Chapter II

REVIEW OF LITERATURE
REVIEW OF LITERATURE

Crop:

*Sesamum indicum* L. is perhaps one of the oldest, annual oilseed crops known to man. It matures usually in 105 days and contains 45% - 60% oil in its small, flat, oblong seeds which are white, brown, blackish-brown or black in colour. The pale yellow sesame seed oil is valued on account of its high quality and stability (Brar and Ahuja, 1979). The origin of sesame is controversial. Due to availability of large number of species in the genus *Sesame*, Africa was considered to be the centre of origin of the crop. But based on the occurrence of wild sesame *S. indicum* ssp. *malabaricum* in India, antiquity of cultivation of the crop and diversity of cultivated forms available, India is now regarded to be the basic centre of origin (Joshi, 1961).

Sesame is grown mostly in the developing countries of the world in a zone extending from 40° North to 40° South latitude. On an area basis, sesame is the 5th most important oilseed crop in the world after soybeans, groundnut, sunflower, rapeseed and mustard. About 35% of the total area under sesame is in India and the other major sesame growing countries, in order of their area under sesame cultivation are China, Sudan, Burma, Nigeria, Mexico, Ethiopia and Venezuela. In India 31% of the total area under sesame is in Uttar Pradesh. The other major sesame growing states are Rajasthan, Andhra Pradesh, Madhya Pradesh, Maharashtra, Tamil Nadu, Gujarat and Orissa (Brar and Ahuja, l.c.).

In the absence of pollinating insects, the characteristic floral biology of sesame ensures selfing (Brar and Ahuja, l.c.). However, the
level of natural cross-pollination varies considerably between 1% and 65% depending on the local conditions as well as on the pollinating insect population. In India, the average level of out-crossing is about 5%, although depending upon environment, it may vary between 14% and 65% (Weiss, 1983). Sesame has, therefore, more genetic variability than most other self-pollinated crop plants. Genetic variability within sesame varieties has been studied by Ramachandran et al. (1972); Murty (1975); Dixit (1976) and others.

Inheritance of discretely segregating plant characters are being extensively carried out by many workers. Brar and Ahuja (1979) in their review included a summary table showing the results of segregation of various plant characters which revealed that monogenic or digenic control along with different inter-allelic and intra-allelic interactions were important for expression of most of the characters. In respect of inheritance of compound vs simple leaves, Nohara (1933) found variable expression of the phenotype. Likewise, variable penetrance for branched vs non-branched and number of capsules per axil (Brar and Ahuja, I.c.) indicate the necessity of further work on such phenotypes. Day-neutral vs short day trait has been reported to be controlled by three pairs of genes (Kotecha et al., 1975); while plant height, glandular leaf and seed oil content were influenced by polygenes. Due to availability of large number of marker traits, it is possible to distinguish the out-crosses at an early stage, even at seedling stage. This would further facilitate genetic analysis for yield and its component characters with suitable marker gene/s as tag/s in inter-specific and inter-varietal hybridization programme.
Yield components:

Informations on the relative association and influence of different yield components with seed yield is of great importance to a plant breeder as seed yield is a complex function and is a product of the action and interaction of the component plant characters. Previous studies revealed that number of capsules per plant, 1000-seed weight and plant height are the three major components of yield in sesame and seem to be the best criteria for selection. The other yield components are the height to first fruit; days to maturity; number of branches per plant and stem girth (Ramachandran et al., 1972); number of capsules on the main shoot (Asthana and Rai; 1970; Dixit, 1975); capsule length and breadth as well as number of nodes and seeds per plant. Relative importance of these different yield components depended on the characteristically adapted plant types for diverse agro-ecological situations (Brar and Ahuja, 1979).

Intensive studies have been carried out by different workers on the correlation of seed yield with different yield components. The major yield attributes considered were:

(a) Plant height (Gupta, 1976; Chavan and Chopde, 1981; Gupta and Labana, 1983; Zhan, 1983; Djigma, 1984; Krishnadoss and Kadambavanasundaram, 1986)

(b) Number of primary branches (Shukla and Verma, 1976; Chavan and Chopde, 1981; Shukla, 1983; Sharma and Chauhan, 1984)

(c) Number of secondary branches (Shukla and Verma, 1976; Sharma and Chauhan, 1983)
(d) Number of branches per plant (Khidir and Osman, 1970; Naphade and Kolte, 1974; Gupta, 1976; Shukla and Verma, 1976; Vinya Rai et al., 1981; Rathnaswamy and Jagathesan, 1982; Krishnadoss and Kadambavanasundaram, 1986)

