CHAPTER ONE

INTRODUCTION
FIG. 1. A view of sesame mutant material grown at Trombay during kharif season.
1. INTRODUCTION

*Sesamum indicum* Linn. (*2n = 26*), commonly known as sesame, til, gingelly, simsim, gergelim etc., belonging to the family Pedaliaceae, is perhaps one of the oldest oil seed crops grown. There are numerous pre-historical, archeological and literary records of this crop from Middle East, Egypt, Iran and India dating from about 4,300 B.C. (Nayar, 1976). The actual origin of sesame is a matter of dispute. Nayar (1976) suggested Ethiopian region and peninsular India as the probable centres of origin.

Sesame is mainly grown in the tropical and sub-tropical regions of the world. Besides India, it is cultivated in China, Pakistan, Burma and in other South-east Asian, African and Latin American countries (Joshi, 1961). In India, it is cultivated in area of about 2.3 million hectares (Statistical Abstract, 1978). The chief sesame producing states are Uttar Pradesh, Rajasthan, Madhya Pradesh, Orissa, Andhra Pradesh, Gujarat, Tamil Nadu, Maharashtra, Karnataka and Bihar. The crop is grown under very diverse conditions from foot of Himalayas to the extreme south of peninsula. It can thrive well in almost all types of soils from light sandy to heavy loam (Rajan, 1957). Sesame is cultivated
mainly as a rainfed (without irrigation) crop, though
in some areas it is also irrigated. Often, it is grown
as a mixed crop with cotton, maize, pigeon pea, pearl
millet, jowar and lesser millets (Joshi, 1961). Seed
yields in India are generally low, ranging between 140
to 490 kg/hectare (mean 210 kg/ha), (Report of National
Commission on Agriculture, 1976). Besides low yield,
the other major drawback is the capsule dehiscence when
plants are dry, resulting in loss of seeds at the time
of harvest. Sesame seeds contain about 50% oil which
is mainly consumed for edible use. The oil yield per
acre from a good sesame crop can be appreciably higher,
compared to other oil seeds (Joshi, 1961). Sesame oil
contains a high percentage of unsaturated fatty acids
but resists oxidation as it contains the glucoside,
seamolin which hydrolyzes to liberate a potent anti-
oxidant, sesamol. Sesame meal obtained after oil extra-
ction contains all major amino acids found in meat in
about the same proportion, including the limiting amino
acids like lysine, tryptophan, methionine and threonine
(Yermanos et al., 1964). The meal obtained after oil
extraction is used as a feed for the poultry and farm
animals and also utilized as organic manure.
1.1. EARLY STUDIES

In India, breeding work on sesame had been going on at several centres for the last fifty years. This has been summarised by Singh (1952), Richharia (1957) and Joshi (1961). Earlier work mainly involved collection and study of the available germplasm. Perhaps, the earliest collection in India was made in 1925 at the then Imperial Agricultural Research Institute, Pusa (Kashi Ram, 1933). Other collections were maintained at Punjab (Ali Mohammad et al., 1933), Madhya Pradesh (Richharia, 1957), Uttar Pradesh, Tamil Nadu, Maharashtra and West Bengal (Joshi, 1961).

Kranti Kumar et al. (1967 a, b) classified and studied variability for the quantitative and qualitative characters in a collection of 188 samples from Rajasthan. Shrivast et al. (1972) prepared a key for identifying 132 distinct types isolated from 216 seed samples of Madhya Pradesh. Trehan et al. (1975) observed significant differences for all the agronomic characters studied in 52 varieties from 15 countries.

Similar studies have been made in the other sesame growing countries. In Russia, Hillebrandt (1932) studied a large collection from several countries and reported variability for a number of qualitative and quantitative
characters. Langham (1945 a,b, 1946, 1947 a,b,c) from Venezuela, reported the inheritance for several characters. Matsuoka and his group from Japan, in a series of publications reported variation in photo-periodic and temperature response, resistance to drought, root development and oil content in genotypes of different geographical origin (1956, 1960 a,b,c,d,e; Ho et al., 1960). Variation in morphological and agronomical characters has been reported from Turkey (Demir, 1962) and Pakistan (Baluch et al., 1966 a). In USA, Massey (1966) studied 900 accessions from 28 countries.

Oil and protein contents have been investigated in the available germplasm collections (Hiltebrandt, 1932; Trehan et al., 1974; Sharma et al., 1975; El Tinay et al., 1976). Yermanos et al. (1972) determined the oil content and fatty acid composition of 721 sesame cultivars from different countries and reported correlations between the seed composition with the other agronomical characters.

