in diallel design and evaluated in F₂ generation over three environments. Inheritance of plant height, maturity, seeds per capsule and seed yield have been reported. The general
combining ability (GCA) and specific combining ability (SCA) mean squares were significant in all the environments for the characters studies. The ratio of GCA and SCA mean squares was significant, indicating the predominance role of additive gene effects in the inheritance.

Dakhore, S.R.; Narkhede, M.N.; Khorgade, P.W. (1987) combining ability for oil content and seed yield and its components was studied using 10 lines and 5 tester. Estimates of general and specific combining ability variance indicate the possible importance of both additive and non-additive genotypic components of variation for days to maturity, number of branches per plant and 1000-seed weight. The additive genotypic components was important for plant height, number of seeds per capsule and oil content. For number of capsule per plant. The non-additive genotypic components was important. Non of the parents showed good GCA for all the characters under study. T 397 X C 219 - 1 - 1, JLS - Jl x C 219 x 1 - 1, AKL 10 x LCK 38 and AKL 10 x C 219 - 1 - 1 were the best crosses for oil content, seed yield and seed yield components on the basis of their high mean performance, high or average GCA effects of parents and comparatively low SCA effects.

Thakur, H.L.; Rana, N.D.; Sood, O.P. (1988) Data from a diallel analysis involving 8 Linum usitatissimum varieties indicated that DPL 21 and Himalini were the best combiner for seed yield and good combiner for various yield
components. The best specific combinations for seed yield and capsules and tillers per plant were Flak - 2 x BS₂ and Himalini x TLP 1.

Manfroni De Silvero Sanz, D.H.; Conde, A.A.; Silvero Sanz, O.I. (1989) combining ability for 7 yield related traits was studied in 5 linseed varieties. Reconquista INTA and CI 2703 were found to be the most suitable parent varieties. Alcorta INTA showed significant positive GCA for oil content and a significant SCA in crosses with tap parama INTA and CI 2838. The GCA of tap parama INTA was positive and significant only for seed per seed ball. The SCA for this traits was significant in a cross with reconquista INTA. CI 2838 showed significant GCA for Idonine number and SCA was significant in a cross with CI 2703.

Niv, Y.C.; Zhang, J.W., Niv, J.Y. (1991) Information on combining ability and heritability is derived from data on 14 characters in 9 Linum usitatissimum lines and their F₁ hybrids. Neiya 2 and swiss red show good GCA for yield and fibre quality, fibre length, corolla diameter, plant height, capsule diameter and 1000-seed weight had high heritabilities.

Khotyleva, L.V.; Polonetskaya, L.M. (1993), the action and interaction of genes controlling height were studied in a diallel set of crosses involving 7 parental varieties. Additive and dominance gene effects were found,
expressed in incomplete dominance of the traits at early stages of growth but in overdominance at complete maturity. The highest frequency of dominant genes for the character crop ressea at complete maturity was detected in Belinka, K6, Madonna and Orshanskii 72.

B. **HETEROISIS AND INBREEDING DEPRESSION** :

Heterosis has been defined as increased vigour of F₁ over the mean of parent or over the better parent (Hayes, Immer and Smith, 1955). Abercromble *et al.* (1961) described heterosis as increased vigour of growth, fertility, etc., in a cross between two genetically different lines as compared with growth etc., in either of the parental lines, associated with increased heterozygosity.

Initially, Hybrid vigour was observed by Koelreuter (1763) in artificial plant crosses. Knight (1799), Darnein (1877) and Focke (1881) reported hybrid vigour in various crosses in plant species and varieties. Genetic basis of heterosis has been explained by many workers including East (1908, 1909), East and Hayes (1912) and String Field (1950).

Carnahan (1947) reported in flax with seed yield and 16 crosses. He reported as average of 40 to 27 percent heterosis over mean of the parents in F₁ and F₂ generations, respectively. High heterosis was recorded for number of capsule per row, number of seeds per capsule and plant height.
Chu (1949) reported in flax heterosis in respect of plant height and 1000-seed weight.