(e) Length of the fruit-bearing branch (Gupta and Labana, 1983)

(f) Number of days to first flowering (Chaudhary et al., 1977; Ibrahim et al., 1983)

(g) Capsule site at a node (Brar, 1977)

(h) Number of capsules per unit length of the main stem (Rathnaswamy and Jagathesan, 1982; Ibrahim et al., 1983)

(i) Number of capsules on the main stem (Ibrahim et al., 1983)

(j) Number of capsules per plant (Vinya Rai et al., 1981; Gupta and Labana, 1983; Ibrahim et al., 1983; Krishnadoss and Kadambavanasundaram, 1986)

(k) Number of seeds per capsule (Khidir and Osman, 1970; Zhan, 1983)

(l) 1000-seed weight (Khidir and Osman, 1970; Gupta, 1976; Yadava et al., 1980; Thangavelu and Rajasekaran, 1983; Zhan, 1983; Djigma, 1984; Sharma and Chauhan, 1984).

The informations available from these studies indicate that selections for capsule site at a node and number of capsules per plant, which show strong positive correlation with seed yield, would be rewarding in breeding for high yield in sesame.

Varisai (1970) studying 12 traits in 10 sesame cultivars found a significant influence of number of seeds per locule on seed yield.
Kaushal et al. (1974) in a study of 32 sesame cultivars, however, found that none of the yield components studied by him had any relationship to seed yield, excepting number of capsules per plant and plant height, which had direct positive effects. Seed yield was found to be directly and positively affected by number of branches per plant and number of capsules per plant by Naphade and Kolte (1974). Number of capsules per plant was the best direct contributor followed in order of merit by 1000-seed weight and number of seeds per capsule to seed yield (Gupta, 1976; Gupta and Gupta, 1977). Direct positive contribution to seed yield by number of capsules per plant, 1000-seed weight, days to 50% flowering and number of primary branches (Yadava et al., 1980); capsule length and number of capsules per plant (Chavan and Chopde, 1981); as well as number of capsules per plant and 1000-seed weight (Thangavelu and Rajasekaran, 1983) as observed by various workers, do indicate that number of capsules per plant would be the most dependable criterion in selection for high seed yield.

Murugesan et al. (1979) analysing 5 yield related plant characters (including number of capsules per plant) in 30 sesame varieties during two seasons (summer and monsoon) reported that the extent of direct contribution of a trait to seed yield varied with season, while Ibrahim et al. (1983) found no seasonal effect on the direct contribution of number of capsules per plant to seed yield. Number of days to first flowering, plant height, capsule length, number of seeds per capsule and 1000-seed weight, according to Pathak and Dixit (1986), had high direct effects on seed yield. In fact, the results of path analysis of around two decades revealed a general agreement on the importance of number of capsules per plant as the best direct contributor to seed yield, while opinions differ regarding the relative merits of other plant characters.
Phenotypic variability among 22 genotypes of sesame was large for different plant characters (Yadava et al., 1980). Chavan and Chopde (1981) found that genotypic correlation was higher than phenotypic correlation in sesame. Solanki and Paliwal (1981) reported high values of genotypic and phenotypic variances for number of capsules per plant and number of seeds per capsule. Heritability was high for number of branches per plant, seed yield per plant, number of capsules per plant, plant height and 1000-seed weight (Mohanty and Sinha, 1965; Naphade and Kolte, 1972; Chaudhary et al., 1977; Gupta and Gupta 1977). In 28 genotypes of sesame, genotypic coefficient of variability was very low, while both heritability and coheritability values were high for number of primary branches and number of capsules on the main stem (Shukla and Verma, 1976). Heritability was more than 90% for 8 out of 9 yield components in a study of 4 sesame varieties (Zhan, 1983).