1.2. CURRENT STATUS OF BREEDING AND GENETICS IN SESAME

Breeding for yield

Plant types suitable for each region were selected from the germplasm collections. This was
followed by hybridizing better strains. The earliest types suitable for different parts of the country (Joshi, 1961) were N.P.3 and 7 for northern India, from Indian Agricultural Research Institute, New Delhi, T.5 and 22 (Punjab), TMV 1, 2 and 3 (Tamil Nadu), No.8, 85 and 128 (Maharashtra) Type 10 (Uttar Pradesh) and Improved Berhampore No.9 and 14 (West Bengal). Presently, the Agricultural Universities at the state level and All India Co-ordinated Research Project on Oilseeds (AICORPO) at national level, evaluate various new cultures entered in the co-ordinated trials.

A number of other improved cultivars have been evolved in the last two decades. The important ones are T-4, T-12 and T-13 for Bundelkhand region in Uttar Pradesh (Pathak et al., 1961, 1969), P.T. 58-35 and P.T. 57-96 (Patel, C.H. et al., 1967) and M.T. 67-52 (Patel, P.K. et al., 1981) for Gujarat, 'Pratap' for clay soils of Rajasthan (Krant Kumar et al., 1969), 'Punjab-1' for Punjab (Gill et al., 1972) and N32 (N62-32) for Madhya Pradesh (Kaushal et al., 1974).

New promising cultivars and strains have been reported from Russia (Simanskii, 1947; Subin, 1948; Boev et al., 1952; Popov et al., 1967), Venezuela (Langham et al., 1949; Mazzani, 1955; Mazzani et al.,
Breeding for non-shattering varieties

Special efforts have been made to evolve cultivars with non-shattering capsules for mechanical harvests in other countries. Langham, (1946) was the first to report the indehiscent capsule character (id) which was followed by other studies (Mazzani et al., 1952; Mazzani, 1954, 1957, 1960; Martin et al., 1955; Arzumanova, 1957, 1970; Culp, 1963 a,b; Ashri et al., 1964; Tahir, 1964; Massey, 1966; Umen, 1967; Kartemychev, 1972; Delgado et al., 1975).

In spite of the breeding efforts made in the past, significant increase in the annual sesame seed production at the national level has not been achieved. The Report of National Commission on Agriculture (1976) has fixed a target production of 600 kg/ha by 2000 A.D. instead of present 210 kg/ha. This leads to the question why the yields are so low in this crop? There are many reasons for the low productivity. Often, sesame is grown as a
mixed crop, with inadequate cultural practices. Crop is grown in lands of poor soil fertility and is largely dependent upon uncertain natural precipitation. Fertilizers and other agro-chemicals are hardly used for this crop. Pests and diseases take heavy toll, resulting in poor plant stand at the time of harvest. Though non-shattering varieties were developed abroad, often this character is reported to be associated with the other undesirable features (Langham, 1946; Kobayashi, 1965; Russell et al., 1967). Continued efforts to utilize the existing natural indehiscent mutant (id) in breeding failed in Venezuela and elsewhere and there is no other allele available in natural and wild germplasms (Ashri, 1980). For Indian conditions where the crop is harvested by hand, semi-shattering types are preferred.

1.3. CYTOGENETICS

1.3.1. Induced polyploidy

Induction of autopolyploids for crop improvement was tried in a number of sesame cultivars. Richharia et al. (1940), were first to develop auto-tetraploid sesame plants using colchicine. This was followed by other reports (Langham, 1942; Kobayashi et al., 1952; Mazzani et al., 1953; Mazzani, 1954; Shrivastava, 1956;
Balachandran et al., 1967; Khidir et al., 1974). The induced auto-tetraploids though exhibiting gigas characters, in general, were poor in fertility compared to the diploids (Joshi, 1961). Hence, they were of interest only from the cytological point of view. Occurrence of haploid plants in sesame was reported by Parthasarathy et al. (1949). Subramanian (1977) detected a trisomic (2n = 27) in a cross between autotetraploid and a diploid.

1.3.2. Interspecific hybridization

Thirty six species were reported under the genus Sesamum in the Index Kewensis and its supplements (Joshi, 1961) of which thirty four are valid species (Nayar et al., 1970). Based on the available data on chromosome number of Sesamum species investigated, three broad groups, 2n = (i) 26, (ii) 32 and (iii) 64, were made (Joshi, 1961; Nayar, 1976). Interspecific crosses have been attempted in about 24 combinations involving S.indicum, S.schenckii, S.grandiflorum, S.alatum, S.capense (all 2n = 26), S.prostratum, S.laciniatum, S.alatum, S.capense (all 2n = 32), S.radiatum and S.angolense (all 2n = 64) (Nayar, 1976) for generating variability, by a number of workers (Ramanujam, 1942, 1944; Abraham, 1945; Raghavan et al., 1947; Ram Nathan,
1950 a,b; Mazzani, 1952, 1964; Nakamura et al., 1958 a,b; Nakamura, 1959; Aiyadurai et al., 1962, 1963; Amirthadevarathinam, 1965; Muhammad et al., 1968; Sastry et al., 1976; Subramanian et al., 1977). Notable among these reports is the true breeding amphidiploid S. indicatum which was synthesised by treating the sterile F₁ hybrids of S. indicum x S. prostratum with colchicine (Ramanujam, 1942, 1944).

