COMBINING ABILITY STUDIES IN SESAMUM (*Sesamum indicum* L.)

By

Sumersing D. Rajput
(Reg. No. 0122)

A Thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARASHTRA, INDIA**

In partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

CYTOGENETICS AND PLANT BREEDING

DEPARTMENT OF AGRICULTURAL BOTANY

**POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
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APPROVED BY

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MAHARASHTRA, INDIA

2003

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or other person to any other University or Institute for a Degree or Diploma

Place : MPKV, Rahuri

(S.D. Rajput)

Dated :24 /6 /2003.

Prof. R.P. Aher
Professor, (Bajra Breeding)
Bajra Research Scheme,
College of Agriculture, Dhule
Maharashtra, (INDIA)

CERTIFICATE

This is to certify that the thesis entitled, "**COMBINING ABILITY STUDIES IN SESAMUM (*Sesamum indicum* L.)**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State, India, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** (AGRICULTURE) in **CYTOGENETICS AND PLANT BREEDING** embodies the results of piece of *bona fide* research work carried out by **Mr. SUMERSING D. RAJPUT,** under my guidance and supervision and that no part of the thesis has been submitted to any other university for degree or diploma or publication in other form.

The assistance and help received during the course of this investigation and sources of reference have been duly acknowledged.

Place : A.C., Dhule

Dated : 24 / 6 /2003.

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Associate Dean,
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Rahuri - 413 722, Dist. Ahmednagar,
Maharashtra, (INDIA)

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(D.M. Sawant)

Place : M.P.K.V., Rahuri
Dated : 24/06/2003.

ACKNOWLEDGEMENT

Indeed the words at my command are not adequate to convey the depth of my feelings and heartfelt, deep sense of gratitude to my Research Guide Prof. R.P. Aher, Professor (Bajara Breeding), Bajra Research Scheme, College of Agriculture, Dhule for his most valuable, inspiring and versatile guidance, concrete suggestions, constant encouragement, enormous help and constructive criticism through out the course of investigation and for critically going through the manuscript of the thesis.

It is a great pleasure for me to express in words in explicable my feelings of reverence and gratitude to the members of advisory committee Dr. S.S. Mehetre, Cotton Breeder and Incharge Biotechnology Centre, M.P.K.V., Rahuri, Prof. A.H. Sonone, Assistant Professor, Department of Botany, Dr. D.P. Kaledhonkar, Assistant Professor, Department of Statistics for their benevolent and inspiring guidance, helpful suggestions and critical discussion of manuscript.

My sincere thanks are due to Dr. Y.M. Shinde, Head, Department of Botany, M.P.K.V., Rahuri Dr. B.N. Narkhede, Ex-Head, Department of Botany and Dr. D.M. Sawant, Associate Dean, Post Graduate Institute, M.P.K.V., Rahuri for providing necessary facilities to carryout the research work.

I pleased to place my profude gratitude to Dr. R.B. Patil, Principal Scientist, Oil Seeds Research Station, Jalgaon for giving me an opportunity to proceed on higher studies.

I feel honoured to extent my grateful thanks to respected Dr. B.L. Lad, Dr. J.V. Patil, Prof. A.D. Dumbare, Dr. K.M. Pol, Dr. S.C. Patil and all other staff members of Botany Department, M.P.K.V., Rahuri for all the helps rendered by them during the course of these studies.

I wish to express my sincere and heartfelt thanks to Prof. S.V. Kale, Prof. S.S. Patil, Prof. P.K. Dharne, Dr. L.L. Mane, Dr. C.D. Deokar, Shri. G.C. Shinde (S.R.A.) Cotton Improvement Project, M.P.K.V., Rahuri, Shri. Dahat, D.V. (S.R.A.), Director of Farms and friends Ravi Andhale, Dr. M.P. Deshmukh, Dr. S.S. Patil, J.M. Patil, Dr. C.D. Badgujar, Chatur Thakare, Tushar Patil, Ramesh, Himmatsing, *Vikas, Vijay, Datta, Kailas Bapu, Girish, Sakechand, Pravin, Sunil, Prashant, Niranjan, Nilesh, Chetan, Santosh, Amol, Shrikrishna for their valuable suggestion and timely help through out the course of investigation.*

I also extend my thanks to Shri. S.M. Suryawanshi, B.M. Anandkar, E.P. Bhawar, N.B. Desai, U.V. Deshmukh, E.S. Wabale and B.T. Pathare for their timely help during the course of this experimentation.

No words are enough to express a heartiest gratitude to my mother Dhanaie, brothers Rajendra Bhau, Satish Bhau and their wives Sau. Nirmala Bhabi and Radha Bhabi, sisters Malatabai, Chayabai, Chitrabai, Rekhabai, Ashabai who have constantly inspired and provided valuable opportunities and affection in building up my carrier.

I will be failing my duties if I would not offer my sincere thanks to my wife Sau. Vandana, daughters Minal (Chiku) and Dnyanaksha for bearing all sorts of disturbances caused during the course of this studies.

I also express my special thanks to Shri. Vishwanath Kadam, 'SUYOG COMPUTERS' Farm Quarter, M.P.K.V., Rahuri for his neat and accurate typing of the manuscript.

Finally, I am thankful to Mahatma Phule Krishi Vidyapeeth, Rahuri for providing me this opportunity undergo higher studies leading to master degree.

Place : M.P.K.V., Rahuri

(Sumersing D. Rajput)

Date :24/ 6 /2003.

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parents Tapi and JLT-54 were found to be early in flowering as well as in maturity. Parents JLT-54 was observed superior for plant height and 1000 seed weight, while parents VRI-1 appeared to be better for plant height and number of branches per plant. The parents Tapi and RT-46 were found to be superior in number of capsules per plant, yield per plant. The parents TKG-21 and RT-46 were superior in length of capsule and number of seeds per capsule. The parents TKG-21 and OS sel.2 were superior in oil percentage.

A considerable amount of heterosis was observed for all the characters. However, percentage of heterosis were high for yield per plant, number of capsules per plant, number of branches per plant, 1000 seed weight, plant height, number of seeds per capsule and oil percentage. The positive heterosis for grain yield per plant was observed in twenty one hybrids and nineteen reciprocal crosses. The direct cross RT-46 x VRI-1 and the reciprocal cross VRI-1 x Sekhar ranked top in respect of heterobeltiosis for yield per plant.

As regards the general combining ability effects among the parental lines parents RT-46 was found to have the best g.c.a. effects for earliness, while the parents OS sel.2 and VRI-1 were found to have the best g.c.a. effects for plant height, number of capsules per plant. The parents JLT-54, OS sel.2 and Gopi were found to have the best g.c.a. effects for length of capsule and 1000 seed weight. While the parents VRI-1, RT-46, OS sel.2 and Tapi were found to have the

Abstract contd...... **S.D. Rajput**

In general, it was observed that the genotypic correlation coefficients were higher than phenotypic correlation coefficients for most of the characters under study. The grain yield per plant showed highly significant positive correlation with number of branches per plant, number of capsule per plant and significantly correlated with plant height, days to maturity at both the levels. The characters length of capsule, number of seeds per capsule, 1000 seed weight and oil content showed non-significant positive correlation with grain yield per plant at both the levels. The number of capsules per plant showed the highest correlation (0.7923) with grain yield.

On the basis of *per se* performance and heterobeltiosis and sca effects the cross RT-46 x VRI-1 appeared to be promising for further confirmation and exploitation.

The traits viz., number of capsules per plant, number of branches per plant, plant height, days to maturity and days to 50 per cent flowering were significantly and positively correlated with yield per plant.

Thus, the present investigations made it possible to select a few superior genotypes as well as specific combinations which could be considered promising and worthy for further breeding on the basis of their performance.

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INTRODUCTION

1. INTRODUCTION

Sesamum (*Sesamum indicum* L.) is one of the most important oil seed crop, not only in India but also in the world. Locally known as till gingelly, sim sim or gergelim is essentially a crop of tropical and subtropical regions. This crop is probably the most ancient oil seed known and used by man. Sesamum has been called the 'queen' of the oil seed crops by virtue of the quality of the oil it produces. The seeds are rich source of oil, protein, calcium, phosphorus and oxalic acid. Sesamum oil is considered to have excellent quality. As much as 20 per cent of the sesamum produced is used for direct domestic consumption. The oil of sesamum is widely used for different purposes such as cooking media, varnishes, lubricants and medicine.

Sesamum stands next to groundnut, in importance among *kharif* oil seed crops and third in total area and production of all the oil seed crops grown in India. India ranks first in the world with 1.74 M ha (37 % of the world) area and 0.60 M tonnes (27 % of the world) production with 7.77 per cent of the total area under all (nine) annual oil seeds (Anonymous 2002a). It contributed around 3.10 per cent to the total oil seeds production in country. The average per hectare yield of sesamum in India is very low (345 kg/ha) as compared with other countries in the world. The main reasons for low productivity of sesamum are its cultivation in marginal and sub-marginal lands, under poor management and input starved rainfed conditions.

However improved varieties and agroproduction technique capable of boosting the productivity levels of sesamum now developed for different agroecological situation in the country. A well managed crop of sesamum can yield 900-1000 kg/ha under irrigated and 500-600 kg/ha under rainfed condition. In Maharashtra state the area under this crop is 1.17 lakh hectares with production 0.374 M tonnes and productivity is 317 kg/ha in 2001-2002 (Anonymous, 2002b).

The origin of sesamum is variously reported from Southern Africa to Central Asia, but the diversity of wild species growing in Africa would tend to favour its origin in that location. Sesamum has been cultivated for centuries in India, Pakistan, Burma, Indochina, Japan and Africa. In more recent times sesamum has been introduced in Mexico, Central America, South America and the U.S.A.

According to Vavilov (1951) India is the basic centre of origin of sesame. It is the self pollinated crop belonging to genus sesamum of the family pedaliaceae. More than 36 species have been described in the genus sesamum. The chromosome number of *Sesamum indicum* L. is 2n-26. It is mainly *kharif* crop but it is also grown in pre-*rabi*, *rabi* and summer season.

Sesamum is also important as *rabi* oil seed crop. It is grown under assured rainfall areas as well as under dry farming areas of Maharashtra, Karnataka, Gujrath, Madhya Pradesh, Tamil Nadu, Andhra Pradesh and Rajasthan.

In Maharashtra Jalgaon, Wardha, Yavtamal, Dhule, Pune and Nagpur are the important districts, where area under this crop is concentrated. Sesamum is considered to be the drought tolerant crop.

The crop is cultivated both as sole, mixed or inter crop with millets, groundnut, pulses, cotton etc in *kharif.* The industrial uses of sesamum oil are minor as compared to the amount used for culinary purposes. It may be used in soap making and for various purposes for which the non-drying oils are generally adopted.

An acute shortage of edible oil is being felt in India since last three decades. This has led to very high prices, unavailability of the oil and its adulteration. To increase the consumption of oil and supply it at reasonable rates, it is necessary to increase the production of oil which can be achieved by increasing the area under oil seeds as sesamum crop and evolving the varieties which will have high yield as well as high percentage of oil under variable environmental conditions. Inadequate, untimely and abnormal distribution of rains has badly affected the oil seed production in India and particularly in Maharashtra. The area under *kharif* groundnut is progressively decreasing. Sesamum can with stand the adverse condition better than groundnut. The area under sesamum is increasing very fast in Jalgaon and adjoining districts. One or two protective irrigations result in very high yield and as such it is becoming a very popular oil seed crop in Maharashtra.

Heterosis has been explored and utilized extensively in boosting the yield in a number of cross fertilized crops and a few self or often cross pollinated crops. The study of genetic parameters is the first prerequisite for better under standing of the genetic make up of genotype programme for the quantitatively inherited traits. The diallel cross technique which involves the crossing of group of lines in all possible combinations and is an efficient method for the study of combining ability, when the material consists of few selected lines. Combining ability is useful tool with the plant breeder for formulating an efficient breeding programme to evolve superior strains of crops.

Recent studies confirm that heterosis is observed in a specific combination in this crop, it could be exploited on a commercial scale. Though the crop is self pollinated, emasculation and pollination is very easy. It will be possible to produce hybrid seeds by hand pollination, which will be quite economical as seed rate is less and the expenses on seed production will be less.

Genetic work carried out on this crop is very meagre. It is therefore very necessary to study the heterosis, combining ability, gene action and correlation among the characters and to find better combinations. The present investigations was therefore undertaken with the following objectives.

1. Assessment of hybrid vigour in 'F_1' combinations for the characters of economic importance.
2. Estimation of general and specific combining ability effects.
3. To investigate the nature of relative magnitude of gene action for various characters.
4. To study the correlation between selected characters under study.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.2.1 The concept of heterosis

Development of hybrids has provided the most important genetic tool for substantial improvement in yield of crop plants. The manifestation of superiority of certain first generation hybrids in size, yield and vegetative vigour was recognised by Koelreuter as early as 1763. During this early period, the phenomenon was also recognised by Knight, Burbank, Darwin and Mendel but it was only the work on hybrid corn that brought a recognition to the concept of heterosis.

Shull (1914) suggested the term 'heterosis' for hybrid vigour, for the heterotic effect or heterozygosity. Recent work indicated that heterosis is not intrinsic property which a hybrid will show with respect to its parents in all environments. Stebbins (1957) has defined heterosis as greater adaptedness to human needs which has been obtained in a particular environment, through artificial selection followed by hybridization.

2.1.2 Heterosis

Sesamum (*Sesamum indicum* L.) is generally considered to be a self pollinated crop. However varying degrees of natural cross fertilization have been reported in this species by Joshi (1961) and Khidir (1972). Pal (1945) reported considerable amount of heterosis in some oil seed crops.

Riccelli and Mazzani (1964) studied 510 F_1 hybrids from diallel cross of 32 sesame cultivars which had widely different geographical origin. They recorded heterosis for height and vigour of growth in different crosses during various developmental phases of the crop. They observed maximum heterosis in the combinations in the genotypes from Israel. The data also showed that the heterosis in the hybrids was manifested in the both early and late maturity groups seedlings survival was also higher in the hybrids.

Sarathe and Dabral (1969) reported high heterotic effects for number of flowers, capsules per plant and seed yield.

Salazar and Onoro (1975) studied three traits *viz.*, plant height, number of capsules per plant and seed weight per plant in sesame. They noticed that per cent heterosis for seed weight per plant and number of capsules was higher than plant height.

Murty (1975) examined the extent of heterosis for six agronomic and two chemical characters in full diallel cross. He reported highest heterosis for seed yield (33 %) followed by number of capsules per plant (16 %). Low heterosis was observed for earliness, plant height and number of primary branches, while it was significant for number of secondary branches and percentage of oil. High heterosis was observed in Indian X Exotic crosses than Indian x Indian and Exotic x Exotic crosses.

Dixit (1976a) studied both F_1 and F_2 generations which were developed from six pure line strains of sesame. He reported that all the hybrids showed considerably higher degree of heterosis for all the characters i.e. days to flowering, number of branches, number of capsules per plant, length of capsules, plant height and yield per plant.

Sarafi (1976) studied six F_1 hybrid from crosses made between four Indian and Foreign varieties and observed that one hybrid exhibited heterosis for late maturity and four were heterotic for plant height. Four hybrids exhibited heterosis for seed yield per plant.

Uzo (1977) effected 75 crosses from 21 selected homozygous lines of diverse origin. He detected hybrid vigour for nine traits which were significantly correlated with yield. However, heterosis exhibited for number of capsules per plant was not highly correlated with yield due to seed less capsules or capsules carrying immature seeds at harvest.

Srivastava and Prakash (1977) reported highest heterobeltiosis in 4827 x SI 897 for seed yield per plant, number of capsules per plant and capsule length. The F_1 from 78167 x Nagpur-128 had the highest heterosis for number of branches per plant and 1000 seed weight.

Yermanos and Kotecha (1978) noticed heterosis based on mean of higher plant in 8 x 8 diallel cross. They observed the range from -2.20 to 34.00 per cent for days to flowering and from -1.7 to 28.1 per cent for days to maturity. Reciprocal hybrids were observed to differ for the respective characters indicating maternal effects.

Nafie (1980) studied diallel in six strains and observed heterosis for number of capsules per plant, capsule length, number of seeds per capsule and yield per plant.

Shrivas and Singh (1981) studied diallel cross involving ten varieties of sesamum for heterosis and reported that the magnitude of negative heterosis was higher than positive heterosis for plant height, number of branches and number of capsules per plant which were found to be the main contributing attributes for seed yield.

Tyagi and Singh (1981) effected crosses of 15 lines of sesame having Indian and exotic origin, involving four testers and evaluated their heterotic effects. Hybrid vigour was seen for number of branches, plant height, number of capsules and yield per plant. Heterosis for days to flower and days to maturity was frequent, but hybrids tended to be late. Less heterosis was marked for characters such as oil content, 1000 seed weight, length of capsule and number of seeds per capsule. Hybrids from the cross combination of medium maturing 'TC-25', Til. No. 1, TC-66 and ES-61 were early maturing. Maternal effect was observed for most of traits.

Chavan *et al.* (1982) evaluated F_1 and F_2 generations of six inter varietal crosses derived from eight varieties for plant height, capsules per plant, number of days to maturity and yield per plant. They reported significant positive heterosis for number of capsules per plant, number of days to maturity and yield per plant.

Paramasivan *et al.* (1982) reported that ten cross combinations out of 13 crosses showed heterosis for plant height, which ranged from 5.85 to 16.42 per cent, 12 hybrids showed heterosis for number of capsules per plant with maximum increase of 1.00 per cent by T.M.V.-2 x iC-14113 and maximum of 41.23 per cent by Si-2145 x I.C. 14120 over superior parent for number of capsules per plant. Four cross combinations showed heterosis for 1000 seed weight with the range of 0.18 per cent to 50.66 per cent, while all cross combinations studied showed heterosis for the seed yield per plant, where the range of heterobeltiosis was from 0.20 to 19.91 per cent.

Sharma and Chauhan (1983) studied the performance of F_1 hybrids involving 10 varieties of sesamum to investigate heterosis for seed yield and eight other component characters. The mid parent and better parent heterosis for seed yield ranged from -16.76 to 105.70 per cent and 34.99 to 60.27 per cent, respectively. The hybrid JT-66-173 x SH-50 and T-12 x SN-62 exhibited the maximum heterosis for seed yield, the value for which were 205.76 and 60.27 per cent, respectively. The heterosis for seed yield appeared to be due to high manifestation of heterosis for number of capsules per plants.

Djigma (1983) studied a diallel cross involving five good varieties and reported low magnitude of heterosis over the better parent for seed yield, plant height, number of capsules per plant and 1000 seed weight.

Chaudhari *et al.* (1984a) effected a diallel crosses involving 8 promising strains of sesame and reported that the positive heterosis was higher than negative heterosis for all the characters except seeds per capsules, days to maturity and percentage of oil. The highest positive heterotic effect was for grain yield (184.60 %) followed by branches per plant and capsules per plant.

Desai *et al.* (1984) studied six yield related characters in crosses of 15 varieties. They reported that the cross B-45 x MT-67-52 gave the highest yield and was the most heterotic for yield and oil content. Heterosis was mainly attributable to increase in number of branches, plant height and 1000 seed weight.

Dora and Kamala (1986) studied full diallel of four self pollinated varieties of sesame and reported more pronounced heterosis for branches per plant, capsule per plant, seeds per capsules and seed yield per plant over the mid parents. It was significant and positive for primary branches, seeds per capsule and seed yield per plant over mid parent values.

Shivaprakash (1986) studied ten quantitative characters in five crosses and observed high heterosis for height in JE x Local as well as capsule length and number of branches in RE x local cross combination.

Singh *et al.* (1986) studied 13 traits in 30 crosses of white seeded sesamum oriental and observed that the number of branches per plant, capsules per plant, harvest index, yield per plant and protein and oil content exhibited significantly high values for heterosis. Till x Pb-1 showed the highest heterosis for yield (327.74 %) over the better parent. It also showed the highest yield superiority (108.36 %) over the standard varieties T-12. The capsules per plant contributed most to heterosis for yield.

Pawar (1987) studied a diallel cross involving 8 parents in sesamum. A considerable amount of heterosis was observed for all the characters studied. However, percentage of heterosis was high for number of capsules per plant, number of branches pre plant, yield per plant and 1000 seed weight. The positive heterosis for grain yield per plant was observed in 15 hybrids and 19 reciprocal crosses.

Tu *et al.* (1988) studied heterosis in seventy seven F_1 hybrids for yield character. The F_1 hybrids gave an average seed yield/plant of 14.78 g as against 11.33 g for their better parent and 13.13 g for the standard check. Heterosis varied greatly among the crosses ranging from -24.8 to 141.1 per cent over the better parent and from -37.1 to 67.6 per cent over the standard check.

Reddy and Haripriya (1990) studied 9 lines and their 36 F_1's. The cross R-84-4-2 x VS-16 showed 71 and 50 per cent heterosis over mid parent and better parent for seed yield, respectively.

Sasikumar and Sardana (1990) studied 8 yield related characters in 8 varieties and their F_1 hybrids. The crosses B-67 x PBMT 82-2-6, B-67 x AT-6, PBMT-82-2-6 x VS-16, PBMT-82-2-6 x Ahutil, Ahutil x VS-16 and OMT-3 x BS-5-18-6 showed heterosis over the better parent for yield and capsules per plant. PBMT-82-2-6 x Ahutil also exhibited significant negative heterosis over the better parent for days to maturity.

Sodani and Bhatnagar (1990) studied 6 yield related characters in 10 genotypes and their 45 F_1 and 45 F_2 hybrids. Heterosis for grain yield was highly correlated with heterosis for component characters. Heterosis for seed yield/plant was greatest in JLT-7 x RSS-52 (43 %) followed by BMI-2 x JLT-7, ES-22 x Til-1, BMI-2 x E-52 and Til-1 x RJS-32.

Zhan *et al.* (1990) studied 43 F_1's and 16 F_2's from crosses of 32 lines. The 43 F_1's had higher mean yields 55.6, 32.6 and 87.8 per cent respectively over mid parent, better parent and check cultivar. Heterosis in yield components of the F_1's was in order yield/plant > capsule/plant > 1000 seed weight > seed/capsule. There were 7 F_1's with a yield 140 per cent higher than the check cultivar Jizhi-1. The 16 F_2's had significantly reduced levels of heterosis compared to the F_1's.

Anitha and Dorairaj (1991) studied 56 diallel crosses (including reciprocals) and observed that heterosis over better parent was high for leaf area index (93 %), harvest index (69 %) and percentage of fruiting nodes on secondary branches (65 %). A high frequency of heterotic crosses was observed for harvest index, capsule volume, fruiting nodes, seeds per capsule and days to flowering but for yield related components only few hybrids gave desirable heterosis. Several heterotic hybrids for seed yield were also heterotic for harvest index, capsule on primary branches, fruiting nodes, capsule volume days to maturity and oil content. Crosses with high heterosis generally involved parents with high x high and high x low gca effects.

Ding *et al.* (1991) studied 10 yield components in 54 cross combinations and reported heterosis was greatest for yield/plants.

Tu *et al.* (1991) studied full diallel crosses of 6 varieties. F_1 hybrids MS-2 x Danbackggae, Danbackggae x Yuzhi-1 and Dambackggae x MS-2 displaced the highest heterosis, their yields surpassed that of the local variety Yuzhi-1 by 155.02, 135.87 and 117.93 per cent, respectively.