Heritability estimates by Gupta (1981) showed that non-additive gene action was more important than additive gene action for all plant characters. Heritability estimates were high for number of days to first flowering and moderate for number of primary branches, number of days to maturity, 1000-seed weight and seed yield. Heritability was high for 1000-seed weight, capsule length, number of seeds per capsule, number of days to maturity and capsules girth; while the same was medium for seed yield per plant and number of capsules per plant. High heritability combined with high genetic advance for number of seeds per capsule, number of days to maturity and number of capsules per plant indicated additive gene action. (Solanki and Paliwal, 1981). Rathnaswamy and Jagathesan (1984) found higher heritability estimates for number of capsules per plant, number of branches per plant and capsule length than that for seed yield. Analysis carried out by Hu (1985) on yield and 8 related plant characters
in 4 F2 populations of sesame, indicated relatively high heritability estimates for number of days to maturity, plant height, capsule length and number of branches per plant. Moreover, the F2 distributions suggested that plant characters were generally under polygenic control, although the influence of a single gene was found to be exhibited for number of branches per plant in 1 cross combination. Based on analysis of data conducted on genotypic and phenotypic variances, genotypic coefficient of variability, heritability and expected genetic advance for yield and 8 related plant characters in 9 sesame varieties grown in three environments, Kandaswamy (1985) suggested that number of branches per plant, number of capsules per branche, number of seeds per capsule and yield, which had high values of heritability and expected genetic advance were mainly controlled by additive gene effects. High values of heritability, genotypic and phenotypic coefficients of variability and genetic advance were obtained for number of capsules per plant, number of branches per plant, capsule length and seed yield, indicating thereby that both additive and non-additive gene effects were significant in their control. Analysis of variance presented by Pathak and Dixit (1986), revealed highly significant differences among 40 sesame varieties for seed yield per plant and 10 related plant characters. Wide variability and high heritability were observed for all the plant characters, excepting capsule length and girth as well as number of seeds per capsule. Genetic advance was greatest for seed yield per plant. Shivapraakash (1986) reported expected genetic advance to be the highest (108.20%) for height to first capsule, followed by seed yield (40.70%) and plant height (38.48%).

Dominant gene effects were considered more important in the
expression of number of branches per plant, number of capsules per plant, whereas both additive and dominant gene effects determined number of days to first flowering, length of the main fruit-bearing branch and yield per plant (Murty, 1975; Dixit, 1976). Chavan et al. (1982) concluded that dominant gene effects were more important than additive gene effects for plant height, number of capsules per plant, number of days to maturity and yield per plant. For number of capsules per plant, number of days to maturity and yield per plant, they found 1 or 2 cross combinations showing complementary gene action and exhibiting fixable gene effects, indicating thereby that selection in segregating generations would be effective for the improvement of these plant characters. However, additive gene action was considered more important in the inheritance of number of days to first flowering, number of days from flowering to maturity, number of days to maturity, number of branches per plant, seed yield per plant, plant height, number of capsules per plant, capsule length and height to first capsule by Chaudhary et al. (1977); Kotecha and Yermanos (1978); Yermanos and Kotecha (1978); Shrivas and Singh (1981); Rathnaswamy and Jagathesan (1984); Chaudhary et al. (1984). Kotecha and Yermanos (1979) further reported that overdominance also plays an important role in the expression of many plant characters.

Combining ability studies for 5 plant characters in a diallel cross involving 10 *Sesamum orientale* varieties, revealed that estimates of sca were higher than the corresponding estimates for gca, indicating thereby the predominance of non-additive gene expression (Shrivas and Singh, 1981). Singh et al. (1983) studied 11 mostly yield-related plant characters in a 12-parent partial diallel cross of
Sesamum indicum. Gca variances were found to be significant for number of primary branches in the $F_1$ and 5 plant characters in the $F_2$. Djigma (1984) found that additive gene effect was predominant for capsule length and 1000-seed weight, whereas interaction effects predominanted for seed yield, main stem length and number of capsules per plant. Godawat and Gupta (1985) analysed data from the sesame parents, $F_1$, $F_2$, $BC_1$ and $BC_2$ of 5 cross combinations for seed yield per plant and 3 related plant characters at four localities and reported that dominance was important for all plant characters. Duplicate epistasis was evident for majority of plant characters in most of cross combinations. Number of locules per capsule and number of capsules per leaf axil were under the control of a single gene (Hu, 1985). Four locules per capsule was dominant over eight locules per capsule, while one capsule per leaf axil was dominant over three capsules per leaf axil. In another investigation, Hu (1985) found that additive gene effects were more important than dominance for capsule length only. Number of seeds per capsule and number of branches per plant were reported to be partially dominant, while overdominance was present for yield, plant height, node length and number of nodes. Significant variation was also noticed in these plant characters, excepting in 1000-seed weight. Reddy et al. (1985) found that parental lines with positive gca effect for number of capsules per plant were good general combiners for both seed and oil yield. According to Murty and Hashim (1974); Dixit (1976); Shivaprakash (1986), epistatic gene action was important for all plant characters studied, while epistasis was found to be absent for number of days to first flowering by Yermanos and Kotecha (1980). Combining ability analysis by Krishnadoss et al. (1987) from a line X tester analysis involving 20 lines and 5 testers, revealed
the predominance of non-additive gene action over additive gene action for yield per plant as well as 6 yield related and developmental traits studied. Biparental mating followed by recurrent selection have been suggested as the protocol for improvement of yield and quality of sesame by Singh et al. (1983); Chaudhary et al. (1984); Krishnadoss et al. (1987).