Jinks (1955) suggested that non-allelic interaction is more likely and frequent cause of heterosis rather than specific relation between the genes at the same locus. Mather (1955) considered heterosis as an expression of genetic balance which depends upon adjustment and intergration of polygenes. Jinks and Jones (1958) described it as a complex phenomenon depending upon the balance additive, dominance and interaction of Homozygous/homozygous and homozygous/heterozygous components as well as on the distribution of genes in the parental lines. Deskalov (1963) concluded that heterosis in $F_1$ is a combined expression of genetical, cytoplasmic, biochemical and physiological factors and may be attributed to stimulation resulting from the interaction of different heritable factors of the parents in $F_1$. Turbin (1963) also observed environmental factors involved in the expression of heterosis.

Kasim (1964) observed many crosses exhibited significant increase in seed yield over their mid-parent values. However, only a few crosses exhibited significant heterosis for oil content.

Dubey and Singh (1964) reported in linseed a high degree of heterosis over the better parent for yield. According to him one hybrid out yielded the better parent by 230.93 percent.
Naidu (1967) studied the existence of heterosis and possibility of its exploitation in two divergent, inter-varietal Indogangetic x penninsular crosses and found that inbreeding depression confirmed non-allelic interaction variation for tiller number and fruiting branches.

Anand and Murty (1968, 1969), observed negative heterosis for flowering time, plant height and seeds per five capsules and positive heterosis for the number of fruit bearing branches and capsule per plant. They further reported positive heterosis for plant height, number of fruiting bearing branches, tillers and capsules per plant.

Shehata et al. (1971) reported six percent average heterosis for seed yield over mid-parent value and 5.5 percent economic heterosis in F₂ population.

Mishra (1977) observed in linseed high heterotic reponse for number of branches, number of capsules and yield per plant.

Chandra (1978) reported the presence of considerable amount of heterosis in F₁ generation for yield and its yield components.

Dakhore, S.R.; Narkhede, M.N.; Khorgade, P.W. (1987) Line x Tester analysis involving 10 lines and 5 testers revealed heterosis for all the branches per plant in some crosses. AKL 10 x LCK 38 showed the highest heterosis over the standard for seed yield per plant (52.32%) and 1000-seed weight (12.36%). JLS 1 x C 219 - 1- 1 exhibited the highest
heterosis over the standard for branches per plant (42.30%). Heterosis over the standard ('useful' Heterosis) was considered a better criterion for comparing heterosis effects than heterosis over the mid parental value or over the better parent. Heterosis was highly associated with SCA. The best crosses for breeding were those with good GCA effects. AKL 10 x LCK 38 was considered the best cross for improving seed yield, 1000 seed weight and seeds per capsules while T 397 x C 219 - 1 - 1 was the best for improving seed oil content.

Verma, A.K.; Sinha, P.K. (1993) reported heterosis over the mid parental value and over the better parent was determined for 8 quantitative traits in hybrids from 42 crosses involving 14 diverse lines pollinated by 3 testers and grown with and without irrigation. Significant heterosis for seed yield under irrigation was seen in 20 crosses relative to the better parent, the corresponding figures under the rainfed regime being 27 and 20 crosses, respectively, the best crosses under irrigation were R 7 x BS 2, LMH 350 x BS 2 and SPS 30 - 5 x BS 2 and without irrigation DPL 20 x T 397, BAULK 1 x T 397, BAUKK 1 x LS 2 and MS 4 x LS 2.

Saraswat, A.V.; Satyendra Kumar (1993) studied heterosis and inbreeding depression in some early hybrids of lin seed. Among F₁-F₂ hybrids from a diallel set of crosses
involving 12 accession, the 5 earlier flowering hybrids were selected for a study of yield traits. Although the hybrids generally gave low yield, high-yielding hybrids did occur in the case of genetically divergent parents. It appeared that the association between earliness and low seed yield could be broken by careful selection. A high degree of heterosis for seed yield over the better parent was seen in L 27 x LC 1010 and SPS 2310 x LCK 152.

C) HERITABILITY AND GENETIC ADVANCE :

The concept of heritability is important both for breeders and geneticists for determining an index of transmissibility of a character from the parents to their offsprings. Lush (1940, 1943, 1948) defined heritability in broad and narrow sense and according to him, broad sense heritability is the ratio of total genetic variance to phenotypic variance while in narrow sense it is the ratio of additive variance to phenotypic variance.