Yadav and Mishra (1991) studied heterosis in Line x tester analysis using five male and eight female parents, heterobeltiosis was observed in both directions for five characters, whereas for number of branches per plant it was in positive direction only. The cross combinations C-7 x B-67 and VS-27 x B-14 showed highest significant positive heterosis/heterobeltiosis for branches per plant, capsule per plant and seed yield per plant.

Brindha and Sivasubramanian (1992) evaluated 6 genotypes and their F_1 hybrids, and reported high heterosis for yield and yield components in crosses B-56-1-1 x TSS-11 TS-11 x Si-1730 and Madhavi x Si-1730 for yield and yield components.

Delgado and Laryisse (1992) evaluated a complete diallel between 6 indehiscent and 2 dehiscent varieties and found the highest levels of heterosis in crosses between indehiscent varieties but those between indehiscent and dehiscent varieties were the highest yielding. The heterosis observed in some indehiscent hybrids.

Ray and Sen (1992) evaluated a full set of diallel crosses of six self pollinated varieties and observed heterosis over better and mid parents was pronounced for plant height, number of days to flowering, 1000 seed weight and seed yield. Heterosis was also significant and positive for number of capsules per plant and number of capsules per main stem in some crosses. Wide range of variation in heterosis estimates of some reciprocal hybrids revealed that choice of pollen and seed parent is important for exploring hybrid vigour.

Reddy et al. (1992) reported the hybrid R-84-4-2 x VS-16 gave the largest seed yield (21.5 g/plant) and showed significant heterosis, from a diallel cross involving 9 diverse homozygous lines of sesamum.

Xiao *et al.* (1992) studied on the theorem of heterosis breeding in sesame and concluded that the development of strong hybrid vigour through selective mating of parents and selection of cross combination may be of use in sesame breeding programmes.

Padmavathi *et al.* (1993) estimated heterosis for seed yield and 14 yield components of 75 F_1's hybrids derived from cross between 15 female and 5 males in line x tester pattern. It was observed that the magnitude of negative heterosis was higher than the positive heterosis for most of the characters and a limited number of crosses exhibited significant positive heterosis. The highest significant positive heterosis was noticed for number of secondary branches which was followed by capsules on branches, first capsule bearing node, seed yield, number of primaries, capsules on main stem, seed number per capsule, height of first capsule and1000 seed weight. The hybrid vigour for yield was found to be mainly due to increase in heterosis for number of primary branches, capsule on main stem, capsule on branches and seed number per capsule.

Reddy and Haripriya (1993) studied heterosis for yield and other component characters in 36 hybrids. The mid parent and better parent heterosis for seed yield ranged from -91.9 to 76.9 per cent and -47.1 to 72 per cent, respectively. Out of 36, 19 hybrids showed significant positive heterosis over the corresponding better parent for seed yield, significant heterosis for all the other components (except plant height and oil per cent). The highest magnitudes being from seed yield on secondaries, seed yield on primaries and seed yield on main stem was also observed, indicating their contribution towards seed yield heterosis.

Shinde *et al.* (1993) studied heterosis in line x tester analysis using 4 females x 6 males. Highest magnitude of standard heterosis (useful heterosis) was recorded in the cross JLT-28 x TC-328 for seed yield per plant.

Mishra *et al.* (1994) studied heterosis for eight characters in a line x tester analysis using three male and five female parents. Heterobeltiosis was observed in both direction for six characters whereas for maturity only a negative values were found. The cross combination TC-25 x VS-81 showed significant positive heterosis/heterobeltiosis for plant height, branches per plant, capsule per plant, capsule length and seed yield per plant.

Ananda Kumar (1995) recorded the range of heterosis percentage for plant height from -14.3 to 34.1 for number of capsule 7.1 to 190.9 per cent and for seed yield from 1.6 to 169.9 per cent.

Fatteh *et al.* (1995) studied the extent of heterosis in a diallel cross of sesamum for yield and yield components. Heterosis in yield was influenced by branches per plant and capsules per plant. The best hybrid combination for grain yield was TMV-3 x H.T.-1 which showed heterosis over better parent to the extent of 68.94 per cent.

Navodiya *et al.* (1995) studied heterosis in 10 x 10 diallel cross excluding reciprocals. The magnitude of heterosis was high for yield per plant, plant height, number of capsule per plant whereas days to flowering, days to maturity, 1000 seed weight and oil content had low heterosis. Hybrid RT-126 x OMT-3 manifested highest heterobeltiosis (101.59) for yield per plant.

Baviskar *et al.* (1998) in their studies of diallel mating system and observed that all characters distinctly differed for the upper limits in both positive and negative directions. The upper limit of desirable heterotic effect was higher for number of capsules per plant, grain yield per plant, number of branches and nodes per plant.

Govindrasu *et al.* (1999) observed that the cross TMV-3 x RJS-1991 exhibited the highest heterosis for seed yield over mid, better and standard control values. The same cross exhibited similar heterotic expression for branch number and capsule number. TMV-4 x RJS-199 exhibited high standard heterosis for seed yield and capsule number while TMV-4 x Si-3315/11 exhibited significant standard heterosis for seed yield over mid and better parental values.

Kamla (1999) heterosis in 6 x 6 full diallel experiment noticed that days to maturity was highly heritable with additive effects, whereas plant height, branches, capsule per plant, seeds per capsule, 1000 seed weight and seed yield per plant were moderate to low heritable with non-additive effect in the form of dominance. The predominance of both additive and non-additive gene influence showed the high genetic potential of the 6 parents for exploiting desirable economic heterosis.

Dixit and Swain (2000) evaluated fifty-five F_1 hybrids from a half diallel set with 11 parents. Heterosis in seed yield was very much associated with heterosis in capsule per plant and branches per plant. The range of relative heterosis and heterobeltiosis for seed yield were -36.8 to 83.5 per cent and -42.5 to 66.0 per cent, respectively. It appeared that heterosis is not a function of genetic divergence.

Ragiba and Reddy (2000a) studied heterosis in 45 single crosses excluding reciprocals (F_1) and 45 single crosses (F_2) of sesame for12 characters. The genotypes X-198, RT-54, R-84-4-2 and VS-16 exhibited high heterosis for most of the characters. The hybrids VS-16 x JLT-6 (high potential for grain yield), X-198 x R-84-4-2 (high potential for number of capsules on primary branches and number of capsule for plant), RT-54 x X-198 (very high negative heterosis for days to 50 per cent flowering and days to maturity) V-10 x Madhavi (highest performance for number of capsules on secondaries and number of capsules per plant) showed higher heterosis over mid parent and B.P. for most of the characters.

Solanki and Gupta (2000) studied heterosis in line x tester model using 20 lines and five testers and evaluated the extent of heterosis for seed yield and yield contributing components in 100 crosses. Heterosis over better and better check was observed for seed yield (118 %, 101.5 %) followed by capsule per plant (71.4, 50.6), branches per plant (62.5, 63.5 %), nodes on main stem (45.5, 45.0 %), 1000 seed weight (44.9, 23.9 %), plant height (36.7, 29.9 %) an days to maturity (-4.9, -5.06 %), respectively.

Dusane *et al.* (2001) studied heterosis in 39 F_1's crosses, most of the hybrids exhibited heterosis for all the traits studied. The crosses Tapi x Yuzhi-7, Tapi x TRS-12 and Tapi x Til. No-1 revealed heterotic vigour for the characters under study in a desirable direction.

Kar *et al.* (2001) studied 42 hybrids of sesame and recorded maximum of 9.73, 3.90 and 55.00 per cent negative heterosis for days to 50 per cent flowering, days to maturity and height up to first fruiting node, respectively.

2.2.1 Concept of combining ability

The concept of combining ability for the evaluation of parents in a crossing programme is of immense significance. It has originated through intensive hybridization work in maize. It is especially useful in connection with testing procedures in which it is desired to study and compare the performance of lines in hybrid combinations. The terms general and specific combining ability were originally defined by Sprague and Tatum (1942) in relation to diallel crossing system as follows the term 'general combining ability' is used to designate the average performance of a line in hybrid combination. The term 'specific combining ability' is used to designate those cases in which certain combinations to relatively better or worse than would be expected on the basis of the average performance of the lines involved. General combining ability (g.c.a.) is relatively more important than the specific combining ability (s.c.a.) in previously unselected material. On the other hand s.c.a. assumes greater importance for the material which is previously selected for general combining ability.

According to Griffing (1956a) s.c.a. involves both dominance and epistasis whereas g.c.a. is composed of additive effects as well as additive x additive types of epistasis.

Griffing (1956b) examined critically the concept of combining ability and concluded that when a set of inbred lines is used in a diallel crossing system a genetic interpretation in terms of quantitative inheritance is made possible by the fact that the analysis is really a 'gamete' combining ability analysis. Thus the genetic properties of a diploid individual may be regarded as a combination of the genetic properties of the two gametes which unite to form the individual.

Different methods, using different mating system have been developed to estimate general and specific combining ability. Of these the top cross method was proposed by Jenkins and Brunson (1932) where an open pollinated variety is used as the top cross parent. Diallel cross method is described in detail by Griffing (1956a) for a estimation of g.c.a. and s.c.a. effects and variances in diallel cross with or without parents and with or without reciprocal F_1's.

2.2.2 Combining ability studies in sesame

Murty (1975) examined the general and specific combining ability for six agronomic and two chemical characters in complete diallel cross experiment involving a set of self pollinated varieties of sesame. General combining ability variances were predominant for days to flowering, plant height and number of primary branches, while specific combining ability variances were in moderate to high proportions for seed yield and percentage of oil.

T.M.V. 2 and SI-770 were found to be the best general combiners for secondary branches while SI-1783 and Sel-12 were found to be the best for earliness and oil content, respectively. Significant variance due to reciprocal effects were also detected for some of the characters.

Dixit (1978) studied five lines and their ten hybrids and showed that Kanpur local had the best general combining ability for seed weight and Jhansi local x Kanpur local was the best specific combination for seed weight.

Yermanos and Kotecha (1978) studied four traits in 8 x 8 diallel cross of sesame and observed that an appreciable amount of variance due to g.c.a. and small amount of variance due to s.c.a. was found for all the yield contributing characters. Similarly, effects of reciprocal were found for all the characters.

Nafie (1980) in his study of diallel cross involving six indehiscent strains of sesame showed that g.c.a. effects were higher than s.c.a. effects for yield, number of capsule per plant and seed weight. The reverse was true for plant height.

Gupta (1981) studied combining ability for four characters *viz.,* plant height, number of branches, capsules per plant and grain yield in F_1 of the diallel cross involving six diverse lines of sesame. He reported that g.c.a. had higher magnitude than s.c.a. Ph. Til No-1 possed high general combining ability variance for grain yield, capsules per plant and number of branches, while negligible specific combining ability variances was associated with Bahadurpur-II. High specific combining ability variance was observed in TS-15-17 for grain yield, capsules per plant and plant height.

Shrivas and Singh (1981) studied five characters in a diallel cross involving ten cultivars of *Sesamum oriental* L. and their 45 hybrids. They reported the estimate for s.c.a. were higher than the g.c.a. Combining ability for high yield was influenced by number of branches and capsules per plant. N-66-175 and TC-66 were found to be the best general combiners, while T.C.-66 x M-3-1 and N-66-173 x S.I.-1551 showed high s.c.a. effects for yield.

Fatteh *et al.* (1982) studied a diallel set of six strains of sesame (*Sesamum indicum* L.) for their combing ability. Importance of g.c.a. and s.c.a. and reciprocal effects were observed for yield and yield components. They observed that parents Mrug-1 and MT-67-62 were the best general combiners and the same were also involved in the best specific combinations. This indicated the usefulness of general combining ability for prediction of yield of hybrids. Specific combinations for earliness and yield *viz.* Mrug-1 x MT-67-52 and Mrug-1 x 1-17-2 were identified and hybrids which were found good in specific combinations were also founds in reciprocal combinations.

Singh *et al.* (1983) studied combining ability in a 12 parent partial diallel cross for yield and yield related characters of sesamum indicum. They observed significant g.c.a. variances for six characters in F_1 and F_2. Specific combining ability variances were significant for number of primary branches in F_1 and five characters in the F_2. Till-1 and BL were observed to be good general combiners for seed yield and oil content. They suggested biparantal crossing followed by recurrent selection to improve yield and quality.

Djigma (1983) in a diallel cross of five good varieties of sesame found that g.c.a. was more important for 1000 seed weight. He reported that Yendov-55 and Jalgaon-128 had good general combining ability estimates for 1000 seed weight.

Rathnaswamy and Jagathesan (1984) reported that g.c.a. variances was greater than s.c.a. variances for seed yield and four yield related characters in sesame. They also reported that the g.c.a. x environment variance was greater than s.c.a. x environment variance. The parental performance appeared to be a good indicator of g.c.a. effects.

Sharma and Chauhan (1985) studied the nature of combining ability in a set of 10 x 10 diallel in sesame. They reported significant variances for g.c.a., s.c.a. and reciprocal effects. The higher magnitude of g.c.a. was recorded in S.H.-50, T-12, B. local and S.H.-62, similarly they were the best general combiners when 4 to 6 characters were considered at a time. The combinations T-2 x N-32, patan-64 x S.H.-62 and Patan-64 x T-13 showed high s.c.a. effects for yield. The superior combinations involved all the three possible combinations between parents of high and low g.c.a. effects i.e. high x high, high x low and low x low. In general the superior combinations involved at least one high general combining parent. Significant variance for reciprocal effects indicated the presence of maternal effects.

Dora and Kamala (1986) studied a full diallel set of four varieties (Gowari, Madhavi, B-7 and IS-103) for 16 characters g.c.a. variances were lower than s.c.a. variances. Highly significant g.c.a. in the absence of significant s.c.a. reflected the probable predominance of additive gene action of Gowari x Madhavi. Reciprocal differences were significant only for seeds/capsules, days to maturity, seed yield/plot and oil content. Gowari and Madhavi were the best general combiners with significant g.c.a. effects for most of the characters. The best specific combinations are indicated with 867 x TS-103 being good for both seed yield and oil content.

Chandraprakash (1987) studied general combing ability in 28 crosses among 8 parents, the g.c.a. variances was greater than specific combing ability (s.c.a.) variances for all 14 characters studied. s.c.a. variances was highly significant for all characters except capsule length. Additive and non-additive effects were important for all character except height of first capsules, number of capsules on the main branch and seed yield. Recessive genes were involved in the control of number of seeds per capsule, oil percentage and test weight. Heritability was high for harvest index and number of capsules on primary branches.

Krishnadoss *et al.* (1987) analysed combining ability data from a line x tester analysis involving 20 lines and 5 testers revealed a predominance of non-additive over additive gene action for yield/plant and the 6 yield, related and developmental traits studied. Si-24412 was a good general combiner for height and number of capsule/plant and 68/20 was for height and yield/plant. Biparental mating followed by recurrent selection is recommended for the improvement of yield.

Kumar *et al.* (1987) studied a line x tester analysis of 24 lines and 3 cultivars (testers). SCA variances was greater than g.c.a. variances, which indicated the predominance of non-additive gene action.

In the studies conducted by Chandramani and Nayar (1988) on F_1's and F_2's of 15 crosses indicated that gca and sca variances were significant for 8 quantitative characters except oil contents.

Goyal and Kumar (1988) studied the combining ability data on 7 yield components in 8 diverse varieties and their 'F_1' hybrids and observed that Vinayak was the best general combiner and Pratap x Vinayak the best specific combination for seed yield.

Khorgade *et al.* (1988) studied combining ability in line x tester analysis, using 8 lines (female) and 3 testers (male). For 8 yield related characters, estimates of GCA and SCA variances indicated the importance of both additive and non-additive gene effects for days to maturity, capsule length, branches per plant, capsules per plant and 1000 seed weight. IC-252 was the best general combiner for plant height, branches per plant and seed yield/plant while IC-252 x N-128 was the best cross on the basis of high mean performance, average GCA of parents and comparatively low SCA effects for branches per plant, 1000 seed weight and seed yield per plant.

Khorgade *et al.* (1989) studied 10 yield components in 8 genotypes and their F_1 crosses, S.P. 125/183 was the best general combiner for plant height, capsule length, branches per plant and seeds per capsule. N-128 was the best general combiner for seed yield per plant and seed oil content. TMV-1 x N-128 was promising for seed yield per plant, capsule per plant and branches per plant and JLT-7 x TC-25 had a high seed oil content.

Ramalingam *et al.* (1990) studied combining ability for the characters seed yield per plant, number of branches per plant and number of capsules per plant in the parents and F_1 crosses between three line and five testers. Result indicated the predominant role of non-additive gene action for all the yield attributes. SI-03-1 was identified as a good general combiner among the pollen parents. The cross combination TMV-3 x SI-8-4 and CO-1 x SVPR-43 showed significant positive SCA effects for seed yield per plant and number of capsules per plant and positive effect for number of branches per plant.

Reddy *et al.* (1990) studied combining ability for four yield components in 9 lines and their F_1 hybrids. The hybrids 89/R-84-4-2, 89/R-84-360-3 and RT-54 x R-84-4-2 had significant SCA effects.

Ding *et al.* (1991) studied combining ability for 10 yield components in 54 cross combinations, specific combining ability were greatest for yield per plant.

Goyal *et al.* (1991) studied 8 yield related traits in 28 F_1's hybrid which were produced in a half diallel set of 8 parents. Variance due to GCA and SCA effects was significant showing the importance of both additive and non-additive (dominance) gene effects, non-additive effects were predominant as evidenced by higher components of SCA variances. Parents Vinayak and SP-1162 were good general combiner for most characters. Type-12 showed good g.c.a. for seeds per capsules, oil content and number of branches, while Pratap was noted for number of capsules per plant, plant height, oil content, days to maturity and number of branches per plant. A number of specific combinations performed well for most of the traits.

Narkhede *et al.* (1991) studied 10 quantitative characters in 8 diverse cultivars and their 28 F_1's, analysis of GCA and SCA effects revealed the presence of additive and non-additive types of gene action. Performances of parents were generally more stable than those of the hybrids over environments and RSE-1 was the best combiner for oil, protein contents and other characters.

Shinde *et al.* (1991) analysed combining ability data from a line x tester analysis involving 8 lines and 5 testers, crosses evaluated for plant height, number of capsules per plant and yield per plant. Genotypic variation was significant for all characters. TC-328 and RT-25 were good combiner for both plant height and seed yield per plant.

Brindha and Sivasubramanian (1992) evaluated 6 genotypes and their F_1 hybrids for combining ability and reported that Gowri and Si-1730 exhibited reciprocal effects when used as female parents for seed yield/plant, days to first flowering, plant height and number of branches/plant, B-56-1-1 and TS-11 had good GCA.

Delgado and Layrisse (1992) studied combing ability in complete diallel between 6 indehiscent and two dehiscent varieties, high S.C.A. observed in some indehiscent hybrids whose yields were as high as those of some commercial varieties, indicates that hybridization between such lines would be useful in reducing seed loss during harvest without affecting yield.

Kadu *et al.* (1992) studied 9 yield related characters in parents and F_1 hybrids of a diallel cross involving 7 diverse genotypes. The best general combiner were N-128 for number of branches/plant and capsule length, Phule Til. No-1 for five hundred seed weight. RAUSS-17-4 for days to maturity and plant height, TC-25 for oil content and JLT-7 for seed yield/plant. The best specific combinations were TC-25 x NI-128, JLT-7 x NI-128 and Phule Til. No-1 x JLT-7.

Reddy *et al.* (1992) studied data on oil content and seed yield in the parents, F_1 and F_2 generations from a diallel cross involving 9 diverse homozygous lines of sesame. Inheritance of oil content was predominant under the control of additive gene action, where as mainly non-additive effects were identified for seed yield. RT-54 and R-84-4-2 possed favourable genes for both traits and the cross RT-54 x R-84-4-2 yielded 49.9 per cent oil and 15.6 g seed/plant is recommended for use in future breeding programme.

Ganeshan *et al.* (1993) studied combining ability in six parents along with their 30 hybrids including reciprocals, data revealed that the parents BS-6-1-1, TSS-11 and Si-1770 registered high perse and g.c.a. effects. The hybrid BS-6-1-1 x TS-11, TSS-11 x BS-6-1-1 and TSS-11 x Si-1770 were fixed as superior hybrids for commercial exploitation of hybrid vigour in sesamum.

Shinde *et al.* (1993) studied combining ability in line x tester analysis using 4 females and 6 males for yield and its attributes. The estimated components of general and specific combining ability variance showed major contribution on additive gene action for plant height, number of capsules/plant and days to maturity and dominance for rest of characters. The female JLSC-1 was the best general combiner for earliness. JLT-26 was good general combiner for plant height, number of capsules/plant, days to maturity and with positive comparatively higher GCA.

Mishra *et al.* (1994) studied combining ability in a line x tester analysis using three male and five female parents for eight characters in sesamum. The combination TC-25 x VS-81 was found to the best on the basis of sca effect and per se performance. Among the female TC-25 and among male VS-81 were the best general combiners for seed yield.

Padmavathi *et al.* (1994) studied combining ability in a line x tester analysis using 15 lines and five testers for 15 characters in sesamum. The hybrids HD-48 x TMV-4, HD-38 x TMV-3, HD-38 x TC-25 and N-62-34/2 x TMV-6 were found to be superior in terms of heterosis and specific combining ability effects for important yield contributing characters. The variances due to lines and line x tester interaction were significant for all the characters excepts the variance due to testers for the number of primary branches and 1000 seed weight.

Fatteh *et al.* (1995) studied in a diallel crosses of sesamum for yield and yield components the parents PT-64 and HT-1 were good general combiner for yield per plant and some of its components. The *per se* performance of parents for various characters was in general not related to their GCA effects. The crosses TMV-3 x HT-1, PT-64 x C-1015 and HT-1 x TMV-3 were found to be best combinations for most of the yield components.

Mcharo *et al.* (1995) studied combining ability in 9 x 9 diallel cross (excluding reciprocals). The parents and 36 F_1's progenies derived from the diallel cross were evaluated. Among the parental cultivars SPS SIK-50/1 was the best general combiner for yield per plant, 1000 seed weight and capsule length. The parental cultivars SIK-131 and SPS SIK-004/1 were found to transmit earliness to their progenies.

Thiyangarajan and Ramanathan (1995) studied combining ability in L x T analysis using 20 lines and three testers, non-additive genetic variances appeared to be important in the expression of this trait. Parents G-51-266, Si-1169 and Si-1703 were good general combiners while Si-953 x Co-1, G-51-266 x Co-1, Si-1703 x Co-1, OTS-2 x TMV-3, Si-1669 x Paiyur-1, Si-1755 x Co-1, ES-139-935 x TMV-3 and Si-1249 x TMV-3 were the best specific combinations. The use of these varieties and hybrids in future breeding programme is recommended.

Thiyangarajan and Ramanathan (1996) studied combining ability for oil content of the seed in the 23 parents and 60 F_1 hybrids from a 20 environments produced by combining three seasons with two soil types. Pooled analysis indicated the occurrence of significant genotype x environment interaction and the importance of non-additive gene effects for oil contents.

Mishra and Yadav (1997) studied combining ability in 8 x 8 diallel cross, two parents *viz.,* JLT-3 and AT-9 were good general combiner for the majority of the characters. The combination JLT-3 x Anand-74, CSF-782 x N-32, HT-6 x AT-9 and AT-9 x 8-14 which combine high sca effects and high mean performance were the best specific combinations.