1.3.3. Intergeneric hybridization

The first attempt for intergeneric hybridization was made by Richharia (1937). It was reported that pollen of Martynia diandra Glox. germinated on the stigma of Sesamum indicum L. and the pollen tube entered the style. Joshi (1961) quoted that Kedarnath (1954) attempted crosses between Sesamum and Ceratotheca. In the literature further information on the above reports was not found.

1.4. MUTATION RESEARCH IN SESAME

1.4.1. Spontaneous mutants

As mentioned earlier, Langham in a series of publications (1945 a, b, 1946, 1947 a, b, c) established the inheritance pattern of naturally occurring mutants in
Sesame. Earlier inheritance studies, on different morphological variants were summarized by Joshi (1961). Subsequently, Pathak et al. (1965) reported a mutant where the corolla tube and stamens shed before fertilization. It showed 28% pollen sterility. Normal capsules were obtained after hand pollinations. Another mutant in which the staminal filaments are petaloid, forming a second corolla tube, within the normal corolla, was reported by Sawant et al. (1970). Dabral (1968) and Dabral et al. (1974) noticed female sterile mutant caused by the browning of stylar base. The studies on capsule mutations include 'Giza-24' which has 24 locules, early maturity and higher oil content (Abou-Sayed et al., 1965), tricarpellate (Yadav et al., 1968) and multicapsule (Nair et al., 1975) mutants. Though all the above mutants were true breeding, their genetics has not been reported.

1.4.2. Induced mutation research in sesame

Literature survey, largely confined to the Plant Breeding Abstracts (1958-1981) revealed that induced mutation studies in sesame have been carried out in India, Israel, Japan, Pakistan and Russia. In these studies, mostly physical mutagens and to a lesser extent chemical mutagens have been used. Among the latter,
ethidium bromide, ethyl methanesulphonate (EMS) and N-nitroso N-methyl urethran (NMU) were utilized. In combination treatments involving two physical mutagens, seeds obtained from plants treated with $^{32}$P, were exposed to X-rays in the following generation (Kobayashi, 1958 c). Treatments using gamma rays with (a) EMS and (b) NMU and EMS in combination with NMU were reported (Zia-Ul-Hasan, 1980).

Dose effects in the $M_1$ generation

With low doses of ionising radiations (X-rays, 8 to 12 krad; gamma rays 7.2 krad), no significant effects on seed germination were observed (Kobayashi, 1958 c). The LD$_{50}$ for cultivar N.P.6 was found to be above 100 krad of X-rays (Rajan et al., 1966). In another study, six doses of gamma rays ranging between 5 to 30 krad had no effect on germination, seedling emergence and plant height on cultivar 'Kayamkulam-1' (Nair et al., 1977), however higher doses in the same range caused decrease in pollen fertility and survival.

Rajan (1969 and 1970) studied the RBE (Relative Biological Effectiveness) of fast neutrons and gamma rays in two sesame cultivars and concluded that the relative resistance of seed could not be related to
the differences in total oil content or to the degree of unsaturated carbon atoms. Zia-Ul-Hasan (1980) observed two of the sesame cultivars were radio-resistant but sensitive to chemical mutagens.

Cytological aberrations induced in the pollen mother cells following the mutagenic treatments were rings, chains, clumping of chromosomes, disorganisation of spindle, multipolar spindles, inversion bridges, micronuclei, laggards, acentric fragments etc. (Kobayashi, 1958 a, b; Rai et al., 1958 a; Zia-Ul-Hasan, 1980). The frequency of chromosomal aberrations showed a linear increase with the dose (Kobayashi, 1958 b).

Chlorophyll mutants

The various induced chlorophyll mutants reported are albina, chlorina, maculata, stariata, virescent, viridis, xantha-alba, xantha-viridis etc. (Nair et al., 1977; Ashri, 1980; Zia-Ul-Hasan, 1980).