Heterosis was manifested by number of capsules per plant, number of branches per plant and plant height. The 7 $F_1$s among 6 sesame cultivars gave maximum heterosis for seed yield, number of capsules per plant, area of the leaf and number of flowers per plant. All the $F_1$s exceeded sesame parents with respect to seed yield (Sarathe and Dabral, 1969). Based on investigation in 3 sesame cross combinations, high heterosis was reported for seed yield. Dixit (1976) studied the $6 F_1$s from 6 sesame parents and found the best hybrid to yield 77% more than the superior parent which by itself was rather low yielding. High heterosis over the better parent was reported by Srivastava and Prakash (1977) in 6 $F_1$s derived from 4 sesame parents for seed yield per plant, number of capsules per plant and capsule length, while negative heterosis was revealed for number of days to first flowering and flowering duration. Ujo (1977) detected hybrid vigour for 9 traits among which number of capsules per plant exhibited heterosis, but was not highly correlated with yield. Heterosis per cent over the better parent ranged from 28.0% to 237.8% for seed yield, -28.8% to 122.6% for number of capsules per plant, -25.7% to 10.6% for capsule length and -2.2% to 34.0% for number of days to first flowering (Kotecha and Yermanos, 1978; Yermanos and Kotecha, 1978). Based on examination for 5 plant characters in a diallel cross involving 10 Sesamum orientale varieties, Shrivas and Singh (1981) found pronounced heterosis for number
of branches per plant, plant height, number of capsules per plant and yield. Analysis presented by Chavan et al. (1982) of the $F_1$ and $F_2$ of 6 intervarietal cross combinations derived from 8 sesame varieties, showed the presence of a low value of inbreeding depression for plant height and number of capsules per plant. Significant positive heterosis was observed in several sesame varieties for number of capsules per plant, number of days to maturity and yield per plant. Godawat and Gupta (1985) reported that heterosis in seed yield was attributable to heterosis for plant height and number of capsules per plant from analysis of data for seed yield per plant and 3 related plant characters in sesame parents, $F_1$, $F_2$, $BC_1$ and $BC_2$ of 5 cross combinations. Heterosis was followed by inbreeding depression in all cross combinations, indicating the involvement of non-additive gene action in the control of seed yield, number of capsules per plant and plant height. Sharma and Chauhan (1983); Desai et al. (1984); Shivaprakash (1986) revealed that heterosis for seed yield was mainly attributable to increased number of branches per plant and plant height. Dora and Kamala (1986) showed that heterosis was significant and positive for number of primary branches, number of seeds per capsule, seed length, seed width and seed yield per plant over the midparental value, while heterobeltiosis was significant and positive for number of primary branches and seed length only.

**Seed Yield:**

Under the best agronomic and climatic conditions, some of the sesame cultivars yielded seed around 1000 kg/ha (Brar and Ahuja, 1979). However, almost all the cultivated sesame varieties available in India, gave comparatively poor seed yields mainly due to their poor plant type
and susceptibility to environmental stresses. Seed yields as high as 2000 kg/ha to 2400 kg/ha are not uncommon in other countries. Search for sesame plant ideotype adaptable to the edapho-climatic regions for sesame in India, has not yet been systematically made. Brar and Ahuja (1979) suggested that a single stemmed sesame plant with uniform maturity; early flowering; semi-determinate growth; intermediate plant height long and narrow leaves; multiple tetracarpellate or long bicarpellate capsules per node; resistance to insects, pests and diseases as well as tolerance to water logging and salinity would be ideal for the sesame zone in India.

Multiple crosses have been used to transfer the required plant characters into a desirable sesame plant genotype. The indehiscent capsule character has been transferred to high yielding phenotypes to evolve non-shattering sesame plant type needed for mechanized agriculture in the developed countries (Kinman and Martin, 1954). Multiple crosses or population improvement programme has also been carried out in India, with a view to incorporate multiple resistance to various diseases (Anon., 1978).