Sinhamahapatra and Tripathi (1997) studied combining ability in 9 x 9 diallel set (excluding reciprocals). The combining ability analysis as well as predictability ratio revealed the involvement of both additive and non-additive gene effects. The parents B-14 and HT-1 had significantly negative GCA effects indicating the possibility of using them as donors of leaf hopper resistance. The crosses B-9 x S-14 and Anand 74 x Sekhar were good specific cross combinations which involved at least one high general combiner.

Baviskar *et al.* (1998) studied combining ability in diallel mating system, selected eight parents were crossed in all possible combinations (without reciprocals). The estimates of g.c.a. and s.c.a. effects showed that parents JLSC-84, Tapi and TKG-67 were the best general combiner for grain yield and nodes/plant. In addition of this JLSC-84 had high g.c.a. for earliness and number of capsules per plant. In general good general combiners for grain yield also had good or average combining ability for one or more of the yield components.

Das *et al.* (1999) studied combining ability in 8 x 8 half diallel cross of sesamum over two years. GCA and SCA manifested significant interaction with year for all characters. The relative magnitude of non-additive x year interaction was greater than additive x year interaction. The variety B-9 was best general combiner for seed yield and its major components. B-14 x B-9 emerged best specific combiner for seed yield and its components, for augmenting seed yield and oil content similarly the cross combination MT-67-52 x TC-25 was found promising.

Thakare *et al.* (1999) studied combining ability in line x tester fashion using 5 lines and 10 testers, the resulted 50 F_1's hybrids along with their 15 parents were estimated for g.c.a. and s.c.a. for eight yield contributing characters. The TC-25 followed by JLT-7 among lines and NT-9-91 and padma among testers showed good g.c.a. effects for yield and most of the yield attributes. Among the hybrids the best performance for seed yield, oil content and s.c.a. effects were noticed by crosses TC-25 x NT-8-91 followed by TC-25 x Padma and TC-25 x NT-9-91 exhibiting importance of both additive and non-additive gene effects for genetic improvement.

Chakraborti and Basu (2000) studied crosses and their progenies evaluated from nine salt tolerant sesame lines under saline and normal conditions. GCA and SCA mean squares were highly significant in most of the cases indicating a preponderance of additive and non-additive gene effects. Parents HT-1 in E_1 and R-9 in E_2 were the best general combiners. R-9, HT-1 and T-12 were good general IET-2 x HT-1 good specific combiners for oil and fatty acid contents.

Jayalakshmi *et al.* (2000) studied combining ability in 10 parental genotypes and their half diallel set revealed the direction and magnitude of g.c.a. and s.c.a. effects indicated RT-54, VS-16 and RB-4-4-2 at the best general combiners and the crosses RT-54 x X-198, VS-16 x AT-3, JLT-5 x Madhavi and JLT-5 x JLT-6 as the best F_3 combinations for some of the character studied.

Ramesh *et al.* (2000) studied fifty one hybrids developed using 17 lines and 3 testers were evaluated along with parents for 15 quantitative traits. The GCA status of parents and s.c.a. and heterotic status of hybrids were determined based on all 15 traits. The study of the relationship between overall GCA, SCA and heterosis established the superiority of crossing lines and high and low overall GCA status introducing greater frequency of heterotic hybrids with high magnitude of heterosis. This further implied the requirement of parental divergence in terms of their GCA status to produce higher frequency of heterotic hybrids.

Rajaravindram *et al.* (2000) studied combining ability in 9 x 9 full diallel mating design, the results revealed that CO-1 was the best general combiner for capsule per plant, 1000 seed weight and seeds per capsule. Based on *per se* performance and SCA effects TMV-6 x DPI-1526 was identified to be superior and promising hybrids for plant height, capsule per plant and seed yield per plant and CO-1 x DPI-1526 for plant height, primary branches per plant and capsule per plant.

Ragiba and Reddy (2000b) studied combining ability analysis in a set of ten parents, 45 F_1's (excluding reciprocals) and their 45 F_2's in a diallel cross programme for yield and yield contributing traits revealed significant estimates of mean squares due to GCA and SCA for all the characters excepts for number of branches (primaries and secondaries) and 1000 seed weight in F_1 and F_2 while for days to 50 per cent flowering in F_2 only. The GCA-SCA variance ration suggested that variance due to SCA was greater than variance due to GCA for most of the characters in F_1 and F_2 except for days to 50 per cent flowering in F_2 and number of secondary branches in F_1. Equal importance of additive and non-additive gene action with slight predominance of additive effect was observed for days to maturity.

Sakila *et al.* (2000b) studied combining ability in line x tester analysis for six quantitative characters in sesame. The GCA and SCA variance ratio revealed non-additive type of gene effect for all character. The best combiner was VRI-1 for days to flowering, plant height and capsules per plant Si-3315/11 for capsule per plant and single plant yield. The cross TMV-6 x Annamalia-1 showed significant SCA effects for capsules on main stem, total capsules per plant and single plant yield.

Saravanan *et al.* (2000) studied combining ability in 6 x 6 diallel cross. The genotypes SI-1125 was identified as superior combiner for all traits of interest. There was good agreement between *per se* performance of parents and their GCA effects. Among thirty crosses the direct and reciprocal combination of the cross combinations involved at least one high general combining parents.

Devasena *et al.* (2001) carried out combining ability analysis in an 8 x 8 diallel fashion for 12 quantitative traits. The results revealed the importance of additive and non-additive gene action for all the traits. However, g.c.a. variances was greater than s.c.a. variance for nine characters excepts for 1000 seed weight and harvest index and revealed the pre-dominance of additive gene action in this experiment. The pattern of GCA effects showed that non of the parents was the best general combiner for all the 12 characters.

Kar *et al.* (2001) studied combining ability in 42 hybrids resulted from 14 lines and 3 testers for seed yield and earliness characters. The correlation coefficients between general combining ability effects and parental means were non-significant. The correlation coefficients of specific combining ability effects with F_1 mean were highly significant.

Krishna Devi *et al.* (2002) studied combining ability in six parental diallel including reciprocals revealed that reciprocal differences in the estimates of combining ability variances were recorded for number of capsule per plant and 1000 seed weight. The genotypes TNDU-120 and TMV-3 were identified as good general combiners for most of the reproductive traits studied. The hybrid Paiyur-1 x TMV-3 showed a high *per se* performance coupled with high specific combining ability effects for the majority of the traits.

Krishnaiah *et al.* (2002) studied combining ability in a 8 x 8 diallel mating design excluding reciprocals in sesame revealed that the parents YLM-7 and Madhavi were good general combiners for majority of the characters. Rajeswari for capsule length and seeds per capsule, Krishna for 100 seed weight and NSI-4 for plant height and harvest index. The specific crosses YLM-11 x T-Brown, Rajeswari x YLM-17, NBI-4 x T- Brown, YLM-11 x Vinayak, Madhavi x T-Brown and Rajeswari x NSI-4 were identified as best specific combiners for yield and its components.

Pushpa *et al.* (2002) studied combining ability in 6 x 6 diallel analysis in sesame revealed that the parents VNP-Local and VRI-1 were relatively good general combiners with high *per se* performance. Among F_1 hybrids PTDL-1 x VNP local and VNP Local x VRI-1 were the best crosses on the basis of *per se* performance and s.c.a. effects.

Senthil Kumar and Ganesan (2002) studied combining ability in line x tester analysis with five lines and three testers in sesame, revealed that based on g.c.a. effect T-6 was the best general combiner for all the nine traits. Based on sca effects TMV-3 x Madhavi was identified as the superior hybrid.

2.3.1 Gene action in sesame

Yield in crop plants is a complex characters. It depends upon a number of yield attributes, which are mainly controlled by polygenes. It is therefore, generally believed that it may not be so readily amenable to genetic analysis.

Thomas (1956) recorded dominance gene action for both short and long capsules but no dominance was found for plant height in sesamum.

Murty (1975) observed that additive as well as non-additive gene action governed the expression of the various characters like seed yield, number of capsules per plant, days to flowering, number of primary branches and percentage of oil.

Dixit (1976b) indicated that dominance gene effect was more important for the expression of number of branches, number of capsules on main branch and number of capsule per plant, while both additive and dominance gene action were important for days to flowering and yield per plant. Epistatic gene action was also important for all the traits studied.

Chaudhari *et al.* (1977) observed that additive type of gene action was operative for days to 50 per cent flowering, number of branches per plant, yield per plant and plant height. They suggested that for evolving tall variety, selection will have to be made in respect of earliness, number of capsules and number of branches per plant.

Uzo (1977) noticed additive type of gene action for yield and other eight yield related traits in 21 selected homozygous lines.

Dixit (1978) also reported that additive gene action was responsible for seed weight.

Gupta (1981) reported that non-additive type of gene action was more important for characters *viz.,* plant height, number of branches, capsules per plant and grain yield in F_1 diallel crosses of sesamum.

Solanki and Paliwal (1981) reported that high heritability combined with high genetic advance for seeds per capsules, day to maturity and capsules per plant indicated additive type of gene action.

Chavan *et al.* (1981) reported that an additive and dominance gene effects were important for plant height, number of capsules on main shoots, seeds per capsules on main shoots, seeds per capsules and yield per plant. However additive gene action was predominating for plant height. They studied that the epistatic effects were influenced by additive x additive gene action which affected all the characters in sesamum.

Shrivas and Singh (1981) noticed that estimates for specific combining ability were higher than the estimates for general combining ability indicating predominance of non-additive type of gene action in a population of sesamum.

Tyagi and Singh (1981) however, reported non-additive gene action for yield and most of the yield components which were studied in fifteen lines of Indian and exotic strains of sesame.

Fatteh *et al.* (1982) observed that the g.c.a. : s.c.a. ratio, the variance were higher for all the characters *viz.,* days to flower, height of plant, number of capsules per plant, ratio of capsule length to branch, days to maturity, yield per plant and weight of 1000 seeds excepts oil per cent and number of branches. This suggested that additive gene action was more important whereas non-additive gene action was important for oil percentage and number of branches.

Chavan *et al.* (1982) studied two generations in successive years. From the observations of the previous year, they reported that additive and dominance gene action were important for only plant height. But in the experiment in next year, they observed that the dominance gene effects were important than additive gene effects for all the characters. However, one or two crosses showed complimentary gene action for capsules per plant, days to maturity and yield per plant.

Djigma (1983) reported that additive type of gene effects were significant for height of the main stem, number of capsules and seed yield in the diallel study of sesame.

Sharma and Chauhan (1983) studied F_1 hybrids involving 10 sesamum varieties. According to them, it was due to high manifestation of heterosis for number of capsules per plant which in turn was due to additive gene action for number of primary and secondary branches.

Chaudhari *et al.* (1984b) observed both additive as well as non-additive gene effects in the study of grain yield and other eight yield related characters in *Sesamum indicum* L. They reported that additive as well as non-additive gene effects were involved. However, they latter played the predominant role for all the characters except days to flowering and maturity.

Sharma and Chauhan (1984) noticed that both additive and dominance gene effects were significant for most of the yield contributing characters in both F_1 and F_2 generations. Over dominance was observed for all the characters except days to flowering in F_1 generation of sesame.

Sharma and Chauhan (1985) studied the nature of combining ability in set of 10 x 10 diallel and reported that the g.c.a. variance had higher magnitude than s.c.a. variances, which indicated that the characters *viz.,* days to flowering, number of primary branches, plant height, number of capsules per plant, days to maturity, 1000 seed weight, seed yield and oil percentage were predominantly governed by additive x additive gene action.

Hu (1985) reported that additive gene effects were more important than dominance only for capsule length, while dominant gene effects were found to be more important for seed number per capsule and number of branches.

Kandaswamy (1985) found additive type of gene effects for number of branches per plant, capsule number per branch, seed number per capsule and yield.

Krishnadoss *et al.* (1987) studied gene action in a line x tester analysis involving 20 lines and 5 testers. They found significant g.c.a. for all the characters and the s.c.a. variance were greater than g.c.a. variances indicating the predominance of non-additive or dominant gene action for all the characters *viz.,* days to 50 per cent flowering, days for maturity, plant height, branches per plant, number of capsules per plant, 1000 seed weight and seed yield per plant.

Khorgade *et al.* (1988) studied gene action in a line x tester analysis involving 8 lines and 3 testers. They found importance of both additive and non-additive gene effects for days to maturity, capsule length, branches per plant, capsules per plant and 1000 seed weight.

Ramalingam *et al.* (1990) reported predominant role of non-additive gene action for all the yield attributes in the parents and F_1's of crosses between 3 lines and 5 testers.

Goyal *et al.* (1991) studied half diallel set (excluding reciprocals) of 8 parents and their 28 F_1's hybrids, they reported the importance of both additive and non-additive gene action for all the eight traits. The estimated components of s.c.a. variances were higher in magnitude for all traits indicating the predominance of non-additive or dominant gene action for the traits.

Narkhede *et al.* (1991) found additive and non-additive types of gene action in 8 diverse cultivars of sesamum and their 28 F_1's for 10 quantitative characters.

Reddy *et al.* (1992) studied gene action in the parental F_1 and F_2 generations from a diallel cross involving 9 diverse, homozygous lines of sesame. Inheritance of oil content was predominantly under the control of additive gene action, whereas mainly non-additive effects were identified for seed yield.

Reddy and Haripriya (1993) reported additive x additive, additive x dominance and dominance x dominance types of gene effects in 36 hybrids which were involved in a 9 x 9 diallel mating design (excluding reciprocals).

Shinde *et al.* (1993) reported major contribution of additive gene action for plant height, number of capsules per plant and days to maturity and a dominance gene action for rest of the characters in the parents and F_1's of crosses between 4 lines and 6 testers.

Mishra *et al.* (1994) studied gene action in a line x tester analysis using three males and five female for eight characters in sesamum and reported that non-additive type gene action played the major role for all yield contributing characters suggesting the possibility of exploitation of hybrid vigour.

Padmavathi *et al.* (1994) studied gene action in a line x tester analysis using 15 lines and 5 testers for 15 characters. The significance of GCA and SCA variances for ten characters revealed that additive and non-additive gene action are present in controlling these trait. However non-additive gene action was found to be more important for the character internode length, first capsule bearing node, 1000 seed weight and oil content.

Anandakumar (1995) reported non-additive gene action in the control of seed yield, number of capsules per plant, plant height and additive gene action for rest of characters in the parents and F_1's of crosses between six lines and three testers.

Fatteh *et al.* (1995) studied gene action in a 8 x 8 diallel cross, including reciprocals and parents. They found predominant role of non-additive gene action in the inheritance of number of effective branches per plant, number of capsules per plant, seed yield per plant and 1000 grain weight. Plant height, number of seed per capsule and length of capsule indicated equal importance of both additive and non-additive. For days to flowering days to maturity and oil content additive gene action was important.

Mcharo *et al.* (1995) studied nature of gene action for yield and yield components in sesame. The parents and the 36 F_1's progenies derived from the diallel cross were evaluated. Additive gene effect were significant for days to 50 per cent flowering, height of first capsule and 1000 seed weight. Non-additive gene effects were preponderant for seeds for capsule, capsule length, capsule per plant and height to first branch.

Thiyangarajan and Ramanathan (1995) studied inheritance of seed yield under six environments through combining ability analysis of crosses of 20 lines with 3 testers. They found non-additive genetic variances appeared to be important in the expression of this trait.

Thiyangarajan and Ramanathan (1996) studied inheritance of oil content under 20 environments produced by combining three seasons with 2 soil types pooled analysis indicated the importance of non-additive gene effects for oil content in the 23 parents and 60 F_1's hybrids.

Mishra and Yadav (1997) studied nature of gene action in 8 x 8 diallel cross in sesame in the F_1 and F_2 generations, they indicated that the characters *viz.,* days to maturity, capsules on main stem, seeds per capsules, capsule length, 1000 seed weight and oil content possessed a fixable additive genetic variance whereas the characters *viz.,* branches per plant, capsule per plant and seed yield per plant showed the predominance of non-additive genetic variance.

Sinhamahapatra and Tripathi (1997) studied gene action in the inheritance of resistance of leaf hopper in a diallel set of 9 x 9 genotypes (excluding reciprocals). They found both additive and non-additive gene effects for the inheritance of resistance of leaf hopper.

Thakare *et al.* (1999) reported importance of both additive and non-additive gene effect for genetic amelioration of the characters like seed yield, oil content and other yield components in the parents and F_1's of crosses between 5 lines and 10 testers.

Das *et al.* (1999) studied gene action in 8 x 8 half diallel cross of sesamum over two years. They reported additive genetic variance was of greater importance for number of primary branches per plant, number of secondary branches per plant, number of capsule per plant and seed yield per plant. While additive and non-additive genetic variance were equally important for days to flowering, 1000 seed weight and oil content. Gca and sca manifested significant interaction with year for all characters. The relative magnitude of non-additive x year interaction was greater than additive x year interaction.

Zhao Yingzhog (1999) studied gene action in a line x tester analysis using five females (branched) and five males (unbranched) revealed that additive gene action were predominant in controlling most of the characters studied, although non-additive gene action were also important in height to first capsule, 1000 seed weight, days to maturity and seed yield per plot.

Chakraborti and Basu (2000) reported preponderance of additive and non-additive gene effects in nine salt tolerant sesame lines were crossed and evaluated together with their progenies under saline and normal conditions.

Jayalakshmi *et al.* (2000) studied combining ability in 10 parental genotypes and their half diallel set revealed the predominant role of non-additive gene action for characters *viz.*, days to 50 per cent flowering, days to maturity, number of primary branches, number of secondary branches, capsules on branches (primary and secondary), capsule per plant and seed yield per plant.

Rajavindram *et al.* (2000) reported additive gene action was predominant for plant height, number of capsules per plant, number of secondary branches per plant, 1000 seed weight and number of seeds per capsule in 72 hybrids obtained from 9 sesamum genotypes.

Ragiba and Reddy (2000b) studied combining ability analysis in a set of ten parents, 45 F_1's (excluding reciprocals) and their 45 F_2's in a diallel cross programme for yield and yield contributing traits, revealed equal importance of additive and non-additive gene action with slight predominance of additive effects was observed for days to maturity.

Saravanan *et al.* (2000) studied gene action in 6 x 6 diallel cross in sesamum. The sca variances was higher than gca variances for seed yield per plant. Both sca and gca variances were significant for 1000 seed weight and oil content. However, the gca variance alone was predominant for all the earliness related traits. The study amply indicated the importance of both additive and non-additive gene action in involving early maturing but high seed and oil yielding genotypes.

Devasena *et al.* (2001) studied nature of gene action in a set of 8 x 8 diallel fashion for 12 quantitative traits and reported that the importance of additive and non-additive gene action for all the traits. However g.c.a. variances was greater than s.c.a. variances. For nine characters excepts for 1000 seed weight and harvest index and revealed the predominance of additive gene action.

Kar *et al.* (2001) reported non-additive gene action for seed yield and three earliness characters such as days to 50 per cent flowering, days to maturity and height up to first fruiting node in 42 hybrids of sesame involving 14 lines and three testers.

Solanki and Gupta (2001) reported additive gene effects were important in the inheritance of seed yield, capsule per plant and 1000 seed weight while non-additive gene effect were important for days to flowering, days to maturity, plant height and oil content in 28 genotypes of sesame were assessed for variability, correlation and coheritability.

Krishna Devi *et al.* (2002) studied gene action in a six parental diallel including reciprocals, revealed the preponderance of additive gene action for number of flower per plant, reproductive efficiency, number of seeds per capsule, total number of seeds per plant and number of filled seeds per plant on the other hand non-additive gene action was found to be important for number of ill-filled seeds per plant and seed yield per plant.

Krishnaiah *et al.* (2002) studied gene action in a 8 x 8 diallel analysis of F_1 generation without reciprocals in sesame, revealed that the variance due to g.c.a. and s.c.a. were highly significant denoting importance of additive and non-additive gene action for all the 13 traits. The estimated components of sca variances were higher in magnitude for all the characters except for plant height and capsule length. Additive gene action was predominant for plant height whereas additive and non-additive gene action govern capsule length.

Pushpa *et al.* (2002) studied gene action in 6 x 6 diallel analysis and reported predominance of additive gene action for all the yield contributing characters excepts 1000 seed weight.

Senthil Kumar and Ganesan (2002) studied nature of gene action in a line x tester analysis involving five lines and three testers. They found that dominant gene action was predominant for plant height, number of branches per plant, number of capsules on main stem, number of capsules on branches, total number of capsules, capsule length, number of seeds per capsule, 1000 seed weight and seed yield per plant.

2.4.1 Correlations

In improvement of any crop yield is the most important character that has to be taken into account. However, the inheritance of yield is complicated as it is governed by a large number of genes and is usually a sum of various physiological process in the plant. Knowledge of association of one or more of these characters especially with yield is therefore, useful in selecting individuals with high yields on the basis of their phenotypic value. Such association between plant characters is statistically elaborated by correlation coefficients.

Genotypic correlation coefficient provides a measure of genotypic conjugation between characters and gives an indication of the more useful characters. In any event, they provide a basic information which is extremely useful to breeders in understanding the nature of the species with which they work. They may also help to identify characters that have little or no importance in the selection programme. In addition to genotypic and phenotypic correlations, the genotypic and phenotypic variances of all the characters are useful in constructing selection indices.

Upto fourth decade of the 20th century, numerous workers studied the correlation in sesame but the values were not further splited into genotypic, phenotypic and environmental correlations.

Kaushal *et al.* (1974) studied seven yield components in 32 varieties which appeared to be significantly correlated either genotypically or phenotypically with yield, although there was negative or positive correlation between some components.

Salazar and Onoro (1975) reported that the number of capsules was correlated with seed weight per plant.

Gupta (1976) reported positive correlation of seed yield with number of branches, number of capsules per plant and height of the fruit bearing branches.

Shukla and Verma (1976) through correlation studies reported that the number of secondary branches, number of capsules per main branches and number of capsules per plant contributed significantly towards seed yield.

Chaudhari *et al.* (1977) revealed that the height is positively related to yield per plant.

Chavan and Chopade (1981) studied 82 M_2 progenies obtained by gama irradiation of the varieties N-58-2, 85 and D-7-11-1. They observed strong phenotypic and genotypic correlation among seed yield per plant, number of primary branches per plant, number of days for 50 per cent flowering and capsule length. Genotypic correlation coefficients were higher than phenotypic correlation coefficients. Seeds per plant was highly correlated with number of primary branches, number of capsules per plant and plant height with the exception of seed number per capsule.

Rathnaswamy and Jagathesan (1984) observed that the number of capsules per plant and branches per plant were significantly correlated with seed yield.

Thangvelu and Rajasekharan (1982) studied 8 yield related characters in 40 genotypes and reported that 7 yield contributing characters were positively associated with seed yield.

Sharma and Chauhan (1986) concluded that the number of capsules per plant, 1000 seed weight and oil content were the most important characters affecting yield.

Krishnadoss *et al.* (1986) observed positive correlation of height, number of branches per plant and number of capsules per plant with yield and with each other.

Tu *et al.* (1988) though correlation studies reported that seed yield was significantly correlated with pod number per plant, pod axis length, plant height and seed number per capsule.

Rong and Wu (1989) through correlation studies reported that genotypic correlation appeared greater than phenotypic correlations. Genetically seed yield per plant showed a highly significant positive correlation with capsules per plant, a highly significant negative correlation with seeds per capsule and a significant correlation with 1000 seed weight.

Osman (1989) through correlation studies reported that the yield of the fertile parent was correlated with that of the F_1 indicating that superior fertile parents can be selected phenotypically. Capsules per plant and seeds per capsule in the F_1 and capsules per plant in the parents made the greatest contribution to yield.