Griffing (1950), Warner (1952), Frey and Horner (1957), Crumpacker and Allard (1962) and Mather and Jinks (1971) proposed different methods to estimate the extent of heritability :-

Lush (1940) suggested the following breeding procedure on the basis of heritability estimates :
(i) When heritability in narrow sense is high, reliance showed be placed mainly on mass selection, however, if heritability of the character under experiment low the population should be put to pedigree selection, sub-tests or progeny tests.

(ii) If over-dominance is predominant, the breeding priority should be towards imbreeding with the object of producing hybrids for commercial use.

(iii) If the epistatic variance is relatively high, more reliance should be placed on selection between families and line breeding.

(iv) If the variance due to interaction between heridity and environment is relatively larger, the breeding plan should tend towards producing a separate variety for different ecological regions.

(v) Heritability in narrow sense may be used to estimate expected improvement due to selection.

Robsaco (1959) while studying $F_1$, $F_2$ and $F_3$ populations of a flax cross, found intermediate inheritance for seed size and plant height with tendency towards dominance in case of tallness. He noted heritability to be 10 percent for yield, 15 percent for plant height and 60 percent for seed size.

Robinson (1965) proposed arbitrary categorization of heritability. He observed 5 to 10 percent in high category.
Rosbaco (1966) found early flowering to be dominant over late flowering in a simple mendelian fashion and observed about 32 percent average heritability for this trait.

Badwal et al. (1972) estimated the heritability of eight characters in broad sense. They found high heritability for number of seeds per capsule, 1000-seed weight, plant height, number of days to 50 percent flowering. Estimates for narrow sense heritability were also high for plant height and number of days to 50 percent flowering and moderate for number of seeds per capsule and 1000-seed a weight.

Dayal et al. (1975) observed high estimate of heritability for days to flowering and maturity, 1000-seeds weight and plant height.

Rao (1980) estimated broad sense heritability and found that yield per plant, seed weight and number of capsules per plant had high heritability estimates in majority of crosses. But few crosses showed low to medium estimates of heritability for components of yield.

Patil and Chopde (1981) reported that the heritability of seed yield was low, especially on saline soils.

Genetic advance is the improvement in the genotypic value in the new population over the base population.
According to Comstock and Robinson (1952) the genetic advance usually depends upon the following three factors:

(i) The amount of genetic variability such as the magnitude of the differences among different individuals in the base or initial population,

(ii) The magnitude of the masking effect of the environmental and interaction components of variability on the genetic diversity and

(iii) The intensity of selection.

Singh (1976) reported that the heritability in narrow sense and genetic Advance in percentage of mean were generally low for number of seeds per capsule and yield per plant, where as there were high for tiller number and 1000 seeds weight and medium to high for days to flower, plant height, branch number, capsule number, capsule length, capsule diameter, days to maturity and oil content.

Neelum (1978) observed high broad sense heritability estimate coupled with low genetic advance for 1000-seed weight, days to flower, number of tillers per plant showed high genetic advance in the material derived through partial diallel and line x tester designs in lin seed.

Singh, S.P. (1984) tabulated data are presented on genetic variances for yield per plant and 6 yield related characters in 3 varieties, plant height, tiller per plant, capsule per plant and plant exhibited high genetic advance and moderately high or high heritability.
Narendra Singh, Dikshit, N.N. (1980) eight foreign and 2 local varieties or lines were crossed in all possible combinations, including reciprocals, during the winter of 1979. $F_1$ and $F_2$ data were recorded on seed yield per plant, fibre content per plant and 9 yield related characters. Plant height, capsule per plant and harvest index showed high heritability and low to moderate gentic advance in the $F_1$, indicating that these characters can be improved by selection.

Shrivas et al. (1984) seed yield and 8 related traits were studied in the $F_2$ 1 BC$_1$ and BC$_2$ of 8 crosses. heritability estimates were high for all traits in 2 crosses. Other showed high heritability for several traits. Estimates of genetic advance generally followed those of heritability in all crosses.

Chatterjee, S.D.; Jha, A.R. (1990) selection on the basis of yield and morphological similarity was performed on 3F$_3$ populations derived from BR$_1$ x Delta. Response to selection from $S_0$ to $S_3$ measured as total genetic advance was 38.3, 48.5 and 73.3, respectively, in these three populations. The increase in yield over the base population was 13.4 - 29.6% in the $S_0$, 16.7 - 27.7% in the $S_2$ cycle and non-significant in the $S_3$.