Induced viable mutants

So far, about 19 mutations affecting different plant characters have been reported. They include the following:
<table>
<thead>
<tr>
<th>Growth habit</th>
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<tbody>
<tr>
<td>Dwarfs</td>
<td>Kobayashi, 1965;</td>
</tr>
<tr>
<td></td>
<td>Nair et al., 1978;</td>
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<tr>
<td></td>
<td>Chavan et al., 1979;</td>
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<tr>
<td>Determinate</td>
<td>Ashri, 1980;</td>
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<tr>
<td>Tall</td>
<td>Nayyar et al., 1969;</td>
</tr>
<tr>
<td></td>
<td>Chavan et al., 1979;</td>
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<table>
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<tr>
<th>Leaf</th>
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<tbody>
<tr>
<td></td>
<td>Anonymous, 1958-'59;</td>
</tr>
<tr>
<td></td>
<td>Ashri, 1980;</td>
</tr>
<tr>
<td>Shape of leaf</td>
<td>Kobayashi, 1958 c;</td>
</tr>
<tr>
<td></td>
<td>Zia-Ul-Hasan, 1980;</td>
</tr>
<tr>
<td>Chlorophyll mutant</td>
<td>Nayyar, 1969;</td>
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</tbody>
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<table>
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<tr>
<th>Flower</th>
<th></th>
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<tr>
<td>Early</td>
<td>Rai et al., 1956, 1958 b;</td>
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<td></td>
<td>Ashri, 1980;</td>
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<td></td>
<td>Zia-Ul-Hasan, 1980;</td>
</tr>
<tr>
<td>White colour</td>
<td>Rai et al., 1956, 1958 b;</td>
</tr>
<tr>
<td>Pink colour</td>
<td>Anonymous, 1958-'59;</td>
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<tr>
<td>Male sterile</td>
<td>Zia-Ul-Hasan, 1980;</td>
</tr>
</tbody>
</table>
**Capsule**

*Multicapsules/axil*

- Anonymous, 1958-’59
- Rajan, 1966
- Baluch et al., 1968
- Neyar, 1970-’71
- Chavan et al., 1979
- Ashri, 1980
- Zia-Ul-Hasan, 1980

*Multilocular capsule*

- Anonymous, 1958-’59
- Chavan et al., 1979
- Zia-Ul-Hasan, 1980

*Long capsule*

- Chavan et al., 1979

*Bold and small capsule mutants*

- Chavan et al., 1979
- Zia-Ul-Hasan, 1980

*Indehiscent*

- Kobayashi, 1975, 1977
- Ashri, 1977, 1980
- Zia-Ul-Hasan, 1980

**Seed coat colour**

*Brown colour*

- Anonymous, 1958-’59
Seed yield

Chaudhary et al., 1954;
Rai et al., 1956, 1958 a;
Kobayashi, 1958 c, 1965 1
1975, 1977;
Arzumanova et al., 1972;

Oil content

Rai et al., 1956, 1958 b;
Nayar (Nair), 1961;

The role of induced mutations for the improvement of sesame has recently been reviewed (Yadav et al., 1979; Ashri, 1980). In this context, it is pertinent to mention that Langham (1960) suggested that the existing genetic variability is adequate for breeding cultivars to meet the specific needs of agriculture and industry. On the other hand, Rajan (1974) expressed the view that the oil-seed breeders had been trying, in vain, to improve the oil content of many oilseeds for the past 30 years by traditional methods. A mutation programme with an objective to increase the genetic variation in this trait would probably be more rewarding.
1.5. OBJECTIVES OF THE PRESENT STUDY

The overall objective of the present study was to explore the possibilities of further improving sesame cultivar N62-32 using mutation approach. The two major objectives were to isolate and evaluate mutants for (1) higher seed yield and (2) increased oil percentage.

A large number of variants affecting morphological and physiological characters were selected in the $M_2$ (second generation) derived from the treatments of gamma rays and EMS (ethyl methanesulphonate). Breeding behaviour of the variants was studied in the $M_3$ and subsequent generations. Further selections were made from 25 true breeding mutants and the following aspects were investigated up to the $M_8$ generation.

1. Seed yield and yield components in the mutant selections for identifying high yielding types. Eleven promising selections were further evaluated for yield in six replicated yield trials spread over a period of four crop seasons.

2. Environmental variability for oil content in N62-32 between seasons, among plants and within a plant to arrive at a reliable method
of screening mutants for higher oil percentage.

3. In the $M_4$ generation, initially 48 selections were screened for oil content and the oil percentage was followed in 10 desirable selections for another three crop seasons (upto the $M_7$ generation).

4. Dry matter and oil accumulation in developing seeds of H62-32 and two mutants with higher oil percentage.

5. Heterotic effect for seed yield and other yield components in the $F_1$ hybrids of mutant x mutant crosses.

6. Inheritance pattern of four mutants.