Sodani and Bhatnagar (1990) studied 6 yield related characters in 10 genotypes and their 45 F_1's and 45 F_2 hybrids concluded that heterosis, for grain yield was highly correlated with heterosis for its component characters.

Zhan *et al.* (1990) studied genetic correlations in 43 F_1's and 16 F_2's from crosses of 32 lines of sesame and reported that yield per plant was significantly correlated with capsule number per plant and also with seeds per capsule.

Pathak and Dixit (1992) studied 11 yield related characters in 40 diverse genotypes of black seeded sesamum and reported that seed yield were correlated with days to maturity, number of branches per plant and capsule girth where as number of branches per plant, capsule girth and seed per capsule was important for oil content.

Vadhvani *et al.* (1992) studied 10 yield related character in 15 *Sesamum indicum* parents and 26 F_1 hybrids and reported that capsule number had the greater effect on yield, oil content was significantly and negatively correlated with the yield.

Reddy *et al.* (1993) studied 15 characters in 50 genotypes of sesamum and reported that dry matter production, harvest index, leaf area index, capsule on main stem and branches, plant height, number of primary branches and secondaries, first capsule bearing node, days to maturity and capsule length are positively and significantly correlated with seed yield. Seed number per capsule was negatively correlated with seed yield, 1000 seed weight and oil content were not significantly.

Balan *et al.* (1996) studied correlation in the progenies and parents of 8 x 8 diallel crosses and reported that capsule weight followed by root weight and total dry matter production were significantly and positively correlated with seed yield. Root weight was significantly and positively correlated with all the other traits. Stem, leaf and capsule dry weight were highly correlated with total dry matter production.

Guirguis *et al.* (1996) studied yield and seed characters in 20 sesamum genotype and reported that significant positive correlation occurred between plant height and number of branches per plant and fruiting zone length, yield per plant was positively correlated with first pod height and number of branches per plant. Highly significant positive correlation occurred between seed yield per plant and yield per feddan.

Jarwal *et al.* (1998) studied the correlation in some qualitative characters in sesame and they reported that days to flowering displayed a negative and significant association with branches per plant while days to maturity and plant height had a positive and significant correlation with yield.

Siddiqui *et al.* (1998) studied correlation in some quantitative characters of seven parents and their twenty one F_1's (excluding reciprocals). A strong positive association of yield per plant with all characters excepts oil content both at phenotypic and genotypic level. Days to flowering was significantly correlated with days to 50 per cent flowering, days to maturity, plant height, number of capsules per plant and 1000 seed weight. Days to maturity has positively and significantly correlated with number of branches per plant, plant height, number of capsule per plant, length of capsule and 1000 seed weight.

Ganesh and Sakila (1999) studied correlation in one hundred and fourteen genotypes for single plant yield and other yield contributing components. All the characters studied showed significant and positive correlation with the single plant yield. The inter correlation between the yield components excepts the number of capsules on the main stem revealed high associations with each other. The character *viz.*, plant height, number of capsules on main stem and number of capsules on branches showed a high positive direct effect on single plant yield.

Kathiresan and Gnanamurthy (2000) studied correlation of different growth and yield attributing characters on the seed yield of sesame with two cultivars grown in two different seasons *viz., kharif* and summer. Analysed data revealed that dry matter accumulation and the number of capsules per plant contributing significantly to seed yield which exhibited a positive correlation that was higher than that for other characters.

Sakila *et al.* (2000a) through correlation studied reported that single plant yield in sesame was positively correlated with plant height, capsules on main stem, height of first capsule and total number of capsules. The trait number of branches showed a non-significant and negative correlation with yield.

Solanki and Gupta (2001) through correlation studies in twenty eight genotypes for seed yield and its attributes reported that seed yield showed highly positive correlation with capsule per plant, branches per plant, 1000 seed weight and oil content had high coheritability with seed yield.

Kumaresan and Nadarajan (2002) studied six yield contributing characters in 64 genotypes including 48 hybrids and 16 parents and reported that except days to 50 per cent flowering and oil content all the remaining characters showed a significant and positive correlation with seed yield. They also had a significant and positive correlation between each other.

Yingzhong and Yishou (2002) studied nine characters in twenty seven core accessions and three genetic male sterile lines and reported that number of capsules per plant and plant height had significantly positive correlation and direct path coefficients on seed yield per plant.

MATERIALS AND METHODS

3. MATERIAL AND METHODS

The present investigations "Combining ability studies in sesamum (*Sesamum indicum* L.) through 8 x 8 diallel analysis were conducted at Post Graduate Research Farm of Department of Botany, Mahatma Phule Agricultural University, Rahuri during the period from February 2002 to December 2002. The details of material used and statistical methods followed during the course of the investigations are given in this chapter.

3.1 Material

The experimental material comprised of eight sesamum genotypes procured from Oil Seed Specialist, Oil Seed Research Station, Jalgaon. The details of all the genotypes used in the investigation are given below.

Sr. No.	Variety	Salient features
1.	Tapi	White and bold seed, early
2.	TKG-21	White seeded, tolerant to Antigestera, bacterial and cerrospora leaf spot
3.	RT-46	White seeded, resistance to oozing complex, tolerant to macrophomina stem and root rot
4.	Sekhar	White seeded, resistance to lodging, tolerant to phyllody and leaf curl
5.	OS Sel-2	Reddish brown seeded multiple resistance, late
6.	JLT-54	White seeded, early, suitable for *Rabi* and summer
7.	VRI-1	Black seeded, multiple resistance, short and erect late
8.	Gopi	White seeded multi capsule local land races

These eight selected parents were used for effecting crosses in all possible combinations including reciprocals. The crosses along with the parents were studied for ten quantitative traits with a view to estimate heterosis, combining ability (general and specific) gene action and correlation in F_1 generation.

3.2 Method

3.2.1 Production of F_1 seeds

The eight cultivars of sesamum listed above were grown in flat beds during summer 2002. Healthy buds were selected and bagged to avoid genetic contamination by foreign pollen. Next day evening between 4 to 6 p.m. such bagged flowers were emasculated easily with hand by pulling out the corolla along with anthers. While emasculating the flowers maximum care was taken to avoid injury either to any of the floral organs or flower stalk. Such emasculated buds were bagged carefully and pollinated next day morning between 7 to 9 a.m. with the pollen from the bagged flowers of the desired parent. The pollinated flowers were again bagged and labelled properly. Simultaneously a few flowers from each of the parents were selfed by bagging to obtain pure parental seed. In this way the crossing was done in diallel mating system to obtain seeds of 56 crosses (including reciprocals).

3.2.2 Experimental design

A uniform piece of land was selected for the trial. It was ploughed, harrowed and the stubbles of the previous crop was collected and to a fine tilth.

The experiment was laid with 56 crosses and eight parents in randomised block design with three replications during *kharif* 2002.

The sowing of seed was done on 28.6.2002 in flat beds of 3.0 x 2.4 m size. Each treatment was sown in one row of 3 m length per replication, spaced at 30 cm apart. Plant to plant distance was 10 cm. The recommended basal dose of fertilizer was applied at the rate of 15 kg N, 25 kg P_2O_5 per hectare through urea, single superphosphate, respectively. After 30 days from the sowing a dose of 15 kg N /ha was given through urea. Timely and proper cultural practices were followed to have satisfactory crop growth, throughout the life of the crop. Due to drought conditions during the year one irrigation was applied after 15 days of sowing and second irrigation was applied after 30 days after sowing.

3.2.3 Observations

Five competitive random plants from each treatment in each replication were selected for recording observations excluding border plants. The selected plants were tagged at the age of 30 days. The following observations were recorded.

a. Days to 50 per cent flowering

The date on which 50 per cent of the plants in the line were flowered was recorded and the number of days from sowing to such flowering was calculated.

b. Days to maturity

Number of days from the date of sowing to the date when capsules on most of the plants in a line matured was recorded i.e. yellowing of capsules was considered as physiological maturity.

c. Plant height (cm)

Plant height was recorded at maturity height, was measured in centimeter from the soil surface to the tip of the main shoot or main branch.

d. Number of branches

The total number of branches present on the main stem was recorded at maturity.

e. Number of capsules per plant

The number of capsules produced on all the branches and the main shoot was counted and recorded.

f. Length of capsule (cm)

The length of five randomly selected capsules from each of the five plants was measured in centimeter from the point of attachment of capsule to the tip of the capsule. The average length of five capsules was then recorded for each plant.

g. Number of seeds per capsule

Five capsules per plant were randomly selected and the seed number for each of the capsule was counted and recorded. The average count of five capsules was recorded as the number of seeds per capsule.

h. Yield per plant (g)

The weight of total seeds harvested per plant was recorded in grams.

i. 1000 seed weight (g)

Thousand seeds from each of five randomly selected plants were weighed and average test weight was recorded in grams.

j. Oil content (%)

The oil content was estimated from a random sample of seed per progeny per replication by the use of soxhlet apparatus i.e. Ether extraction method.

3.2.4 Statistical analysis

The quantitative characters recorded above were further subjected to statistical analysis using Griffings (1956a) model-I, method-I approach.

a. Testing the significance of genotypic differences

The first step followed in the analysis was to test the null hypothesis that there were no genotypic differences. The data were subjected to analysis of variance for randomised block design as given below.

Sr. No.	Source of variation	D.F.	S.S.	M.S.S.	Calculated value of F
1.	Replication	(r-1)	R.S.S.	$\frac{\text{R.S.S.}}{(r-1)}$	$\frac{\text{R.M.S.S.}}{\text{E.M.S.S.}}$
2.	Treatments	(n-1)	Tr.S.S.	$\frac{\text{Tr.S.S.}}{(n-1)}$	$\frac{\text{Tr.M.S.S.}}{\text{E.M.S.S.}}$
3.	Error	(r-1) x (n-1)	E.S.S.	$\frac{\text{E.S.S.}}{(r-1)(n-1)}$	

Where,

D.F.	=	Degree of freedom
S.S.	=	Sum of squares
M.S.S.	=	Mean sum of squares
r	=	Number of replications
n	=	Number of treatments
R	=	Replication
Tr	=	Treatment
E	=	Error

For determining the significance of genotypic differences the M.S.S. due to treatment was tested against error M.S.S. at their respective degrees of freedom.

b. Heterosis

Heterosis was calculated over mid and superior parental values and expressed in percentage of the parents involved in cross combinations the parents which exhibited higher values for the characters studied were regarded as superior parents excepts for the characters earliness and maturity. For these the parents with lower values were regarded as superior, since such values are commercially beneficial. Following formulae were used for calculating per cent heterosis over mid and superior parents.

1. Per cent heterosis over mid parent

$$= \frac{\overline{F_1} - \overline{M.P.}}{\overline{M.P}} \times 100$$

Where,

F_1 = Mean value of the cross

$\overline{M.P.} = \dfrac{\overline{P_1} + \overline{P_2}}{2}$ i.e. mean value of the two parents of that particular cross

2. Per cent heterosis over superior parents

$$= \frac{\overline{F_1} - \overline{S.P.}}{\overline{S.P.}} \times 100$$

Where,

$\overline{S.P.}$ = Mean value of the superior parent of a particular cross

The significance of heterosis was tested at least significant difference after 'F' test as follows.

1. L.S.D. for M.P. = $\sqrt{\dfrac{3\ me}{2r}} \times t$

Where,

't' value at 5 % and 1 % level of degree freedom.

2. L.S.D. for S.P. = $\sqrt{\dfrac{2\ me}{r}} \times t$

Where,

't' value at 5 % and 1 % level of error degree freedom.

me = The error mean square of the R.B.D.

r = Number of replications

L.S.D. = Least significance difference

c. Combining ability analysis

The combining ability analysis was carried out by the procedure developed by Griffing (1956a). Analysis was made as per the procedure of Method-I and Model-I (i.e. parents, direct crosses and reciprocal crosses).

The mathematical model for the combining ability analysis was assumed to be :

$$Xij = \mu + gi + gj + sij + rij + \frac{1}{bc} \sum_{K} \sum_{I} eijkl$$

i, j = 1 .... p

k = 1........... b

l = 1 c

Where,

μ = Population mean

gi (gj) = The g.c.a. effect for i^{th} (j^{th}) parent

Sij = The s.c.a. effect for the cross between the i^{th} and j^{th} parents

rij = The reciprocal effect for the reciprocal cross betwen i^{th} and j^{th} parents

$\frac{1}{bc} \sum_{K} \sum_{I} eijkl$ = The environmental effect associated with the $ijkl^{th}$ observation

p = Number of parental lines

b = Number of blocks

c = Number of plants per family

The following restrictions are imposed on the combining ability elements $\sum_i gi = 0$ and $\sum_j sij = 0$ (for each i)

The data were analysed to estimate the sum of squares due to g.c.a., s.c.a. and reciprocals as presented below.

Analysis combing ability in Method-I (Model-I)

Sr. No.	Source of variation	D.F.	S.S.	M.S.	Calculated value of F
1.	g.c.a.	P-1	Sg	Mg	$\sigma^2 + \frac{1}{2P(P-1)} \sum gi^2$
2.	s.c.a.	$\frac{P(P-1)}{2}$	Ss	Ms	$\sigma^2 + \frac{2}{P(P-1)} \sum_i \sum_j sij^2$
3.	Reciprocal	$\frac{P(P-1)}{2}$	Sr	Mr	$\sigma^2 + 2\left(\frac{2}{P(P-1)}\right) \sum_{i<j} \sum rij^2$
4.	Error	m	Se	Me	σ^2

Where,

P = Number of parents

M = ab (a = No. of varieties, b = No. of replications)

$$Sg = \frac{1}{2P} \sum_i (Xj. + X.j)^2 - \frac{2}{P^2} X...2\ ;$$

$$Ss = \frac{1}{2} \sum_i \sum_j X ij\ (Xij + Xji) - \frac{1}{2P} j\ (X.i + Xi)^2 + \frac{1}{P^2} X$$

$$Sr = \frac{1}{2} \sum_{i<j} \sum (Xij - Xji)^2$$

Where,

Sg is the sum of squares due to g.c.a.

Ss is the sum of squares due to s.c.a.

Sr is the sum of squares due to reciprocal effect

Xij (Xji) is the value of the cross between i^{th} and j^{th} parent

Xi. (X.i) is the total of array and column of the i^{th} (j^{th}) parent in the diallel table

X.. is the ground total of the diallel table

M is the error degrees of freedom available in the design used for the experiment

Se is the error mean squares obtained in R.B.D. analysis of variance.

$$M'e = \frac{Se}{b}$$ Where b = number of replications

The variance ratio against M'e was used in testing significance of general specific and reciprocal combining ability variances as follow.

1. $$\frac{\text{Test for g.c.a. effects}}{F\,[(P-1),\, M] = Mg/M'e}$$

2. $$\frac{\text{Test for s.c.a. effects}}{F\,[P(P-1)/2,\, M] = Ms/M'e}$$

3. $$\frac{\text{Test for reciprocal effects}}{F\,[P(P-1)/2,\, M] = Mr/M'e}$$

Estimates of combining ability effects

The estimates of general, specific and reciprocal combining ability effects were obtained by using the following formulae :

1. $\hat{gi} = \frac{1}{2P} (Xi. + X.i) - \frac{1}{P^2} X \ldots i$

Where, gi is the g.c.a. effect of the i^{th} parents

2. $\hat{sij} = \frac{1}{2} (Xij + Xji) \frac{2}{2P} (Xi. + X.i + X.j) - \frac{1}{P^2} X \ldots i$

Where, Sij is the s.c.a. effects of the ij^{th} cross

3. $\hat{rij} = \frac{1}{2} (Xij - Xji)$

Where, rij is the reciprocal effect of the ij^{th} cross

The variance standard error and critical differences to test the significance of difference between two estimates where obtained as follows.

$$\text{Var.} (\hat{gi}) = \frac{P-1}{2 P^2} \sigma^2 e$$

$$\text{Var.} (\hat{Sij}) = \frac{1}{2P^2} (P^2 - 2P + 2) \sigma^2 ej \ (i \neq j)$$

$$\text{Var.} (\hat{rij}) = \frac{1}{2} \sigma^2 ej \ (i \neq j)$$

$$\text{Var.} (\hat{g}i - \hat{g}j) = \frac{1}{P} \sigma^2 e \quad (i \neq j)$$

$$\text{Var.} (\hat{S}ij - \hat{S}ik) = \frac{P-1}{P} \sigma^2 ej \quad (i \neq j, K : J \neq K)$$

$$\text{Var.} (\hat{S}ij - \hat{S}KL) = P\text{-}2 \; \sigma^2 ej \; ; (i \neq j, K, L \; J \neq K, L, I \;\; K \neq L)$$

$$\text{Var.} (\hat{r}ij - \hat{r}KL) = \sigma^2 e \; ; (i \neq j \; ; K \neq L)$$

The least significant differences was made use of to test the significance of differences between two estimates and was calculated as a product between the table t' value against the error degree of freedom and the standard error of differences between two estimates. The standard error of differences was taken a square root of variance of the difference between two estimates.

L.S.D. = S.E. x 't' value at error d.f. at 5 % and 1 % level

Where S.E. = $\sqrt{\text{Variance}}$

d. Gene action

The variances due to general and specific combining ability were used to determine the gene action involved. If the variance due to g.c.a. were greater than those due to s.c.a., the gene action were regarded as additive ~~otherwise non-additive~~.

e. Correlations

In order to study the various types of inter relationships between different characters, phenotypic and genotypic correlations at varietal level were worked out. For this the method of analysis of co-variance was adopted.

For estimation of phenotypic and genotypic correlation coefficients the following formulae suggested by Craxton and Cowden (1964) were used.

$$r_p = \frac{\text{Co-variance } XY_p \text{ (Phenotypic)}}{\sqrt{\text{Variance Xp . Variance Yp}}}$$

$$r_g = \frac{\text{Co-variance } XY_g \text{ (Genotypic)}}{\sqrt{\text{Variance Xg . Variance Yg}}}$$

Where,

r_p = Phenotypic correlation coefficient between character 'X' and 'Y'

r_g = Genotypic correlation coefficient between the characters 'X' and 'Y'.

Significance of correlation was tested by application of 't' test as given below.

$$t \text{ (by calculation)} = \frac{r \times \sqrt{n-2}}{\sqrt{1-r^2}}$$

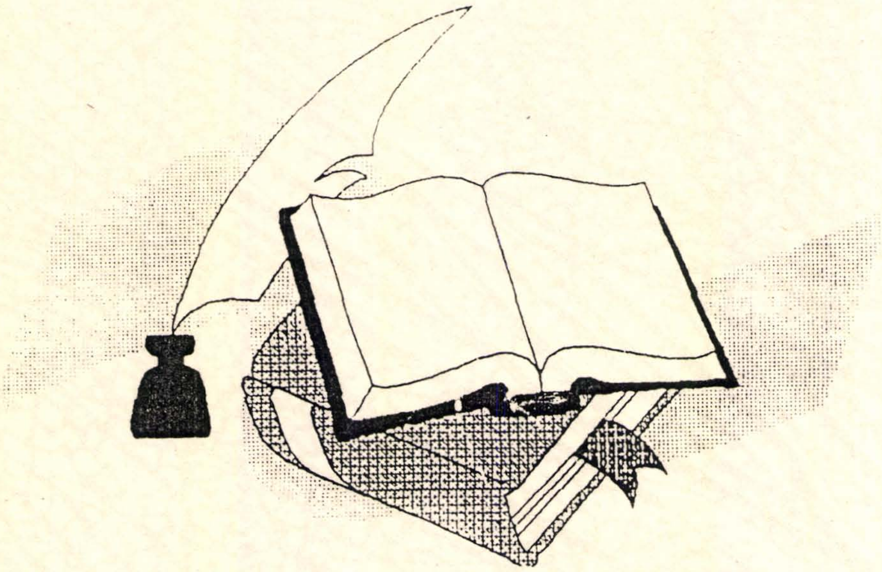
Where,

r = Coefficient of correlation

n = Number of pairs of observations

Degree of freedom for 't' = (n - 2)

The significance of correlation co-efficient was tested against 'r' values given by Fisher and Yates (1963) at (t-2) degrees of Freedom at five per cent and one per cent levels of significance.



EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

The present investigations were carried out to asses the magnitude of heterosis and combining ability (general and specific), to study the nature of gene action and correlation for ten characters involving development capsule and grain characteristics of sesamum (*Sesamum indicum* L.). A set of full diallel (8 x 8) was grown during the year 2002. All the eight parental lines involved were diverse genotypes both morphologically as well as geographically.

The experimental data were subjected to appropriate statistical analysis and the findings are presented under the following heads.

4.1 Analysis of variance

The analysis of variance for experimental design has been presented in Table 1. The variation among the genotypes was highly significant for all the characters, which indicated the presence of substantial amount of genetic variability for all the characters under study. Similarly, the parents F_1's and parents Vs hybrids showed significant variation for all the characters.

The mean values for the parents and crosses with respect to the characters studied are given in Table 2. These values were used for computing heterosis.