Field trials conducted with sesame on loam soil in the high plains of Texas and irrigated three times after establishment gave seed yields of 800 lb/ac to 1000 lb/ac (Brigham and Young, 1988). In a study of 10 sesame cultivars grown in the rainy season, Kalita et al. (1980) found seed yields of 2.22 t/ha to 2.72 t/ha and 2.32 t/ha to 2.87 t/ha in two different years. While Vinayak gave the highest seed yield being closely followed by M3-1 with 2.65 t/ha to 2.76 t/ha. Popov et al. (1980) reported that the new sesame cultivars (Byal Sadovski-5 and
Zhult Sadovski - 6 and the standard sesame cultivar (Sadovo-1) gave average seed yield of 1.29 t/ha, 1.24 t/ha and 1.20 t/ha for three years respectively when grown with irrigation. The new sesame cultivar matured in 101 days and resisted bacterial leaf spot. Seed yield and disease reactions were also studied by Vyas (1981) for 9 sesame cultivars grown in five states of India. Moneim Babu Fatih and Mahmoud Ahmed (1983) have shown that combined variance analysis of yield data on 18 local lines and cross combinations of local sesame varieties with introduced lines grown at three localities in three years, gave higher yields for the local lines than cross combinations, without showing any marked differences in stability. Yield and stability data tabulated by Krishnaswami and Appadurai (1985) for 20 genotypes of sesame grown over three seasons have revealed that the 3 highest yielders (7828/1-15-1-4-1, 7722-1-1 and 7722/10-8-1) were all stable.

Oil content:

High seed oil content and excellent stability in seed oil quality have given fifth rank in order of merit to sesame as an important oilseed crop in the world in spite of its poor yield (Brar and Ahuja, 1979). Due to the high methionine content in seed, it is a valuable supplement to food and feeds deficient in this amino acid. On account of these reasons, the emphasis has, therefore, been to breed for sesame cultivars giving more oil per unit area per unit time. Several workers from various places have reported on oil content of seeds, but large variation in this trait has been detected only by Yermanos et al. (1964, 1972). The earlier literature on the chemistry and biochemistry of sesame seed oil was
comprehensively reviewed by Joshi (1961); Johnson and Raymond (1964); Weiss (1971). Sesame oil is generally colourless, but the presence of different colours in it was found to be due to seed coat colour (Yermanos et al., 1972).

Locations and sesame cultivars were found to greatly influence oil content of sesame seeds (Kinman and Stark, 1954). In a study of 24 sesame cultivars grown in ten locations, the range of seed oil content for sesame cultivars and locations were 47.3% to 53.4% and 50.6% to 56.6% respectively. Obviously, seed oil content of sesame cultivars was markedly influenced by the locations. Vyas (1981) found seed oil content to range between 51.3% and 54.0% for 9 sesame cultivars grown in five states of India. Extended photoperiod raised the oil content of the seeds and in a world sesame collection, the early maturing lines had higher seed oil content (Yermanos et al., 1972). Large variation in oil content was also observed within the lines (Brar and Ahuja, 1979). Oil content was found to be correlated with seed coat colour by some workers, but not by others (Yermanos et al., 1972; Hussein and Noamann, 1976). An increase in row spacing from 30.0 cm to 37.5 cm, increased oil content from 49% to 51% (Ahuja et al., 1971). The geographic locations were also found to influence seed oil per cent (Abidi et al., 1976; Anon., 1978, 1979). Since the seed samples were analysed by different laboratories at each of the cooperating stations under the auspices of the Indian Council of Agricultural Research, some of the differences may only be due to error in method of oil determination. The seed oil content of 77% found in colchicine induced polyploids, probably was the highest reported in sesame (Weiss, 1971).

The inheritance of oil content in F$_2$ of N-124 X K-8 was found to
be complex and most of the genetic variation was due to additive type of gene action. Oil content, however, was found to be influenced by dominant gene action (Murty and Hashim, 1973). Suweon-26, derived from Suweon-5 × (Shirogoma × Suweon-5) has an oil content of 50.7% (Lee et al., 1980).

In view of the informations that have already been accumulated on genetics of yield components and the availability of diverse sesame cultivars, it will not be out of context to further analyse and compare the response of some traditional and new yield components through interpretation of diallel effects. The use of a half diallel design would help to explore the possibility of further improvement of this oilseed crop through intensive inter-varietal cross-breeding, in order to determine the pattern of genetic control through statistical analyses and predictions on the advantageous yield contributing characters along with identification of the strategy for the crop improvement protocol.