D) CORRELATION AND PATH COEFFICIENT:

Badwal et al. (1970) worked out the genotypic correlation and path coefficient between same characters in
lin seed. They found that primary branches had a high positive association with seed yield. The estimate of path coefficient revealed that capsule number had the maximum direct effect on seed yield. The other characters like 1000 seed weight, plant height and days to 50 percent flowering in addition to direct effect also influenced yield through capsule number per plant. Tiller number and primary branches influenced yield mainly through capsule number. They concluded that capsule number and 1000 seed weight are to main factor for seed yield.

Kumar and Singh (1970) estimated association between nine characters in American flows. Significant positive correlation were obtained between seed yield per plant and branch number, flower size and seed size, 1000 seed weight and capsule number, fibre and plant height and capsule number and branch number. Significant negative correlation were recorded between 1000 seed weight and number of seed per capsule and branch number and plant height.

Chandra (1978) worked out inter-relationship between seed yield and its components in some varieties or lin seed. No observed that exotics and two Indian varieties differed significant in seven characters with both number and 1000 seed weight. Path coefficient analysis showed per hectare direct effect of capsule per plant and 1000 seed weight.

Patil et al. (1980) studied correlation and path analysis in lin seed. They found that yield per plant has
significant positive correlation with capsule per plant and seed per capsule. Path coefficient analysis revealed the importance of number of branches per plant, seed per capsule and 1000 seeds weights which have direct effect on yield. Grain yield showed negative association with 1000-seeds weight and concluded that it would not possible to select plant per for large seed weight without effecting the number of seed per capsule.

Rao et al. (1983) seed yield per plant and 6 related characters were studied in 16 genotypes in 1976-77. Regression analysis indicated that 1000-seed weight and number of capsules per plant were the most important contents of seed yield per plant.

Gupta et al. (1984) analysis of data on seed yield per plant and 7 yield related traits from 8 parents and their 56 $F_1$S and 28 $F_2$S revealed that (1) seed yield per plant was significantly and positively correlated with seed number per capsule, 200 seed weight and plant height and (2) 200 seed weight capsule number per plant and seed number per capsule had the greatest positive direct effects on seed yield per plant.

Li et al. (1985) in a study of 11 agronomic characters fibre content had the highest heritability value, genetic coefficient of variation to lodging resistance and fibre yield were 72% fibre content, stem yield seedling
survival rate and number of days from sowing to flowering correlated with fibre yield.

Satpathi, D.; Mishra, R.C.; Panda, B.S. (1987) data are tabulated on variation in and correlation among seed yield per plant and 7 related characters studied in 40 strains. Number of branches and capsules and seed yield per plant showed high heritability and high genetic advance, indicating additive gene effects. Number of capsules per plant and seed per capsule and seed weight showed high positive correlations with seed yield.

Jayadev, P.N. (1990) reported role of the harvest index in the improvement of lin seed at rainfed conditions. Among 20 genotypes evaluated during Rabi (1987-88) variability for harvest index (H1) was high (24.5-46.1%) but lower for economic yield (EY; 1.07-2.93g) and biological yield (BY; 2.81-9.29g). Estimates of heritability and genic advance were high for H1 and EY. Correlation analysis indicated a positive association between H1 and both EY and BY.

Gonzalez, H.H; Goddenberg, J.B; Caro, R.F. (1993). Studied associations between characters of agronomic importance in linseed. Field studies were carried out at the pergamino experiment station in argentina to determine phenotypic and genotypic correlations involving yield and its components. Plant height, seed weight, oil content and aspects of the vegetative and reproductive stages of growth
the material studied comprised the F₁, F₂, BC₁ and BC₂ from the crosses Alcorta x Clay (C 1880 and H 1284 F₃ 13/74 x Stewart (C 1879). There was a negative genotypic correlation between yield and the duration of the sowing to flowering period (r = -0.7) but there was no genotypic correlation between yield and seed weight. The correlation found between seed weight and oil content and flowering period was positive (r = 0.4). It appeared that oil content could be increased by selecting late material.