Table 1. Analysis of variance of parents and hybrids for 10 characters in 8 x 8 diallel cross of sesamum

Sr. No.	Source	D.F.	Mean sum of squares									
			No. of days to 50 % flowering	Days to maturity	Plant height (cm)	No. of branches per plant	Characters: No. of capsules per plant	Characters: Length of capsule (cm)	No. of seeds per capsules	Yield per plant (g)	1000 seed weight (g)	Oil content (%)
1.	Replication	2	1.0208	0.4740	12.4636	0.00094	48.4341	0.0008	0.1956	0.3037	0.0001	0.0007
2.	Treatments	63	26.4415**	111.0317**	199.3688**	3.0078**	1029.7851**	0.1367**	50.5674**	54.7138**	0.2387**	33.4179**
3.	Parents	7	9.1190**	78.2798**	72.4880**	4.2046**	370.6458**	0.2683**	75.3086**	11.4057**	0.1334**	29.1675**
4.	Hybrids	55	28.3861**	110.8155**	214.5659**	2.8971**	1077.1402**	0.1173**	45.0070**	55.7071**	0.2563**	31.3706**
5.	Parent Vs Hybrids	1	40.7411**	382.1905**	251.6977**	0.7183***	3039.2292**	0.2847**	183.5499**	303.2400**	0.0045**	175.7700**
6.	F_1's	27	28.0547**	107.0053**	203.5262**	2.3124**	827.5948**	0.1430**	45.0332**	47.4115**	0.1892**	34.2841**
7.	Reciprocals	27	18.3086**	84.3329**	229.7327**	3.4380**	1338.1843**	0.0959**	40.1945**	64.4540**	0.2999**	28.9230**
8.	Error	126	0.6557	0.5374	7.4632	0.0015	20.3464	0.0118	0.1679	0.1700	0.0001	0.0016

* Significant at 5 % level

** Significant at 1 % level

Table 2. Means of parents, direct crosses and reciprocal crosses for 10 characters in 8 x 8 diallel crosses of sesamum

Sr. No.	Parents and crosses	Characters									
		No. of days to 50 % flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule	Yield per plant (g)	1000 seed weight (g)	Oil content (%)
	Parents										
1.	Tapi	41.33	89.33	102.95	4.60	68.62	3.00	62.83	12.22	2.86	44.05
2.	TKG–21	41.66	90.66	95.66	3.39	49.00	3.30	66.20	6.65	3.16	49.90
3.	RT-46	42.66	92.66	104.60	4.24	63.25	3.30	70.33	9.90	3.12	43.17
4.	Sekhar	43.00	96.00	101.00	3.79	46.00	2.85	62.70	7.79	2.96	44.06
5.	OS sel.2	44.33	98.33	103.14	4.00	58.42	2.80	55.06	8.90	2.80	49.14
6.	JLT-54	41.33	90.33	110.42	4.01	49.20	3.16	55.70	8.15	3.22	43.80
7.	VRI-1	46.33	104.66	109.20	5.00	50.66	2.40	59.43	6.54	2.66	45.05
8.	Gopi	44.00	96.66	108.66	1.10	32.85	3.00	59.26	6.80	3.21	40.49

Table 2. Means of parents, direct crosses and reciprocal crosses for 10 characters in 8 x 8 diallel crosses of sesamum

Sr. No.	Direct crosses	Characters									
		No. of days to 50 % flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule	Yield per plant (g)	1000 seed weight (g)	Oil content (%)
1.	Tapi x TKG-21	38.66	87.66	100.85	2.78	41.85	3.15	58.50	7.26	3.25	46.70
2.	Tapi x RT-46	38.66	88.66	111.50	3.58	65.20	2.65	61.60	13.01	2.77	40.76
3.	Tapi x Sekhar	44.66	100.66	101.00	3.75	60.80	2.95	63.76	17.88	2.92	48.63
4.	Tapi x OS sel.2	45.66	102.66	116.62	4.91	78.20	2.90	66.76	14.17	2.66	51.41
5.	Tapi x JLT-54	42.00	94.00	124.20	5.78	96.08	2.90	63.33	20.52	3.38	49.59
6.	Tapi x VRI-1	39.66	89.66	103.80	3.21	41.53	2.70	65.03	8.23	3.30	48.79
7.	Tapi x Gopi	43.00	96.00	102.62	3.80	73.80	2.83	63.13	9.84	3.20	49.22
8.	TKG-21 x RT-46	38.66	88.66	100.00	3.60	44.50	2.63	66.26	6.91	2.87	50.12
9.	TKG-21 x Sekhar	41.33	92.33	112.60	3.73	64.86	2.90	67.86	11.06	3.23	42.39
10.	TKG-21 x OS sel.2	49.33	109.66	113.03	4.99	92.86	2.80	64.63	18.02	3.29	50.24
11.	TKG-21 x JLT-54	43.00	97.00	100.23	2.38	43.80	2.60	63.80	13.24	3.02	50.19
12.	TKG-21 x VRI-1	43.33	97.33	121.06	4.25	54.66	2.45	65.83	10.96	2.94	48.02
13.	TKG-21 x Gopi	39.66	89.66	107.33	3.68	41.79	2.70	67.63	7.63	3.12	49.20
14.	RT-46 x Sekhar	41.00	94.66	106.14	3.04	54.33	2.90	61.93	9.92	3.21	49.04
15.	RT-46 x OS sel.2	42.66	94.66	107.71	3.55	59.57	2.80	60.60	12.02	2.56	51.60
16.	RT-46 x JLT-54	42.33	95.33	101.18	3.86	76.87	3.00	69.93	14.97	3.14	43.84
17.	RT-46 x VRI-1	42.00	95.00	107.44	4.73	84.66	2.60	66.63	21.60	2.93	52.08
18.	RT-46 x Gopi	38.00	86.00	102.80	3.59	45.66	2.85	62.53	8.08	3.15	51.80
19.	Sekhar x OS sel.2	46.00	102.00	108.37	4.40	60.62	3.06	67.76	9.53	2.82	52.79
20.	Sekhar x JLT-54	42.66	95.66	105.75	2.67	50.08	3.15	63.60	8.71	3.51	51.60
21.	Sekhar x VRI-1	46.00	102.00	121.83	5.59	85.33	2.84	65.63	11.66	2.98	46.20
22.	Sekhar x Gopi	42.33	94.33	98.90	3.81	65.83	2.92	67.13	11.21	3.30	47.60
23.	OS sel.2 x JLT-54	48.00	106.00	123.79	4.11	72.18	3.20	77.60	10.49	3.21	43.59
24.	OS sel.2 x VRI-1	47.00	104.00	120.79	4.46	73.33	2.95	62.56	14.44	3.40	45.79
25.	OS sel.2 x Gopi	46.33	103.33	113.93	2.52	76.00	3.00	68.96	10.25	2.83	50.39
26.	JLT-54 x VRI-1	43.66	97.66	112.60	3.60	48.60	3.38	79.96	8.63	3.54	50.78
27.	JLT-54 x Gopi	44.66	98.66	96.49	2.50	40.49	2.83	69.83	8.16	2.92	45.60
28.	VRI-1 x Gopi	47.00	102.33	101.00	3.36	44.16	2.45	61.26	8.10	2.90	41.20

Table 2 contd...

Sr. No.	Reciprocal crosses	Characters									
		No. of days to 50 % flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule	Yield per plant (g)	1000 seed weight (g)	Oil content (%)
1.	TKG-21 x Tapi	47.00	104.00	119.12	3.37	59.50	2.85	57.80	12.39	3.01	48.20
2.	RT-46 x Tapi	43.33	95.33	113.00	4.50	68.90	3.05	67.00	15.52	3.52	46.24
3.	RT-46 x TKG-21	40.66	90.66	102.80	4.85	62.55	2.70	63.40	9.33	3.14	50.20
4.	Sekhar x Tapi	42.66	95.66	100.33	3.01	47.66	2.90	61.80	9.71	3.01	51.18
5.	Sekhar x TKG-21	44.00	97.00	98.20	3.05	45.00	2.84	56.80	6.94	3.00	48.80
6.	Sekhar x RT-46	42.66	94.66	98.99	3.52	39.66	2.75	70.80	12.39	3.23	49.59
7.	OS sel.2 x Tapi	47.33	105.33	107.88	4.40	70.46	3.08	68.60	17.20	2.71	49.02
8.	OS sel.2 x TKG-21	47.33	105.33	107.85	4.20	72.42	2.70	64.03	17.16	2.80	41.60
9.	OS sel.2 x RT-46	45.66	101.33	104.30	4.10	73.50	2.90	68.40	12.71	2.81	43.40
10.	OS sel.2 x Sekhar	47.00	104.00	127.55	4.68	92.77	3.00	62.60	9.38	3.08	47.79
11.	JLT-54 x Tapi	46.66	102.33	96.50	2.01	41.00	2.90	65.20	6.93	2.57	50.29
12.	JLT-54 x TKG-21	46.00	102.00	98.20	3.51	44.00	2.70	59.60	6.84	2.93	50.02
13.	JLT-54 x RT-46	48.00	106.0	110.33	5.38	78.00	2.95	67.93	16.17	3.28	50.39
14.	JLT-54 x Sekhar	43.66	94.00	100.25	3.37	71.41	2.75	61.22	11.80	3.10	51.02
15.	JLT-54 x OS sel.2	44.33	97.33	110.75	3.60	43.12	2.80	63.00	7.48	2.90	44.03
16.	VRI-1 x Tapi	50.00	110.00	113.37	6.68	102.00	2.70	64.80	19.41	2.57	50.81
17.	VRI-1 x TKG-21	50.00	110.00	96.14	4.05	68.11	2.65	60.20	8.12	2.53	50.02
18.	VRI-1 x RT-46	46.00	102.00	98.80	5.84	83.00	2.30	57.80	11.72	2.55	42.80
19.	VRI-1 x Sekhar	46.33	102.00	121.30	5.06	134.11	2.85	63.00	22.55	2.75	49.21
20.	VRI-1 x OS sel.2	50.00	110.00	109.22	4.38	86.00	2.80	64.00	10.69	3.03	50.34
21.	VRI-1 x JLT-54	43.33	96.33	102.13	4.59	58.50	2.85	61.80	15.53	3.13	49.58
22.	Gopi x Tapi	47.00	103.66	104.00	3.30	42.00	2.86	59.80	8.27	2.64	42.01
23.	Gopi x TKG-21	47.00	104.00	99.86	4.40	64.40	3.10	65.56	15.83	2.67	44.34
24.	Gopi x RT-46	48.00	106.66	101.83	5.49	64.33	3.10	62.60	11.67	3.03	44.29
25.	Gopi x Sekhar	47.66	104.00	105.00	2.58	45.33	2.80	59.00	6.66	2.56	42.80
26.	Gopi x OS. sel.2	43.66	97.66	113.47	2.60	56.60	3.10	68.00	7.08	2.56	48.80
27.	Gopi x JLT-54	42.00	93.33	112.19	3.40	71.11	3.05	67.40	18.12	3.46	47.39
28.	Gopi x VRI-1	46.00	102.00	126.33	5.03	74.22	3.06	65.00	17.40	3.70	46.31

4.2 Heterosis

Heterosis measured as the deviation from F_1 over the mid parent and superior parent is presented in Table 3 to 7a while the range of heterosis for ten characters is presented in Table 8.

It may be seen that there was considerable heterosis in almost all the characters studied. The results of heterosis in direct and reciprocal crosses for various characters are described below.

4.2.1 Days to 50 per cent flowering.

The range of days for 50 per cent flowering in the parental lines was from 41.33 days (Tapi, JLT-54) to 46.33 days (VRI-1). In F_1's (direct) it ranged from 38 days (RT-46 x Tapi) to 49.33 days (TKG-21 x OS Sel. 2).

a. F_1's

The range of heterosis was -12.30 (RT-46 x Gopi) to 14.75 (TKG-21 x O.S. Sel. 2) and -14.39 (Tapi x VRI-1) to 11.28 (TKG--21 x O.S. Sel-2) per cent over M.P. and S.P., respectively.

Thirteen crosses exhibited significant positive heterosis and eleven crosses exhibited significant and positive heterobeltiosis. Whereas twelve and fourteen crosses exhibited significant negative heterosis over M.P. and S.P., respectively. The rest of crosses however, did not show significant heterosis either over M.P. or S.P. The cross RT-46 x Gopi had maximum negative heterosis over its M.P. while the cross Tapi x VRI-1 had maximum negative heterosis over its S.P.

b. Reciprocals

The period for 50 per cent flowering in the reciprocal crosses ranged from 42 (Gopi x JLT-54) to 50 days (VRI-1 x Tapi, VRI-

Table 3. Heterosis in direct crosses of sesamum for days to 50 per cent flowering and days to maturity

Sr. No.	Direct crosses	Number of days to 50 % flowering					Days to maturity				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	Tapi x TKG-21	38.66	41.49	41.66	-6.82**	-7.20**	87.66	89.99	90.66	-2.59**	-3.31**
2.	Tapi x RT-46	38.66	41.99	42.66	-7.93**	-9.38**	88.66	90.99	92.66	-2.56**	-4.32**
3.	Tapi x Sekhar	44.66	42.16	43.00	5.93**	3.86**	100.66	92.66	96.00	8.63**	4.85**
4.	Tapi x OS sel.2	45.66	42.83	44.33	6.61**	3.00**	102.66	93.83	98.33	9.41**	4.40**
5.	Tapi x JLT-54	42.00	41.33	41.33	1.62**	1.62*	94.00	89.83	90.33	4.64**	4.06**
6.	Tapi x VRI-1	39.66	43.83	46.33	-9.51**	-14.39**	89.66	96.99	104.66	-7.56**	-14.33**
7.	Tapi x Gopi	43.00	42.66	44.00	0.80	-2.27**	96.00	92.99	96.66	3.24**	-0.68
8.	TKG-21 x RT-46	38.66	42.16	42.66	-8.30**	-9.38**	88.66	91.66	92.66	-3.27**	-4.32**
9.	TKG-21 x Sekhar	41.33	42.33	43.00	-2.36**	-3.88**	92.33	93.33	96.00	-1.07*	-3.82**
10.	TKG-21 x OS sel.2	49.33	42.99	44.33	14.75**	11.28**	109.66	94.49	98.33	16.05**	11.52**
11.	TKG-21 x JLT-54	43.00	41.49	41.66	3.64**	3.22**	97.00	89.83	90.33	7.98**	7.38**
12.	TKG-21 x VRI-1	43.33	43.99	46.33	-1.50*	-6.47**	97.33	97.66	104.66	-0.34	-7.00**
13.	TKG-21 x Gopi	39.66	42.83	44.00	-7.40**	-9.86**	89.66	93.66	96.66	-4.27**	-7.24**
14.	RT-46 x Sekhar	41.00	42.83	43.00	-4.27**	-4.65**	94.67	94.33	96.00	-0.36	-1.39**
15.	RT-46 x OS sel.2	42.66	43.49	44.33	-1.91**	-3.76**	94.66	95.49	98.33	-0.87	-3.73**
16.	RT-46 x JLT-54	42.33	41.99	42.66	0.81	-0.77	95.33	91.49	90.33	4.20**	5.54**
17.	RT-46 x VRI-1	42.00	44.49	46.33	-5.60**	-9.35**	95.00	98.66	104.66	-3.71**	-9.23**
18.	RT-46 x Gopi	38.00	43.33	44.00	-12.30**	-13.64**	96.00	94.66	96.66	-9.15**	-11.03**
19.	Sekhar x OS sel.2	46.00	43.66	44.33	5.36**	3.77**	102.00	97.16	98.33	4.98**	3.73**
20.	Sekhar x JLT-54	42.66	42.16	43.00	1.19*	-0.79	95.66	93.16	96.0	2.68**	-0.35
21.	Sekhar x VRI-1	46.00	44.66	46.33	3.00**	-0.71	102.00	100.33	104.66	1.66**	-2.54**
22.	Sekhar x Gopi	42.33	43.50	44.00	-2.69**	-3.79**	94.33	96.33	96.66	-2.08**	-2.41**
23.	OS sel.2 x JLT-54	48.00	42.83	44.33	12.07**	8.28**	106.00	94.33	98.33	12.37**	7.80**
24.	OS sel.2 x VRI-1	47.00	45.33	46.33	3.68**	1.45*	104.00	101.49	104.66	2.47**	-0.63
25.	OS sel.2 x Gopi	46.33	44.16	44.33	4.91**	4.51**	103.33	97.49	98.33	5.99**	5.08**
26.	JLT-54 x VRI-1	43.66	43.83	46.33	-0.39	-5.76**	97.66	97.49	104.66	0.17	-6.69**
27.	JLT-54 x Gopi	44.66	42.66	44.00	4.69**	1.50*	98.66	93.49	96.66	5.53**	2.07**
28.	VRI-1 x Gopi	47.00	45.16	46.33	4.07**	1.45*	102.33	100.66	14.66	1.66**	-2.23**
	S.E.				0.57	0.66				0.52	0.60

* Significant at 5 % level ** Significant at 1 % level

Table 3A. Heterosis in reciprocal crosses of sesamum for days to 50 % flowering and days to maturity

Sr. No.	Reciprocal crosses	Number of days to 50 % flowering					Days to maturity				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	TKG-21 x Tapi	47.00	41.49	41.6	13.28**	12.82**	104.00	89.99	90.66	15.57**	14.71**
2.	RT-46 x Tapi	43.33	41.99	42.66	3.19**	1.57*	95.33	90.99	92.66	4.77**	2.88**
3.	RT-46 x TKG-21	40.66	42.16	42.66	-3.56**	-4.69**	90.66	91.66	92.66	-1.09*	-2.16**
4.	Sekhar x Tapi	42.66	42.16	43.00	1.19*	-0.79	95.66	92.66	96.00	3.24**	-0.35
5.	Sekhar x TKG-21	44.00	42.33	43.00	3.94**	2.33**	97.00	93.33	96.00	3.93**	1.04
6.	Sekhar x RT-46	42.66	42.83	43.00	-0.40	-0.79	94.66	94.33	96.00	0.35	-1.39*
7.	OS sel.2 x Tapi	47.33	42.83	44.33	10.51**	6.77**	105.33	93.83	98.33	12.26**	7.12**
8.	OS sel.2 x TKG-21	47.33	42.99	44.33	10.09**	6.77**	105.33	94.49	98.33	11.47**	7.12**
9.	OS sel.2 x RT-46	45.66	43.49	44.33	4.98**	3.00**	101.33	95.49	98.33	8.21**	5.08**
10.	OS sel.2 x Sekhar	47.00	43.66	44.33	7.65**	6.02**	104.00	97.16	98.33	7.03**	5.77**
11.	JLT-54 x Tapi	46.66	41.33	41.33	12.90**	12.90**	102.33	89.83	90.33	13.91**	13.28**
12.	JLT-54 x TKG-21	46.00	41.49	41.66	10.87**	10.42**	102.00	89.83	90.33	13.55**	12.91**
13.	JLT-54 x RT-46	48.00	41.99	42.66	14.31**	12.52**	106.00	91.49	90.33	15.85**	14.39**
14.	JLT-54 x Sekhar	43.66	42.16	43.00	3.56**	1.53*	94.00	93.16	96.00	0.90	-2.08**
15.	JLT-54 x OS sel.2	44.33	42.83	44.33	3.50**	0.00	97.33	94.33	98.33	3.18**	-1.02
16.	VRI-1 x Tapi	50.00	43.83	46.33	14.07**	7.92**	110.00	96.99	104.66	13.41**	5.10**
17.	VRI-1 x TKG-21	50.00	43.99	46.33	13.66**	7.92**	110.00	97.66	104.66	12.63**	5.10**
18.	VRI-1 x RT-46	46.00	44.49	46.33	3.39**	-0.71	102.00	98.66	104.66	3.38**	-2.54**
19.	VRI-1 x Sekhar	46.33	44.66	46.33	3.74**	0.00	102.00	100.33	104.66	1.66**	-2.54**
20.	VRI-1 x OS sel.2	50.00	45.33	46.33	10.34**	7.92**	110.00	101.49	104.66	8.38**	5.10**
21.	VRI-1 x JLT-54	43.33	43.83	46.33	-1.14*	-6.47**	96.33	97.49	104.66	-1.19*	-7.96**
22.	Gopi x Tapi	47.00	42.66	44.00	10.17**	6.82**	103.66	92.99	96.66	11.47**	7.24**
23.	Gopi x TKG-21	47.00	42.83	44.0	9.74**	6.82**	104.00	93.66	96.66	11.03**	7.59**
24.	Gopi x RT-46	48.00	43.33	44.00	10.78**	9.09**	106.66	94.66	96.66	12.68**	10.34**
25.	Gopi x Sekhar	47.66	43.50	44.00	9.56**	8.32**	104.00	96.33	96.66	7.96**	7.59**
26.	Gopi x OS. sel.2	43.66	44.16	44.33	-1.13*	-1.51*	97.66	97.49	98.33	0.17	-0.68
27.	Gopi x JLT-54	42.00	42.66	44.00	-1.55**	-4.55**	93.33	93.49	96.66	-0.17	-3.45**
28.	Gopi x VRI-1	46.00	45.16	46.33	1.86**	-0.71	102.00	100.66	104.66	1.33*	-2.54**
	S.E.				0.57	0.66				0.52	0.60

* Significant at 5 % level ** Significant at 1 % level

1 x TKG-21, VRI-1 x O.S. Sel. 2). The range of heterosis was from -3.56 (RT46 x TKG-21) to 14.31 (JLT-54 x RT-46) and -6.47 (VRI-1 x JLT-54) to 12.90 (JLT-54 x Tapi) per cent over M.P. and S.P., respectively.

Twenty three reciprocals appeared to be positively significant over M.P. and eighteen over S.P. while four reciprocals showed negative heterosis over M.P. and S.P. The rest of crosses, however did not show significant heterosis. The cross RT-46 x TKG-21 had maximum negative heterosis over its M.P. while the cross VRI-1 x JLT-54 had maximum negative heterosis over its S.P.

4.2.2 Days to maturity

The range from 89.33 days (Tapi) to 104.66 days (VRI-1) was observed for days for maturity. In F_1's (direct) it ranged from 86 days (RT-46 x Gopi) to 109.66 (TKG-21 x OS Sel.2).

a. F_1's

The range of heterosis was -9.15 (RT-46 x Gopi) to 16.05 (TKG-21 x OS Sel. 2) per cent over M.P. while -14.33 (Tapi x VRI-1) to 11.52 (TKG-21 x OS sel. 2) over S.P. values.

Fifteen crosses showed significant positive heterosis over M.P. and ten crosses showed significant positive heterosis over S.P. values, nine crosses showed significantly negative heterosis over their M.P. values and fifteen crosses showed significantly negative heterosis over S.P. values. The cross RT-46 x Gopi has maximum negative heterosis over its M.P. while the cross Tapi x VRI-1 had maximum negative heteorsis over its S.P.

b. Reciprocals

The maturity period in the reciprocal crosses ranged from 90.66 days (RT-46 x TKG-21) to 110 days (VRI-1 x Tapi, VRI-1 x TKG-21, VRI-1 x OS sel. 2). The extent of heterosis ranged from -1.09 (RT-46x TKG-21) to 15.85 (JLT-54 x RT-46) per cent over M.P., while over S.P. it ranged from -7.96 (VRI-1 x JLT-54) to 14.71 (TKG-21 x Tapi).

Twenty two crosses showed significant positive heterosis over M.P. and sixteen crosses showed significantly positive heterosis over S.P. value, whereas two reciprocal showed significant negative heterosis over M.P. and eight reciprocals exhibited significant negative heterosis over S.P. The reciprocal cross VRI-1 x JLT-54 had maximum negative heterosis over both M.P. as well as S.P.

4.2.3 Plant height (cm)

The plant height in the parents ranged from 95.66 (TKG-21) to 110.42 (JLT-54). In F_1's (direct) it ranged from 96.49 cm (JLT-54 x Gopi) to 124.20 cm (Tapi x JLT-54).

a. F_1's

The range of heterosis was from -11.91 (JLT-54 x Gopi) to 18.19 (TKG-21 x V.R.I.-1) and -12.61 (JLT-54 x Gopi) to 13.07 (Tapi x OS sel.2) per cent over M.P. and S.P., respectively.

Thirteen crosses showed positive and highly significant heterosis and eleven crosses showed significant positive heterobeltiosis, whereas four and nine crosses showed significant negative heterosis over M.P. and S.P., respectively. The cross TKG-21

Table 4. Heterosis in direct crosses of sesamum for plant height and number of branches per plant

Sr. No.	Direct crosses	Plant height (cm)					Number of branches per plant				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	Tapi x TKG-21	100.85	99.30	102.95	1.56	-2.04	2.78	3.99	4.60	-30.33**	-39.57**
2.	Tapi x RT-46	111.50	103.77	104.60	7.45**	6.59**	3.58	4.42	4.60	-19.00**	-22.17**
3.	Tapi x Sekhar	101.00	101.97	102.95	-0.95	-1.89	3.75	4.19	4.60	-10.50**	-18.48**
4.	Tapi x OS sel.2	116.62	103.04	103.14	13.17**	13.07**	4.91	4.30	4.60	14.19**	6.74**
5.	Tapi x JLT-54	124.20	106.68	110.42	16.42**	12.48**	5.78	4.30	4.60	34.42**	25.65**
6.	Tapi x VRI-1	103.80	106.07	109.20	-2.14	-4.95*	3.21	4.80	5.00	-33.13**	-35.80**
7.	Tapi x Gopi	102.62	105.80	108.66	-3.00	-5.56**	3.80	2.85	4.60	33.33**	-17.39**
8.	TKG-21 x RT-46	100.00	100.13	104.60	-0.13	-4.40	3.60	3.81	4.24	-5.51**	-15.09**
9.	TKG-21 x Sekhar	112.60	98.33	101.00	14.51**	11.49**	3.73	3.59	3.79	3.90**	-1.58**
10.	TKG-21 x OS sel.2	113.03	99.40	103.14	13.71**	9.59**	4.99	3.69	4.00	35.23**	24.75**
11.	TKG-21 x JLT-54	100.23	103.04	110.42	-2.73	-9.23**	2.38	3.70	4.01	-35.68**	-40.65**
12.	TKG-21 x VRI-1	121.06	102.43	109.20	18.19**	10.86**	4.25	4.19	5.00	1.43**	-15.00**
13.	TkG-21 x Gopi	107.33	102.16	108.66	5.06**	-1.23	3.68	2.45	3.39	50.20**	8.55**
14.	RT-46 x Sekhar	106.14	12.80	104.60	3.25	1.47	3.04	4.01	4.24	-24.19**	-28.30**
15.	RT-46 x OS sel.2	107.71	103.87	104.60	3.70*	2.97	3.55	4.12	4.24	-13.83**	-16.27**
16.	RT-46 x JLT-54	101.18	107.51	110.42	-5.89**	-8.37**	3.86	4.12	4.24	-6.31**	-8.96**
17.	RT-46 x VRI-1	107.44	106.90	109.20	0.50	-1.61	4.73	4.62	5.00	2.38**	-5.40**
18.	RT-46 x Gopi	102.80	106.63	108.66	-3.59	-5.40**	3.59	2.67	4.24	34.46**	-15.33**
19.	Sekhar x OS sel.2	108.37	102.07	103.14	6.17**	5.07*	4.40	3.89	4.00	13.11**	10.00**
20.	Sekhar x JLT-54	105.75	105.71	110.42	0.04	-4.23*	2.67	3.90	4.01	-31.54**	-33.42**
21.	Sekhar x VRI-1	121.83	105.10	109.20	15.92**	11.57**	5.59	4.39	5.00	27.33**	11.80**
22.	Sekhar x Gopi	98.90	104.83	108.66	-5.66**	-8.99**	3.81	2.44	3.79	56.15**	0.53**
23.	OS sel.2 x JLT-54	123.79	106.78	110.42	15.93**	12.11**	4.11	4.0	4.01	2.75**	2.49**
24.	OS sel.2 x VRI-1	120.79	106.17	109.20	13.78**	10.61**	4.46	4.50	5.00	-0.89**	-10.80**
25.	OS sel.2 x Gopi	113.93	105.90	108.66	7.58**	4.85*	2.52	2.55	4.00	-1.18**	-37.00**
26.	JLT-54 x VRI-1	112.60	109.81	110.42	2.54	1.97	3.60	4.50	5.00	-20.00**	-28.00**
27.	JLT-54 x Gopi	96.49	109.54	110.42	-11.91**	-12.61**	2.50	2.55	4.01	-1.96**	-37.66**
28.	VRI-1 x Gopi	101.00	108.93	109.20	-7.28**	-7.51**	3.36	3.05	5.00	10.16**	-32.80**
	S.E.				1.93	2.23				0.027	0.032

* Significant at 5 % level ** Significant at 1 % level

Table 4A. Heterosis in reciprocal crosses of sesamum for plant height and number of branches per plant

Sr. No.	Reciprocal crosses	Plant height (cm)					No. of branches per plant				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	TKG-21 x Tapi	119.12	99.30	102.95	19.96**	15.71**	3.37	3.99	4.60	-15.54**	-26.74**
2.	RT-46 x Tapi	113.00	103.77	104.60	8.89**	8.03**	4.50	4.42	4.60	1.81**	-2.17**
3.	RT-46 x TKG-21	102.80	100.13	104.60	2.67	-1.72	4.85	3.81	4.24	27.30**	14.39**
4.	Sekhar x Tapi	100.33	101.97	102.95	-1.61	-2.54	3.01	4.19	4.60	-28.16**	-34.57**
5.	Sekhar x TKG-21	98.20	98.33	101.00	-0.13	-2.77	3.05	3.59	3.79	-15.04**	-19.52**
6.	Sekhar x RT-46	98.99	102.80	104.60	-3.71	-5.36*	3.52	4.01	4.24	-12.22**	-16.98**
7.	OS sel.2 x Tapi	107.88	103.04	103.14	4.70*	4.60*	4.40	4.30	4.60	2.33**	-4.35**
8.	OS sel.2 x TKG-21	107.85	99.40	103.14	8.50**	4.57*	4.20	3.69	4.00	13.82**	5.00**
9.	OS sel.2 x RT-46	104.30	103.87	104.60	0.41	-0.29	4.10	4.12	4.24	-0.48**	-3.30**
10.	OS sel.2 x Sekhar	127.55	102.07	103.14	24.96**	23.67**	4.68	3.89	4.00	20.31**	17.00**
11.	JLT-54 x Tapi	96.50	106.68	110.42	-9.54**	-12.61**	2.01	4.30	4.60	-53.26**	-56.30**
12.	JLT-54 x TKG-21	98.20	103.04	110.42	-4.70*	-11.07**	3.51	3.70	4.01	-5.14**	-12.47**
13.	JLT-54 x RT-46	110.33	107.51	110.42	2.62	-0.08	5.38	4.12	4.24	30.58**	26.89**
14.	JLT-54 x Sekhar	100.25	105.71	110.42	-5.16**	-9.21**	3.37	3.90	4.01	-13.59**	-15.96**
15.	JLT-54 x OS sel.2	110.75	106.78	110.42	3.72*	0.30	3.60	4.00	4.01	-10.00**	-10.22**
16.	VRI-1 x Tapi	113.37	106.07	109.20	6.88**	3.82	6.68	4.80	5.00	39.17**	33.60**
17.	VRI-1 x TKG-21	96.14	102.43	109.20	-6.14**	-11.96**	4.05	4.19	5.00	-3.34**	-19.00**
18.	VRI-1 x RT-46	98.80	106.90	109.20	-7.58**	-9.52**	5.84	4.62	5.00	26.41**	16.80**
19.	VRI-1 x Sekhar	121.30	105.10	109.20	15.41**	11.08**	5.06	4.39	5.00	15.26**	1.20**
20.	VRI-1 x OS sel.2	109.22	106.17	109.20	2.87	0.02	4.38	4.50	5.00	-2.67**	-12.40**
21.	VRI-1 x JIT-54	102.13	109.81	110.42	-6.99**	-7.51**	4.59	4.50	5.00	2.00**	-8.20**
22.	Gopi x Tapi	104.00	105.80	108.66	-1.70	-4.29*	3.30	2.85	4.60	15.79**	-28.28**
23.	Gopi x TKG-21	99.86	102.16	108.66	-2.25	-8.10**	4.40	2.24	3.39	96.43**	29.79**
24.	Gopi x RT-46	101.83	106.63	108.66	-4.50*	-6.29**	5.49	2.67	4.24	105.62**	29.48**
25.	Gopi x Sekhar	105.00	104.83	108.66	0.16	-3.37	2.58	2.44	3.79	5.74**	-31.93**
26.	Gopi x OS. sel.2	113.47	105.90	108.66	7.15**	4.43*	2.60	2.55	4.00	1.96**	-35.00**
27.	Gopi x JLT-54	112.19	109.54	110.42	2.42	1.60	3.40	2.55	4.01	33.33**	-15.21**
28.	Gopi x VRI-1	126.33	108.93	109.20	15.97**	15.69**	5.03	3.05	5.00	64.92**	0.60**
	S.E.				1.93	2.23				0.027	0.032

* Significant at 5 % level ** Significant at 1 % level

x VRI-1 and Tapi x OS sel.2 had maximum positive heterosis over M.P. and S.P., respectively.

b. Reciprocals

The values for plant height in reciprocals ranged form 96.14 (VRI-1 x TKG-21) to 127.55 (OS sel.2 x Sekhar). The extent of heterosis ranged from -9.54 (JLT-54 x Tapi) to 24.96 (OS sel.2 x Sekhar) and -12.61 (JLT-54 x Tapi) to 23.67 (OS sel. 2 x Sekhar) per cent over M.P. and S.P., respectively.

Nine and eight reciprocals exhibited significant positive heterosis over M.P. and S.P., respectively, whereas seven reciprocals over M.P. and ten reciprocals over S.P. showed significant negative heterosis. Reciprocal cross OS sel.2 x Sekhar had maximum positive heterosis and heterobeltiosis.

4.2.4 Number of branches per plant

Number of branches among the parents ranged from 1.10 (Gopi) to 5.00 (VRI-1), while among F_1's (direct) it ranged from 2.38 (TKG-21 x JLT-54) to 5.78 (Tapi x JLT-54).

a. F_1's

The extent of heterosis in F_1's ranged between -35.68 (TKG-21 x JLT-54) to 56.15 (Sekhar x Gopi) and –40.65 (TKG-21 x JLT-54) to 25.65 (Tapi x JLT-54) per cent over M.P. and S.P., respectively.

Fourteen crosses over M.P. and eight crosses over S.P. showed highly significant positive heterosis, while fourteen crosses over M.P. and twenty crosses over S.P. showed significant negative heterosis. Hybrid Sekhar x Gopi had maximum positive heterosis over

M.P. and hybrid Tapi x JLT-54 had maximum positive heterosis over S.P.

b. Reciprocals

The number of branches in reciprocal crosses ranged from 2.01 (JLT-54 x Tapi) to 6.68 (VRI-1 x Tapi). Extent of heterosis ranged from -53.26 (JLT-54 x Tapi) to 105.62 (Gopi x RT-46) and -56.30 (JLT-54 x Tapi) to 33.60 (VRI-1 x Tapi) over M.P. and S.P., respectively.

Seventeen crosses over M.P. and ten crosses over S.P. showed highly significant positive heterosis, while eleven crosses over M.P. and eighteen crosses over S.P. showed significant negative heterosis. The cross combination Gopi x RT-46 and VRI-1 x Tapi had maximum positive heterosis over M.P. and S.P., respectively.

4.2.5 Number of capsules per plant

The range of variation for number of capsules per plant was very wide. The eight parents selected for the present study showed a range of 32.85 (Gopi) to 68.62 (Tapi) for this character. In F_1 (direct) it ranged from 40.49 (JLT-54 x Gopi) to 96.08 (Tapi x JLT-54).

a. F_1's

The extent of heterosis exhibited by F_1's ranged from -30.36 (Tapi x VRI-1) to 74.49 (Sekhar x VRI-1) and -39.48 (Tapi x VRI-1) to 66.46 (Sekhar x VRI-1) per cent over M.P. and S.P., respectively.

Fourteen crosses over M.P. and thirteen crosses over S.P. showed highly significant positive heterosis whereas four crosses over M.P. and ten crosses over S.P. showed negative heterosis. The cross

Table 5. Heterosis in direct crosses of sesamum for number of capsules per plant and length of capsule

Sr. No.	Direct crosses	Number of capsules per plant					Length of capsule (cm)				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	Tapi x TKG-21	41.85	58.81	68.62	-28.84**	-39.01**	3.15	3.15	3.30	0.00	-4.55**
2.	Tapi x RT-46	65.20	65.93	68.62	-1.11	-4.98	2.65	3.15	3.30	-15.87**	-19.70**
3.	Tapi x Sekhar	60.80	57.31	68.62	6.09	-11.40**	2.95	2.92	3.00	1.03**	-1.67**
4.	Tapi x OS sel.2	78.20	63.52	6862	23.11**	13.96**	2.90	2.90	3.00	0.00	-3.33**
5.	Tapi x JLT-54	96.08	58.91	68.62	63.10**	40.02**	2.90	3.08	3.16	-5.84**	-8.23**
6.	Tapi x VRI-1	41.53	59.64	68.62	-30.36**	-39.48**	2.70	2.70	3.00	0.00	-10.00**
7.	Tapi x Gopi	73.80	50.73	68.62	45.43**	7.55*	2..83	3.00	3.00	-5.67**	-5.67**
8.	TKG-21 x RT-46	44.50	56.12	63.25	-21.71**	-29.64**	2.63	3.30	3.30	-20.30**	-20.30**
9.	TKG-21 x Sekhar	64.86	47.50	49.00	36.55*	32.37**	2.90	3.07	3.30	-5.54**	-12.12**
10.	TKG-21 x OS sel.2	92.86	53.71	58.42	72.89**	58.95**	2.80	3.05	3.30	-8.20**	-15.15**
11.	TKG-21 x JLT-54	43.80	49.10	49.20	-10.79**	-10.98**	2.60	3.23	3.30	-19.50**	-21.21**
12.	TKG-21 x VRI-1	54.66	49.83	50.66	9.69**	7.89**	2.45	2.85	3.30	-14.04**	-25.76**
13.	TKG-21 x Gopi	41.79	40.92	49.00	2.13	-14.71**	2.70	3.15	3.30	-14.29**	-18.18**
14.	RT-46 x Sekhar	54.33	54.62	63.25	-0.53	-14.10**	2.90	3.07	3.30	-5.54**	-12.12**
15.	RT-46 x OS sel.2	59.57	60.83	63.25	-2.07	-5.82	2.80	3.05	3.30	-8.20**	-15.15**
16.	RT-46 x JLT-54	76.87	56.22	63.25	36.73**	21.53**	3.00	3.23	3.30	-7.12**	-9.09**
17.	RT-46 x VRI-1	84.66	56.95	63.25	48.66**	33.85**	2.60	2.85	3.30	-8.77**	-21.21**
18.	RT-46 x Gopi	45.66	48.05	63.25	-4.97	-27.81**	2.85	3.15	3.30	-9.52**	-13.64**
19.	Sekhar x OS sel.2	60.62	52.21	58.42	16.11**	3.77	3.06	2.82	2.85	8.51**	7.37**
20.	Sekhar x JLT-54	50.08	47.60	49.20	5.21	1.79	3.15	3.00	3.16	5.00**	-0.32**
21.	Sekhar x VRI-1	84.33	48.33	50.66	74.49**	66.46**	2.84	2.62	2.85	8.40**	-0.35**
22.	Sekhar x Gopi	65.83	39.42	46.00	67.00**	43.11**	2.92	2.92	3.00	0.00	-2.67**
23.	OS sel.2 x JLT-54	72.18	53.81	58.42	34.14**	23.55**	3.20	2.98	3.16	7.38**	1.27**
24.	OS sel.2 x VRI-1	73.33	54.54	58.42	34.45**	25.52**	2.95	2.60	2.80	13.46**	5.36**
25.	OS sel.2 x Gopi	76.00	45.63	58.42	66.56**	30.09**	3.00	2.90	3.00	3.45**	0.00
26.	JLT-54 x VRI-1	48.60	49.93	50.66	-2.66	-4.07	3.38	2.78	3.16	21.58**	6.96**
27.	JLT-54 x Gopi	40.49	41.02	49.20	-1.29	-17.70**	2.83	3.08	3.16	-8.12**	-10.44**
28.	VRI-1 x Gopi	44.16	41.75	50.66	5.77	-12.83**	2.45	2.70	3.00	-9.26**	-18.33**
	S.E.				3.19	3.68				0.077	0.089

* Significant at 5 % level ** Significant at 1 % level

Table 5A. Heterosis in reciprocal crosses of sesamum for number of capsules per plant and length of capsule

Sr. No.	Reciprocal crosses	Number of capsules per plant					Length of capsule (cm)				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	TKG-21 x Tapi	59.50	58.81	68.62	1.17	-13.29**	2.85	3.15	3.30	-9.52**	-13.64**
2.	RT-46 x Tapi	68.90	65.93	68.62	4.50	0.41	3.05	3.15	3.30	-3.17**	-7.58**
3.	RT-46 x TKG-21	62.55	56.12	63.25	11.46**	-1.11	2.70	3.30	3.30	-18.18**	-18.18**
4.	Sekhar x Tapi	47.66	57.31	68.62	-16.84**	-30.55**	2.90	2.92	3.00	-0.68**	-3.33**
5.	Sekhar x TKG-21	45.00	47.50	49.00	-5.26	-8.16*	2.84	3.07	3.30	-7.49**	-13.94**
6.	Sekhar x RT-46	39.66	54.62	63.25	-27.39**	-37.29**	2.75	3.07	3.30	-10.42**	-16.67**
7.	OS sel.2 x Tapi	70.46	63.52	68.62	10.92**	2.68	3.08	2.90	3.00	6.21**	2.67**
8.	OS sel.2 x TKG-21	72.42	53.71	58.42	34.83**	23.96**	2.70	3.05	3.30	-11.48**	-18.18**
9.	OS sel.2 x RT-46	73.50	60.83	63.25	20.83**	16.21**	2.90	3.05	3.30	-4.92**	-12.12**
10.	OS sel.2 x Sekhar	92.77	52.21	58.42	77.69**	58.80**	3.00	2.82	2.85	6.38**	5.26**
11.	JLT-54 x Tapi	41.00	58.91	68.62	-30.40**	-40.25**	2.90	3.08	3.16	-5.84*	-8.23*
12.	JLT-54 x TKG-21	44.00	49.10	49.20	-10.39**	-10.57**	2.70	3.23	3.30	-16.41**	-18.18**
13.	JLT-54 x RT-46	78.00	56.22	63.25	38.71**	23.32**	2.95	3.23	3.30	-8.67**	-10.61**
14.	JLT-54 x Sekhar	71.41	47.60	49.20	50.02**	45.14**	2.75	3.00	3.16	-8.33**	-12.97**
15.	JLT-54 x OS sel.2	43.12	53.81	58.42	-19.80**	-26.19**	2.80	2.98	3.16	-6.04**	-11.39**
16.	VRI-1 x Tapi	102.00	59.64	68.62	71.02**	48.64**	2.70	2.70	3.00	0.00	-10.00**
17.	VRI-1 x TKG-21	68.11	49.83	50.66	36.68**	34.44**	2.65	2.85	3.30	-7.02**	-19.70**
18.	VRI-1 x RT-46	83.00	56.95	63.25	45.74**	31.22**	2.30	2.85	3.30	-19.30**	-30.30**
19.	VRI-1 x Sekhar	134.11	48.33	50.66	177.49**	164.72**	2.85	2.62	2.85	8.78**	0.00
20.	VRI-1 x OS sel.2	86.00	54.54	58.42	57.68**	47.21**	2.80	2.60	2.80	7.69**	0.00
21.	VRI-1 x JLT-54	58.50	49.93	50.66	17.16**	15.48**	2.85	2.78	3.16	2.52**	-9.81**
22.	Gopi x Tapi	42.00	50.73	68.62	-17.21**	-38.79**	2.86	3.00	3.0	-4.67**	-4.67**
23.	Gopi x TKG-21	64.40	40.92	49.00	57.38**	31.43**	3.10	3.15	3.30	-1.59**	-6.06**
24.	Gopi x RT-46	64.33	48.05	63.25	33.88**	1.71	3.10	3.15	3.30	-1.59**	-6.06**
25.	Gopi x Sekhar	45.33	39.42	46.00	14.99**	-1.46	2.80	2.92	3.00	-4.11**	-6.67**
26.	Gopi x OS. sel.2	56.60	45.63	58.42	24.04**	-3.12	3.10	2.90	3.00	6.90**	3.33**
27.	Gopi x JLT-54	71.11	41.02	49.20	73.35**	44.53**	3.05	3.08	3.16	-0.97**	-3.48**
28.	Gopi x VRI-1	74.22	41.75	50.66	77.77**	46.51**	3.06	2.70	3.00	13.33**	2.00**
	S.E.				3.19	3.68				0.077	0.089

* Significant at 5 % level ** Significant at 1 % level

combination Sekhar x VRI-1 (74.49, 66.46) had maximum positive heterosis over both M.P. and S.P.

b. Reciprocals

Among the reciprocal crosses, the range for number of capsules per plant was from 39.66 (Sekhar x RT-46) to 134.11 (VRI-1 x Sekhar). The range of heterosis exhibited by reciprocals was from -30.40 (JLT-54 x Tapi) to 177.49 (VRI-1 x Sekhar) and -40.25 (JLT-54 x Tapi) to 164.72 (VRI-1 x Sekhar) per cent over M.P. and S.P., respectively.

Nineteen reciprocals over M.P. and fourteen over S.P. indicated highly significant positive heterosis while six reciprocals over M.P. and eight reciprocals over S.P. showed significant negative heterosis. The reciprocal cross VRI-1 x Sekhar had maximum positive heterosis for number of capsules per plant over M.P. and S.P.

4.2.6 Length of capsule (cm)

The parents showed a range of 2.40 (VRI-1) to 3.30 (RT-46 and TKG-21) for this character. In F_1 (direct) it ranged from 2.45 cm (TKG-21 x VRI-1, VRI-1 x Gopi) to 3.38 cm (JLT-54 x VRI-1).

a. F_1's

The extent of heterosis exhibited by F_1's for length of capsule ranged from -20.30 (TKG-21 x RT-46) to 21.58 (JLT-54 x VRI-1) per cent. Over their corresponding M.P. values, while -25.76 (TKG-21 x VRI-1) to 7.37 (Sekhar x OS sel. 2) per cent over their respective S.P. values.

Eight and four crosses exhibited highly significant positive heterosis over M.P. and S.P., respectively. Whereas sixteen crosses exhibited significant negative heterosis over their corresponding M.P. value and twenty three crosses exhibited significant negative heterosis over their corresponding S.P. values. The cross JLT-54 x VRI-1 showed maximum positive heterosis over M.P. and the cross Sekhar x OS sel.2 had maximum positive heterosis over S.P. for this character.

b. Reciprocals

The range for capsule length of reciprocal crosses was from 2.30 (VRI-1 x RT-46) to 3.10 (Gopi x TKG-21, Gopi x RT-46, Gopi x OS sel.2). The range of heterosis was from -19.30 (VRI-1 x RT-46) to 13.33 (Gopi x VRI-1) and -30.30 (VRI-1 x RT-46) to 5.26 (OS sel.2 x Sekhar) per cent over their corresponding M.P. and S.P. values.

Seven reciprocals over M.P. and four reciprocals over S.P. showed highly significant positive heterosis while, twenty and twenty two reciprocals showed significant and negative heterosis over their respective M.P. and S.P. values. The reciprocal crosses Gopi x VRI-1 had maximum positive heterosis over M.P. and OS sel.2 x Sekhar had maximum positive heterosis over S.P. for this character.

4.2.7 Number of seeds per capsule

The number of seeds per capsule among the parents ranged from 55.06 (OS sel.2) to 70.33 (RT-46), while in the F_1's (direct) it ranged form 58.50 (Tapi x TKG-21) to 77.60 (OS sel.2 x JLT-54).

a. F_1's

The extent of heterosis in F_1's ranged from -9.32 (Tapi x TKG-21) to 40.12 (OS Sel.2 x JLT-54) per cent over M.P. values and -

Table 6. Heterosis in direct crosses of sesamum for number of seeds per capsule and yield per plant

Sr. No.	Direct crosses	No. of seeds per capsule					Yield per plant (g)				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	Tapi x TKG-21	58.50	64.51	66.20	-9.32**	-11.63**	7.26	9.43	12.22	-23.01**	-40.59**
2.	Tapi x RT-46	61.60	66.58	70.33	-7.48**	-12.41**	13.01	11.06	12.22	17.63**	6.46**
3.	Tapi x Sekhar	63.76	62.76	62.83	1.59**	1.48**	17.88	10.00	12.22	78.80**	46.32**
4.	Tapi x OS sel.2	66.76	58.94	62.83	13.26**	6.25**	14.17	10.56	12.22	34.19**	15.96**
5.	Tapi x JLT-54	63.33	59.26	62.83	6.87**	0.80*	20.52	10.18	12.22	101.57**	67.92**
6.	Tapi x VRI-1	65.03	61.13	62.83	6.38**	3.50**	8.23	9.38	12.22	-12.26**	-32.65**
7.	Tapi x Gopi	63.13	61.04	62.83	3.42**	0.48	9.84	9.51	12.22	3.47**	-19.48**
8.	TKG-21 x RT-46	66.26	68.26	70.33	-2.93**	-5.79**	6.91	8.27	9.90	-16.44**	-30.20**
9.	TKG-21 x Sekhar	67.86	64.45	66.20	5.29**	2.51*	11.06	7.22	7.79	53.19**	41.98**
10.	TKG-21 x OS sel.2	64.63	60.63	66.20	6.60**	-2.37**	18.02	7.77	8.90	131.92**	102.47**
11.	TKG-21 x JLT-54	63.80	60.95	66.20	4.68**	-3.63**	13.24	7.40	8.15	78.92**	62.45**
12.	TKG-21 x VRI-1	65.83	62.81	66.20	4.81**	-0.56	10.96	6.59	6.65	66.31**	64.81**
13.	TKG-21 x Gopi	67.63	62.73	66.20	7.81**	2.16**	7.63	6.72	6.80	13.54**	12.20**
14.	RT-46 x Sekhar	61.93	66.51	70.33	-6.89**	-11.94**	9.92	8.84	9.90	12.22**	0.20
15.	RT-46 x OS sel.2	60.60	62.69	70.33	-3.33**	-13.83**	12.02	9.40	9.90	27.87**	21.41**
16.	RT-46 x JLT-54	69.93	63.01	70.33	10.98**	-0.57	14.97	9.02	9.90	65.96**	51.21**
17.	RT-46 x VRI-1	66.63	64.88	70.33	2.70**	-5.26**	21.60	8.22	9.90	162.77**	118.18**
18.	RT-46 x Gopi	62.53	64.79	70.33	-3.49**	-11.09**	8.08	8.35	.90	-3.23**	-18.38**
19.	Sekhar x OS sel.2	67.76	58.88	62.70	15.08**	8.07**	9.53	8.34	8.90	14.27**	7.08**
20.	Sekhar x JLT-54	63.60	59.20	62.70	7.43**	1.44**	8.71	7.97	8.15	9.28**	6.87**
21.	Sekhar x VRI-1	65.63	61.06	62.70	7.48**	4.67**	11.66	7.16	7.79	62.85**	49.68**
22.	Sekhar x Gopi	67.13	60.98	62.70	10.08**	7.07**	11.21	7.29	7.79	53.77**	17.87**
23.	OS sel.2 x JLT-54	77.60	55.38	55.70	40.12**	39.32**	10.49	8.52	8.90	87.05**	62.25**
24.	OS sel.2 x VRI-1	62.56	57.24	59.43	9.29**	5.27**	14.44	7.72	8.90	87.05**	62.26**
25.	OS sel.2 x Gopi	68.96	57.16	59.26	20.64**	16.37**	10.25	7.85	8.90	30.57**	15.17**
26.	JLT-54 x VRI-1	70.96	57.56	59.43	23.28**	19.40**	8.63	7.34	8.15	17.57**	5.89**
27.	JLT-54 x Gopi	69.83	57.48	59.26	21.48**	17.84**	8.16	7.47	8.15	9.24**	0.12
28.	VRI-1 x Gopi	61.26	59.34	59.43	3.23**	3.08**	8.10	6.67	6.80	21.44**	19.12**
	S.E.				0.29	0.33				0.29	0.34

* Significant at 5 % level ** Significant at 1 % level

Table 6A. Heterosis in reciprocal crosses of sesamum for number of seeds per capsule and yield per plant

Sr. No.	Reciprocal crosses	No. of seeds per capsule					Yield per plant				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	TKG-21 x Tapi	57.80	64.51	66.20	-10.40**	-12.69**	12.39	9.43	12.22	31.39**	1.39**
2.	RT-46 x Tapi	67.00	66.58	70.33	0.63*	-4.73**	15.52	11.06	12.22	40.32**	27.00**
3.	RT-46 x TKG-21	63.40	68.26	70.33	-7.12**	-9.85**	9.33	8.27	9.90	12.82**	-5.76**
4.	Sekhar x Tapi	61.80	62.76	62.83	-1.53**	-1.64**	9.71	10.00	12.22	-2.90**	-20.54**
5.	Sekhar x TKG-21	56.80	64.45	66.20	-11.87**	-14.20**	6.94	7.22	7.79	-3.88**	-10.91**
6.	Sekhar x RT-46	70.80	66.51	70.33	6.45**	0.67*	12.39	8.84	9.90	40.16**	25.15**
7.	OS sel.2 x Tapi	68.60	58.94	62.83	16.39**	9.18**	17.20	10.56	12.22	62.88**	40.75**
8.	OS sel.2 x TKG-21	64.03	60.63	66.20	5.61**	-3.28**	17.16	7.77	8.90	120.85**	92.81**
9.	OS sel.2 x RT-46	68.40	62.69	70.33	9.11**	-2.74**	12.71	9.40	9.90	35.21**	28.33**
10.	OS sel.2 x Sekhar	62.60	58.88	62.70	6.32**	-0.16	19.38	8.34	8.90	132.37**	117.75**
11.	JLT-54 x Tapi	65.20	59.26	70.33	10.02**	-7.29**	6.93	10.18	12.22	-31.92**	-43.29**
12.	JLT-54 x TKG-21	59.60	60.95	66.20	-2.21**	-9.97**	6.84	7.40	8.15	-7.57**	-16.07**
13.	JLT-54 x RT-46	67.93	63.01	70.33	7.81**	-3.41**	16.17	9.02	9.90	79.27**	63.33**
14.	JLT-54 x Sekhar	62.22	59.20	62.70	5.10**	-0.76*	11.80	7.97	8.15	48.06**	44.79**
15.	JLT-54 x OS sel.2	63.00	55.38	55.70	13.76**	13.10**	7.48	8.52	8.90	-12.21**	-15.96**
16.	VRI-1 x Tapi	64.80	61.13	62.83	6.00**	3.13**	19.41	9.38	12.22	106.93**	58.84**
17.	VRI-1 x TKG-21	60.20	62.81	66.20	-4.16**	-9.06**	8.12	6.59	6.65	23.22**	22.11**
18.	VRI-1 x RT-46	57.80	64.88	70.33	-10.91**	-17.82**	11.72	8.22	9.90	42.58**	18.38**
19.	VRI-1 x Sekhar	63.00	61.06	62.70	3.18**	0.48	22.55	7.16	7.79	214.94**	189.47**
20.	VRI-1 x OS sel.2	64.00	57.24	59.43	11.81**	7.69**	10.69	7.72	8.90	38.47**	20.11**
21.	VRI-1 x JLT-54	61.80	57.56	59.43	7.37**	3.99**	15.53	7.34	8.15	111.58**	90.55**
22.	Gopi x Tapi	59.80	61.04	62.83	-2.05**	-4.82**	8.27	9.51	12.22	-13.04**	-32.32**
23.	Gopi x TKG-21	65.56	62.73	66.20	4.51**	-0.97**	15.83	6.72	6.80	135.57**	132.79**
24.	Gopi x RT-46	62.60	64.79	70.33	-3.38**	-10.99**	11.67	8.35	9.90	39.76**	17.88**
25.	Gopi x Sekhar	59.00	60.98	62.70	-3.25**	-5.90**	6.66	7.29	7.79	-8.64**	-14.51**
26.	Gopi x OS. sel.2	68.00	57.16	59.26	18.98**	14.75**	7.08	7.85	8.90	-9.81**	-20.45**
27.	Gopi x JLT-54	67.40	57.48	59.26	17.26**	13.74**	18.12	7.47	8.15	142.57**	122.33**
28.	Gopi x VRI-1	65.00	59.34	59.43	9.54**	9.37**	17.40	6.67	8.80	160.87**	155.88**
	S.E.				0.29	0.33				0.29	0.34

* Significant at 5 % level ** Significant at 1 % level

-13.83 (RT-46 x OS sel.2) to 39.32 (OS sel.2 x JLT-54) per cent over S.P.

Twenty two and sixteen crosses showed highly significant positive heterosis and heterobeltiosis, respectively, while six and nine crosses showed negative heterosis and heterobeltiosis, respectively. The cross OS sel.2 x JLT-54 showed maximum heterosis over both the M.P. and S.P.

b. Reciprocals

The number of seeds per capsule in reciprocal crosses ranged from 56.80 (Sekhar x TKG-21) to 70.80 (Sekhar x RT-46). The extent of heterosis ranged from -11.87 (Sekhar x TKG-21) to 18.98 (Gopi x OS sel.2) and -17.82 (VRI-1 x RT-46) to 14.75 (Gopi x OS sel.2) per cent over their corresponding M.P. values and over their corresponding S.P. values, respectively.

Eighteen and nine reciprocal crosses showed significant positive heterosis over M.P. and S.P., respectively. However, ten and seventeen reciprocal crosses showed significant negative heterosis over M.P. and S.P., respectively. The reciprocal Gopi x OS sel.2 exhibited maximum positive heterosis over M.P. and S.P.

4.2.8 Yield per plant (g)

Great variability was observed in the parents for seed yield per plant. It ranged from 6.54 g (VRI-1) to 12.22 g (Tapi) in the parents, while in F_1's it ranged from 6.91 g (TKG-21 x RT-46) to 21.60 g (RT-46 x VRI-1).

a. F_1's

The extent of heterosis ranged from -23.01 (Tapi x TKG-21) to 162.77 (RT-46 x VRI-1) and -40.59 (Tapi x TKG-21) to 118.18 (RT-46 x VRI-1) per cent over M.P. and S.P., respectively.

Twenty four crosses and twenty one crosses exhibited highly significant positive heterosis over M.P. and S.P., respectively while four and five crosses showed significant negative heterosis over M.P. and S.P. The cross combination RT-46 x VRI-1 expressed maximum positive heterosis over M.P. and S.P.

b. Reciprocals

Yield per plant in the reciprocal crosses ranged from 6.66 (Gopi x Sekhar) to 22.55 g (VRI-1 x Sekhar). The extent of heterosis ranged from -31.92 (JLT-54 x Tapi) to 214.94 (VRI-1 x Sekhar) and -43.29 (JLT-54 x Tapi) to 189.47 (VRI-1 x Sekhar) per cent over its M.P. and S.P. values, respectively.

Twenty and nineteen reciprocal crosses showed highly significant positive heterosis over M.P. and S.P. However eight and nine reciprocal crosses showed significant negative heterosis over M.P. and S.P., respectively. The reciprocal cross VRI-1 x Sekhar manifested maximum beneficial heterosis over M.P. as well as S.P.

4.2.9 1000 seed weight (g)

Among the parents 1000 seed weight ranged from 2.66 g (VRI-1) to 3.22 g (JLT-54). While in F_1's (direct) it ranged from 2.56 g (RT-46 x OS sel.2) to 3.54 g (JLT-54 x VRI-1).

Table 7. Heterosis in direct crosses of sesamum for 1000 seed weight and oil content (%)

Sr. No.	Direct crosses	1000 seed weight (g)					Oil content (%)				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	Tapi x TKG-21	3.25	3.01	3.16	7.97**	2.85**	46.70	46.97	49.90	-0.57**	-6.41**
2.	Tapi x RT-46	2.77	2.99	3.12	-7.36**	-11.22**	40.76	43.61	44.05	-6.53**	-7.47**
3.	Tapi x Sekhar	2.92	2.91	2.96	0.34**	-1.35**	48.63	44.05	44.06	10.40**	10.37*
4.	Tapi x OS sel.2	2.66	2.83	2.86	-6.00**	-6.99**	51.41	46.59	49.14	10.35**	4.62**
5.	Tapi x JLT-54	3.38	3.04	3.22	11.18**	4.97**	49.59	43.92	44.05	12.91**	12.58**
6.	Tapi x VRI-1	3.30	2.76	2.86	19.57**	15.38**	48.79	44.55	45.05	9.52**	8.30**
7.	Tapi x Gopi	3.20	3.03	3.21	5.61**	-0.31**	49.22	42.27	44.05	16.44**	11.74**
8.	TKG-21 x RT-46	2.87	3.14	3.16	-8.60**	-9.18**	50.12	46.53	49.90	7.71**	0.44**
9.	TKG-21 x Sekhar	3.23	3.06	3.16	5.56**	2.22**	42.39	46.98	49.90	-9.77**	-15.05**
10.	TKG-21 x OS sel.2	3.29	2.98	3.16	10.40**	4.11**	50.24	49.52	49.90	1.45**	0.68**
11.	TKG-21 x JLT-54	3.02	3.19	3.22	-5.33**	-6.21**	50.19	46.85	49.90	7.14**	0.58**
12.	TKG-21 x VRI-1	2.94	2.91	3.16	1.03**	-6.96**	48.02	47.47	49.90	1.14**	-3.77**
13.	TKG-21 x Gopi	3.12	3.18	3.21	-1.89**	-2.80**	49.20	45.19	49.90	8.87**	-1.40**
14.	RT-46 x Sekhar	3.21	3.04	3.12	5.59**	2.88**	49.04	43.61	44.06	12.47**	11.30**
15.	RT-46 x OS sel.2	2.56	2.96	3.12	-13.51**	-17.95**	51.60	46.15	49.14	11.81**	12.85**
16.	RT-46 x JLT-54	3.14	3.17	3.22	-0.95**	-2.48**	43.84	43.48	43.80	0.83**	0.09**
17.	RT-46 x VRI-1	2.93	2.89	3.12	1.38**	-6.09**	52.08	44.11	45.05	18.07**	15.60**
18.	RT-46 x Gopi	3.15	3.16	3.21	-0.32**	-1.87**	51.80	41.83	43.17	23.83**	19.99**
19.	Sekhar x OS sel.2	2.82	2.88	2.96	-2.08**	-4.73**	52.79	46.60	49.14	13.28**	7.43**
20.	Sekhar x JLT-54	3.51	3.09	3.22	13.59**	9.00**	51.60	43.93	44.06	17.46**	17.11**
21.	Sekhar x VRI-1	2.98	2.81	2.96	6.05**	0.68**	46.20	44.55	45.05	3.70**	2.55**
22.	Sekhar x Gopi	3.30	3.08	3.21	7.14**	2.80**	47.60	42.27	44.06	12.61**	8.03**
23.	OS sel.2 x JLT-54	3.21	3.01	3.22	6.64**	-0.31**	43.59	46.47	49.14	-6.20**	-11.29**
24.	OS sel.2 x VRI-1	3.40	2.73	2.80	24.54**	21.43**	45.79	47.09	49.14	-2.76**	-6.82**
25.	OS sel.2 x Gopi	2.83	3.00	3.21	-5.67**	-11.84**	50.39	44.81	49.14	12.45**	2.54**
26.	JLT-54 x VRI-1	3.54	2.94	3.22	20.41**	9.94**	50.78	44.42	45.05	14.32**	12.72**
27.	JLT-54 x Gopi	2.92	3.21	3.22	-9.03**	-9.32**	45.60	42.14	43.80	8.21**	4.11**
28.	VRI-1 x Gopi	2.90	2.93	3.21	-1.02**	-9.66**	41.20	42.77	45.05	-3.67**	-8.55**
	S.E.				0.008	0.009				0.028	0.033

* Significant at 5 % level ** Significant at 1 % level

Table 7A. Heterosis in reciprocal crosses of sesamum for 1000 seed weight and oil content (%)

Sr. No.	Reciprocal crosses	1000 seed weight (g)					Oil content (%)				
		F_1	M.P.	S.P.	% heterosis over		F_1	M.P.	S.P.	% heterosis over	
					M.P.	S.P.				M.P.	S.P.
1.	TKG-21 x Tapi	3.01	3.01	3.16	0.00	-4.75**	48.20	46.97	49.90	2.62**	-3.41**
2.	RT-46 x Tapi	3.52	2.99	3.12	17.73**	12.82**	46.24	43.61	44.05	6.03**	4.97**
3.	RT-46 x TKG-21	3.14	3.14	3.16	0.00	-0.63**	50.20	46.53	49.90	7.89**	0.60**
4.	Sekhar x Tapi	3.01	2.91	2.96	3.44**	1.70**	51.18	44.05	44.06	16.19**	16.16**
5.	Sekhar x TKG-21	3.00	3.06	3.16	-1.96**	-5.06**	48.80	46.98	49.90	3.87**	-2.20**
6.	Sekhar x RT-46	3.23	3.04	3.12	6.25**	3.53**	49.59	43.61	40.06	13.71**	12.55**
7.	OS sel.2 x Tapi	2.71	2.83	2.86	-4.24**	-5.24**	49.02	46.59	49.14	5.22**	-0.24**
8.	OS sel.2 x TKG-21	2.80	2.98	3.16	-6.04**	-11.39**	41.60	49.52	49.90	-15.99**	-16.63**
9.	OS sel.2 x RT-46	2.81	2.96	3.12	-5.07**	-9.94**	43.40	46.15	49.14	-5.96**	-11.68**
10.	OS sel.2 x Sekhar	3.08	2.88	2.96	6.94**	4.05**	47.79	46.60	49.14	2.55**	-2.75**
11.	JLT-54 x Tapi	2.57	3.04	3.22	-15.46**	-20.19**	50.29	43.92	44.05	14.50**	14.16**
12.	JLT-54 x TKG-21	2.93	3.19	3.22	-8.15**	-9.00**	50.02	46.85	49.98	6.77**	0.24**
13.	JLT-54 x RT-46	3.28	3.17	3.22	3.47**	1.86**	50.39	43.48	43.88	15.89**	15.05**
14.	JLT-54 x Sekhar	3.10	3.09	3.22	0.32**	-3.73**	51.02	43.93	44.06	16.14**	15.80**
15.	JLT-54 x OS sel.2	2.90	3.01	3.22	-3.65**	-9.94**	44.03	46.47	49.14	-5.25**	-10.40**
16.	VRI-1 x Tapi	2.57	2.76	2.86	-6.88**	-10.14**	50.81	44.55	45.05	14.05**	12.78**
17.	VRI-1 x TKG-21	2.53	2.91	3.16	-13.06**	-19.94**	5.02	47.47	49.90	5.37**	0.24**
18.	VRI-1 x RT-46	2.55	2.89	3.12	-11.76**	-18.27**	42.80	44.11	45.05	-2.97**	-4.99**
19.	VRI-1 x Sekhar	2.75	2.81	2.96	-2.14**	-7.09**	49.21	44.55	45.05	10.46**	9.23**
20.	VRI-1 x OS sel.2	3.03	2.73	2.80	10.99**	8.21**	50.34	47.09	49.14	6.90**	2.44**
21.	VRI-1 x JLT-54	3.13	2.94	3.22	6.46**	-2.80**	49.58	44.42	45.05	11.62**	10.05**
22.	Gopi x Tapi	2.64	3.03	3.21	-12.87**	-1.76**	42.01	42.27	44.05	-0.61**	-4.63**
23.	Gopi x TKG-21	2.67	3.18	3.21	-16.04**	-16.79**	44.34	45.19	49.90	-1.80**	-11.14**
24.	Gopi x RT-46	3.03	3.16	3.21	-4.11**	-5.61**	44.29	41.83	43.17	5.88**	2.59**
25.	Gopi x Sekhar	2.56	3.08	3.21	-16.88**	-20.25**	42.80	42.27	44.06	1.25**	-2.86**
26.	Gopi x OS. sel.2	2.56	3.00	3.21	-14.67**	-20.25**	48.80	44.81	49.14	8.90**	-0.69**
27.	Gopi x JLT-54	3.46	3.21	3.22	7.79**	7.45**	47.39	42.14	43.80	12.46**	8.20**
28.	Gopi x VRI-1	3.70	2.93	3.21	26.28**	15.26**	46.31	42.77	45.05	8.28**	2.80**
	S.E.				0.008	0.009				0.028	0.033

* Significant at 5 % level ** Significant at 1 % level

a. F_1's

The extent of heterosis for this character ranged from -13.51 (RT-46 x OS sel.2) to 24.54 (OS sel.2 x VRI-1) and -17.95 (RT-46 x OS sel.2) to 21.43 (OS sel.2 x VRI-1) per cent over their respective M.P. and S.P. values.

Sixteen and eleven crosses exhibited highly significant positive heterosis over corresponding M.P. and S.P. values, while twelve and seventeen crosses showed significant negative heterosis over their corresponding M.P. and S.P. values. The cross OS sel.2 x VRI-1 showed maximum positive heterosis for 1000 seed weight over both M.P. and S.P. values.

b. Reciprocals

Among the reciprocals, 1000 seed weight ranged from 2.53 (VRI-1 x TKG-21) to 3.70 (Gopi x VRI-1). The extent of heterosis however ranged from -16.88 (Gopi x Sekhar) to 26.28 (Gopi x VRI-1) and -20.25 (Gopi x Sekhar), (Gopi x OS sel.2) to 15.26 (Gopi x VRI-1) per cent over their respective M.P. and S.P. values.

Highly significant positive heterosis was found in ten and eight reciprocals while significantly negative heterosis in sixteen and nineteen reciprocals over the respective M.P. and S.P. values. The reciprocal cross Gopi x VRI-1 showed maximum heterosis for 1000 seed weight over both M.P. and S.P. values.

4.2.10 Oil content (%)

The range of variation for oil content was very small. The eight parents selected for present study showed very narrow range of 40.49 (Gopi) to 49.90 (TKG-21) per cent for this character. The F_1's (direct) however ranged from 40.76 (Tapi x RT-46) to 52.79 (Sekhar x OS sel.2) per cent.

a. F_1's

The extent of heterosis exhibited by F_1's ranged from -9.77 (TKG-21 x Sekhar) to 23.83 (RT-46 x Gopi) and -15.05 (TKG-21 x Sekhar) to 19.99 (RT-46 x Gopi) per cent over corresponding M.P. and S.P. values.

Twenty two and twenty crosses showed highly significant positive heterosis over M.P. and S.P., respectively while six and eight crosses showed significantly negative heterosis over their respective M.P. and S.P. values. The cross RT-46 x Gopi had maximum heterosis over M.P. and S.P. for oil content among all the crosses.

b. Reciprocals

Among the reciprocal crosses, the range for oil content was from 41.60 (OS sel.2 x TKG-21) to 51.18 (Sekhar x Tapi). The range of heterosis exhibited by reciprocals was -15.99 (OS sel.2 x TKG-21) to 16.19 (Sekhar x Tapi) and -16.63 (OS sel.2 x TKG-21) to 16.16 (Sekhar x Tapi) per cent over M.P. values and S.P. values, respectively.

Twenty two and sixteen reciprocals crosses showed highly significant positive heterosis over M.P. and S.P., respectively, whereas six and twelve reciprocals showed significantly negative heterosis over the M.P. and S.P., respectively. The reciprocal cross Sekhar x Tapi had maximum heterosis over both M.P. and S.P. among all the reciprocals.

Table 8. Range of heterosis for 10 characters in sesamum

Sr. No.	Characters	Range			
		Over M.P.		Over S.P.	
		Direct crosses	Reciprocal crosses	Direct crosses	Reciprocal crosses
1.	No. of days for 50 % flowering	-12.30 to 14.75	-3.56 to 14.31	-14.39 to 11.28	-6.47 to 12.90
2.	Days for maturity	-9.15 to 16.05	-1.19 to 15.85	-14.33 to 11.52	-7.96 to 14.71
3.	Plant height (cm)	-11.91 to 18.19	-9.54 to 24.96	-12.61 to 13.07	-12.61 to 23.67
4.	No. of branches per plant	-35.68 to 56.15	-53.26 to 105.62	-40.65 to 25.65	-56.30 to 33.60
5.	No. of capsules per plant	-30.36 to 74.49	-30.40 to 177.49	-39.48 to 66.46	-40.25 to 164.72
6.	Length of capsule (cm)	-20.30 to 21.58	-19.30 to 13.33	-25.76 to 7.37	-30.30 to 5.26
7.	No. of seeds per capsule	-9.32 to 40.12	-11.87 to 18.96	-13.83 to 39.32	-17.82 to 14.75
8.	Yield per plant (g)	-23.01 to 162.77	-31.92 to 214.94	-40.59 to 118.18	-43.29 to 189.47
9.	1000 seed weight (g)	-13.51 to 24.54	-16.88 to 26.28	-17.95 to 21.43	-20.25 to 15.26
10.	Oil content (%)	-9.77 to 23.83	-15.99 to 16.19	-15.05 to 19.99	-16.63 to 16.16

4.3 Combining ability analysis

The analysis of variance for combining ability following Griffing's method-I, model-I (1956a) was carried out for the ten characters of sesamum under study and is presented in Table 9.

The partitioning of the total variation among the variances due to general combining ability and specific combining ability were highly significant for almost all the characters. Similarly, the variances due to reciprocals were also highly significant for all the ten characters.

The magnitude of g.c.a. variance was higher as compared to s.c.a. variance for all the character except number of seeds per capsules and oil content. The magnitude of s.c.a. variance when compared with variance due to reciprocal effects was higher for the characters *viz.*, length, capsules, number of seeds per capsules and oil content, while the magnitude of reciprocal combing ability variances was higher for the characters *viz.*, days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, 1000 seed weight and yield per plant thus indicating presence of reciprocal effects for these characters. This may be due to the influence of maternal effect or cytoplasmic influence, which could be well ascertained in the later segregating generations.

The effects of g.c.a., s.c.a. and reciprocal are presented in Table 10, 11, 12, respectively. However only significant effects in favourable directions are described while comparing the parents and F_1's for their respective general combining ability and specific combining ability effects.

Table 9. Analysis of variance for combining ability for 10 characters in 8 x 8 diallel crosses of sesamum

Sr. No.	Source	D.F.	Mean sum of squares									
			Characters									
			Days to 50% flowering	Days for maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsules	Yield per plant (g)	1000 seed weight (g)	Oil content (%)
1.	General combining ability	7	21.5000**	97.3055**	116.7965**	2.9109**	596.7079**	0.0932**	11.8081**	16.7948**	0.0971**	9.8676**
2.	Specific combining ability	28	3.8648**	19.2192**	49.995**	0.6731**	293.6700**	.0475**	19.2697**	15.5615**	0.0590**	11.7224**
3.	Reciprocal effects	28	10.5912**	39.7282**	74.2279**	0.8551**	329.4918**	0.0316**	15.7038**	21.2752**	0.0957**	10.8740**
4.	Error	126	0.2186	0.1791	2.4878	0.0005	6.7821	0.0039	0.0559	0.0567	0.00004	0.0005

* Significant at 5 % level

** Significant at 1 % level

4.3.1 General combining ability (g.c.a.) effects

The estimates of g.c.a. effects of the eight parents for the ten characters are given in Table 10.

Parents RT-46, Tapi, TKG-21, JLT-54, Sekhar showed highly significant negative g.c.a. effects for days to 50 per cent flowering which suggested earliness for flowering of these lines.

Parents RT-46, Tapi, TKG-21, JIT-54 and Sekhar showed highly significant g.c.a. effects for days to maturity indicating earliness for maturity.

Parents RT-46, Tapi, TKG-21, JLT-54 and Sekhar appeared to be the good general combiners in the descending order, for days to 50 per cent flowering and days to maturity.

The parents OS sel.2 and VRI-1 showed highly significant positive g.c.a. effects for plant height in the descending order, thus exhibiting their good general combining ability for this character. The parents VRI-1, RT-46, OS sel.2 and Tapi exhibited highly significant positive g.c.a. effects for the number of branches per plant in the descending order, indicating there by that they are good general combiners for this character.

Parents VRI-1 and OS sel.2 exhibited highly significant positive g.c.a. effects for number of capsules per plant while parents Tapi and RT-46 exhibited only significant effect for this character. Parents VRI-1 and OS sel.2 showed highly significant positive g.c.a. effects for number of capsules per plant in descending order, indicating good general combining ability for this trait. Parents JLT-54, OS sel.2 and Gopi showed highly significant positive g.c.a. effects

Table 10. Estimates of general combining ability effect in sesamum

Sr. No.	Parents	Characters									
		Days to 50% flowering	Days for maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsules	Yield per plant (g)	1000 seed weight (g)	Oil content (%)
1.	Tapi	-0.615**	-1.292*	0.059	0.091**	1.571*	0.026	-0.854*	1.104*	-0.058*	0.071*
2.	TKG-21	-0.594*	-1.167*	-3.196**	-0.200**	-6.423**	-0.039**	-0.758*	-1.383*	-0.002	0.626*
3.	RT-46	-1.615*	-3.146*	-2.732*	0.331**	1.427*	-0.014	1.353*	0.544*	0.018*	-0.459*
4.	Sekhar	-0.302**	-0.648**	-0.720	-0.187**	0.274	0.019	-0.446*	-0.135*	0.029*	0.435*
5.	OS sel.2	1.885**	4.042**	4.489**	0.130**	7.503**	0.043*	0.826*	0.707*	-0.119*	0.578*
6.	JLT-54	-0.365**	-1.167**	-0.268	-0.253*	-4.423*	0.087*	0.698*	-0.202*	0.149*	0.356*
7.	VRI-1	1.510**	3.396**	3.406**	0.750*	8.384*	-0.164*	-0.816*	0.939*	-0.037*	0.137*
8.	Gopi	0.094	-0.021	-1.039*	-0.661*	-8.311*	0.041*	-0.004	-1.575*	0.019*	-1.744*
	S.E. ± (gi)	0.109	0.099	0.369	0.005	0.609	0.015	0.055	0.056	0.001	0.005
	S.E. ± (gi-gi)	0.165	0.150	0.558	0.008	0.921	0.022	0.084	0.084	0.003	0.008

* Significant at 5 % level

** Significant at 1 % level

for the length of capsule in the descending order showing that they are good general combiners for this character.

Highly significant positive g.c.a. effects were displayed by the parents RT-46, OS sel.2 and JLT-54 for number of seeds per capsule in descending order showing that they are good general combiners for this character. The parents Tapi, VRI-1, OS sel.2 and RT-46 exhibited highly significant positive g.c.a. effects for the yield per plant in descending order. All these parents thus, proved to be good general combiners for the character yield per plant. The parents JLT-54, Sekhar, Gopi and RT-46 exhibited highly significant positive g.c.a. effects, for 1000 seed weight in descending order. Thus these parents appeared to be the good general combiners for 1000 seed weight.

The parents TKG-21, OS sel.2, Sekhar, JLT-54, VRI-1 and Tapi showed highly significant positive g.c.a. effects for oil content .

4.3.2 Specific combining ability (s.c.a.) effects

The estimates of s.c.a. effects of 28 direct crosses for ten characters are presented in Table 11.

4.3.2.1 Days to 50 per cent flowering

Four crosses exhibited highly significant negative s.c.a. effects for days to 50 per cent flowering and two crosses exhibited significant negative s.c.a. effects. Thus they indicated their good specific combining ability for this trait. The crosses TKG-21 x RT-46 and JLT-54 x VRI-1 had the highest negative s.c.a. effects closely followed by OS sel.2 x Gopi and Tapi x RT-46.

Table 11. Estimates of specific combining ability effects in sesamum

Sr. No.	Crosses	Characters									
		No. of days to 50 % flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule	Yield per plant (g)	1000 seed weight (g)	Oil content (%)
1.	Tapi x TKG-21	-0.260	-0.167	5.638**	-0.741**	-5.583**	0.137**	-4.392**	-1.591**	0.180**	-0.735**
2.	Tapi x RT-46	-1.073**	-2.021**	7.439**	-0.309**	1.277	-0.038	-0.353*	0.922*	0.174**	-3.602**
3.	Tapi x Sekhar	0.281	1.646**	-6.158**	-0.452**	-10.392**	0.004	-0.071	1.130*	-0.017**	1.913**
4.	Tapi x OS sel.2	0.927**	2.625**	0.218	0.512**	2.481	0.047	3.558**	2.180*	-0.148**	2.075**
5.	Tapi x JLT-54	1.010**	2.167**	3.074**	0.131**	8.617*	-0.089*	0.269	1.127*	-0.123*	2.029**
6.	Tapi x VRI-1	-0.365	-0.729**	-2.364**	0.175**	-0.965	-0.038	2.433**	0.084	0.023**	2.102**
7.	Tapi x Gopi	1.219**	2.687**	-3.194**	0.196**	1.863	-0.096*	-1.830**	-2.172**	-0.055**	-0.200**
8.	TKG-21 x RT-46	-2.427**	-4.479**	-0.156	0.171**	-4.255**	-0.156**	0.085	-2.736**	-0.019**	2.505**
9.	TKG-21 x Sekhar	-0.740**	-1.979**	1832	-0.149**	-1.695	0.016	-0.617**	-1.175*	0.078**	-2.952**
10.	TKG-21 x OS sel.2	2.740**	6.167**	1.665	0.741**	18.786**	-0.129**	0.112	6.570**	0.156**	-2.775**
11.	TKG-21 x JLT-54	1.156**	3.375**	-4.804**	-0.530**	-8.031**	-0.273**	-2.394**	-0.070	-0.182**	1.635**
12.	TKG-21 x VRI-1	1.448**	2.979**	0.909	-0.328**	-3.348*	-0.122**	0.437**	-1.710**	-0.233**	0.766**
13.	TkG-21 x Gopi	-0.469	-0.438	0.349	0.973**	5.056**	0.023	3.208**	2.991**	-0.132**	0.397**
14.	RT-46 x Sekhar	-0.552	-0.475	-1.464	-0.791**	-17.478**	-0.056	1.306**	-0.951*	0.167**	1.849**
15.	RT-46 x OS sel.2	-0.406	-1.354**	-3.236**	-0.561**	-5.172**	-0.055	-1.832**	-0.582*	-0.222**	-0.110**
16.	RT-46 x JLT-54	2.844**	6.521**	1.271	0.615**	17.655**	0.026	2.729**	3.533**	0.034**	-0.273**
17.	RT-46 x VRI-1	-0.198	-0.208	-5.036**	0.278**	11.246**	-0.247**	-2.474**	3.485**	-0.252**	0.271**
18.	RT-46 x Gopi	0.219	1.042**	-1.396	0.941**	-0.892	0.073	-2.936**	-0.788*	0.045**	2.760**
19.	Sekhar x OS sel.2	0.615	1.146**	6.707**	0.668**	6.141**	0.092*	0.650**	2.185**	0.027**	1.793**
20.	Sekhar x JLT-54	-0.469	-1.812**	-3.495**	-0.464**	2.122	-0.032	-1.493**	-1.106*	0.119**	3.030**
21.	Sekhar x VRI-1	0.656*	0.792**	11.397**	0.838**	37.787**	0.114**	1.425**	4.602**	-0.137**	-0.356**
22.	Sekhar x Gopi	0.906**	1.375**	-3.775**	0.114**	0.842	-0.075	-0.638**	-1.047*	-0.128**	-0.982**
23.	OS sel.2 x JLT-54	0.344	0.500	5.568**	0.053**	-8.205**	-0.005	4.623**	-3.214**	0.017**	-4.611**
24.	OS sel.2 x VRI-1	0.802**	1.104**	-0.370	-0.386**	1.001	0.121**	-0.880**	-0.772*	0.361**	-0.141**
25.	OS sel.2 x Gopi	-1.281**	-1.979**	2.770**	-0.838**	4.331**	0.091*	3.508**	-2.161**	-0.215**	3.272**
26.	JLT-54 x VRI-1	-1.948**	-3.687**	-3.256**	-0.329**	-13.188**	0.317**	2.348**	-0.352*	0.211**	2.199**
27.	JLT-54 x Gopi	-0.698*	-1.271**	-1.831	-0.063**	5.761**	-0.061	3.769**	3.226**	0.014**	0.395**
28.	VRI-1 x Gopi	0.594*	0.333	3.816**	0.182**	-3.656*	0.003	-0.201	1.692**	0.306**	-2.129**
	S.E.± (Sij)	0.290	0.260	0.980	0.014	1.630	0.039	0.150	0.150	0.004	0.014
	S.E. ± (Sij -Sik)	0.440	0.390	1.470	0.021	2.440	0.059	0.220	0.220	0.006	0.022
	S.E. ± (Sij - SKL)	0.400	0.370	1.360	0.019	2.250	0.054	0.200	0.210	0.005	0.020

* Significant at 5 % level ** Significant at 1 % level

Nine hybrid combinations exhibited highly significant positive s.c.a. effect for days to 50 per cent flowering and three crosses exhibited significant positive s.c.a. effects. The crosses RT-46 x JLT-54 and TKG-21 x OS sel.2 had the highest positive s.c.a. effects closely followed by TKG-21 x VRI-1 and Tapi x Gopi.

4.3.2.2 Days to maturity

Nine crosses showed highly significant negative s.c.a. effects for days to maturity and thirteen crosses showed highly significant positive s.c.a. effects. The crosses TKG-21 x RT-46 and JLT-54 x VRI-1 had the highest negative significant s.c.a. effects closely followed by Tapi x RT-46 and TKG-21 x Sekhar.

The highest significant positive s.c.a. effects was recorded for RT-46 x JLT-54 and TKG-21 x OS sel.2 followed by TKG-21 x JLT-54 and TKG-21 x VRI-1.

4.3.2.3 Plant height

Eight hybrid combinations exhibited highly significant negative s.c.a. effects and one cross showed significant negative s.c.a. effects for plant height, while eight crosses indicated highly significant positive s.c.a. effects. The highest negative s.c.a. effect was exhibited by Tapi x Sekhar followed by RT-46 x VRI-1 and the highest positive s.c.a. effect was exhibited by Sekhar x VRI-1 followed by Tapi x RT-46.

4.3.2.4 Number of branches per plant

Thirteen crosses showed highly significant negative s.c.a. effects for number of branches per plant and fifteen crosses showed highly significant positive s.c.a. effects. The cross combination TKG-

21 x Gopi exhibited maximum positive s.c.a. effect closely followed by RT-46 x Gopi for this character.

4.3.2.5 Number of capsules per plant

Out of twenty eight crosses nineteen crosses showed significant s.c.a. effects for number of capsules per plant. Nine crosses showed highly significant positive s.c.a. effects while eight crosses showed highly significant negative s.c.a. effects and two crosses showed significant negative s.c.a. effects. The cross Sekhar x VRI-1 revealed highest positive significant s.c.a. effect followed by TKG-21 x OS sel.2 and RT-46 x JLT-54. The cross RT-46 x Sekhar exhibited highest negative significant s.c.a. effect for this character.

4.3.2.6 Length of capsule

Among twenty eight crosses thirteen crosses showed significant s.c.a. effects for length of capsule. Out of these thirteen crosses four crosses showed highly significant positive s.c.a. effects and two crosses showed significant positive s.c.a. effect while five crosses showed highly significant negative s.c.a. effect and two showed significant negative s.c.a. effect. The cross TKG-21 x JLT-54 exhibited higher negative significant s.c.a. effect while JLT-54 x VRI-1 exhibited highest positive significant s.c.a. effect for this character.

4.3.2.7 Number of seeds per capsule

Out of twenty eight crosses, twenty three exhibited significant s.c.a. effects for number of seeds per capsules. Twelve crosses exhibited highly significant positive s.c.a. effects while ten crosses showed highly significant negative s.c.a. effects and only one cross showed significant negative s.c.a. effects. The cross OS sel.2 x

JLT-54 exhibited highest positive significant s.c.a. effect where as the cross Tapi x TKG-21 indicated highest negative significant s.c.a. effect.

4.3.2.8 Yield per plant (g)

The estimates of specific combining ability effects for yield per plant revealed that, nine crosses exhibited highly significant positive s.c.a. effect and three crosses showed significant positive s.c.a. effect, while six crosses exhibited highly significant negative s.c.a. effect and seven cross showed significant negative s.c.a. effects. The cross TKG-21 x OS sel.2 had the highest positive significant s.c.a. effects while the cross OS sel.2 x JLT-54 revealed highest negative significant s.c.a. effect.

4.3.2.9 1000 seed weight

Fifteen crosses exhibited highly significant positive s.c.a. effect for 1000 seed weight while thirteen crosses showed highly significant negative s.c.a. effects. The cross OS sel.2 x VRI-1 revealed highest positive significant s.c.a. effect while OS sel.2 x Gopi exhibited highest negative s.c.a. effect.

4.3.2.10 Oil content

The estimates of specific combining ability effects for oil per cent revealed that sixteen crosses exhibited highly significant positive s.c.a. effects and twelve revealed highly significant negative s.c.a. effects. The cross OS sel.2 x Gopi revealed highest positive significant s.c.a. effect while OS sel.2 x JLT-54 exhibited highest negative s.c.a. effect.

4.3.3 Reciprocal effects

The estimates of reciprocal effects of 28 reciprocal crosses for ten characters are presented in Table 12.

Highly significant negative reciprocal effects were recorded in eighteen reciprocal crosses for days to 50 per cent flowering. The reciprocal cross VRI-1 x Tapi registered the highest (-5.17) and the crosses Sekhar x RT-46, OS sel.2 x Tapi showed lowest (-0.83) significant reciprocal effect, while nineteen reciprocals crosses showed highly significant negative reciprocal effect for days for maturity. The reciprocal (Gopi x RT-46) exhibited the highest (-10.33) and the reciprocal RT-46 x TKG-21 the lowest significant reciprocal effects (-1.00) for days to maturity.

Highly significant positive reciprocal effects were recorded in twelve reciprocal crosses for plant height. The highest value for the reciprocal effect (13.85) was exhibited by the reciprocal JLT-54 x Tapi, while the lowest (2.59) by OS sel.2 x TKG-21 for plant height.

Eleven reciprocals exhibited highly significant positive reciprocal effect for number of branches per plant. The cross JLT-54 x Tapi showed the highest (1.88) and the VRI-1 x OS Sel.2, the lowest (0.043) significantly positive reciprocal effects for number of branches.

Ten reciprocals showed highly significant positive reciprocal effect for number of capsules per plant. Among these, the reciprocal JLT-54 x Tapi exhibited the highest (27.52) and the combination of OS sel.2 x Tapi showed the lowest (3.87) s.c.a. values. Five reciprocals registered highly significant positive reciprocal effects

Table 12. Estimates of reciprocal effects in sesamum

Sr. No.	Crosses	Characters									
		No. of days to 50 % flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsule	Yield per plant (g)	1000 seed weight (g)	Oil content (%)
1.	TKG-21 x Tapi	-4.167**	-8.167**	-9.135**	-0.297**	-7.158**	0.150**	0.350**	-2.565**	0.123**	-0.747**
2.	RT-46 x Tapi	-2.333**	-3.333**	-0.750	-0.462**	-1.848	-0.200**	-2.700**	-1.252*	-0.373**	-2.738**
3.	RT-46 x TKG-21	-1.000**	-1.000**	-1.400	-0.625**	-9.025**	-0.033	1.433**	-1.210*	-0.137**	-0.037*
4.	Sekhar x Tapi	1.000**	2.500**	0.335	0.372**	6.570**	0.025	0.983**	4.083**	-0.047**	-1.273**
5.	Sekhar x TKG-21	-1.333**	-2.333**	7.200**	0.337**	9.933**	0.028	5.533**	2.058**	0.115**	-3.203**
6.	Sekhar x RT-46	-0.833**	0.833**	3.572**	-0.238**	7.333**	0.075	-4.433**	-1.237*	-0.010**	-0.273**
7.	OS sel.2 x Tapi	-0.833**	-1.500**	4.370**	0.255**	3.868*	-0.092*	-0.917**	-1.518**	-0.025*	1.195**
8.	OS sel.2 x TKG-21	1.000**	2.167**	2.592**	0.393**	10.223**	0.050	0.300*	0.428*	0.248**	4.320**
9.	OS sel.2 x RT-46	-1.500**	-3.333**	-1.705**	-0.140**	-6.965**	0.050	-3.900**	-0.347	-0.127**	4.100**
10.	OS sel.2 x Sekhar	-0.500	-1.000**	-9.590**	-0.140**	-16.075**	0.030	2.583**	-4.925**	-0.130**	2.500**
11.	JLT-54 x Tapi	-2.333**	-4.167**	13.850**	1.885**	27.542**	-0.050	-0.933**	6.797**	0.405**	-0.350**
12.	JLT-54 x TKG-21	-1.500**	-2.500**	1.017	-0.567**	-0.100	-0.050	2.100**	3.203**	0.042	0.088**
13.	JLT-54 x RT-46	-2.833**	-5.333**	-4.575**	-0.758**	-0.565	0.025	1.000**	-0.600*	-0.070**	-3.275**
14.	JLT-54 x Sekhar	-0.500	0.833**	2.748**	-0.352**	-10.667**	0.200**	0.687**	-1.545**	0.207--	0.288**
15.	JLT-54 x OS sel.2	1.833**	4.167**	6.523**	0.252**	14.532**	0.200**	7.300**	1.502**	0.157**	-0.217**
16.	VRI-1 x Tapi	-5.167**	-10.167**	-4.785**	-1.735**	-30.233**	-0.050	0.117	-5.588**	0.365**	-1.008**
17.	VRI-1 x TKG-21	-3.333**	-6.333**	12.463**	0.102**	-6.723**	-0.100*	2.817**	1.418**	0.205**	-1.000**
18.	VRI-1 x RT-46	-2.000**	-3.500**	4.322	-0.552**	0.833	0.150**	4.417**	4.940**	0.192**	4.640**
19.	VRI-1 x Sekhar	-0.167	-3.333**	0.267	0.263**	-24.888**	-0.005	1.317**	-5.445**	0.115**	-1.507**
20.	VRI-1 x OS sel.2	-1.500**	-3.000**	5.788**	0.043**	-6.335**	0.075	-0.717**	1.875**	0.182**	-2.275**
21.	VRI-1 x JLT-54	0.167	0.667*	5.233**	-0.497**	-4.950**	0.265**	4.583**	-3.447**	0.207**	0.603**
22.	Gopi x Tapi	-2.000**	-3.833**	-0.690	0.252**	15.900**	-0.013	1.667**	0.785*	0.280**	3.608**
23.	Gopi x TKG-21	-3.667**	-7.167**	3.732**	-0.358**	-11.302**	-0.200**	1.033**	-4.102**	0.222**	2.430**
24.	Gopi x RT-46	-5.000**	-10.333	0.483	-0.950**	-9.333**	-0.125**	-0.033	-1.793**	0.062**	3.752**
25.	Gopi x Sekhar	-2.667**	-4.833**	-3.050**	0.615**	10.252**	0.060	4.067**	2.275**	0.367**	2.400**
26.	Gopi x OS. sel.2	1.333**	2.833**	0.230	-0.040**	9.700**	-0.050	0.483**	1.588**	0.138**	0.797**
27.	Gopi x JLT-54	1.333**	2.667**	-7.850**	-0.448**	-15.307**	-0.108**	1.217**	-4.980**	-0.272**	-0.898**
28.	Gopi x VRI-1	0.500	0.167	-12.667	-0.837**	-15.027**	-0.305**	-1.867**	-4.652**	-0.398**	-2.555**
	S.E. ± (rij)	0.330	0.300	1.110	0.016	1.840	0.044	0.170	0.170	0.004	0.016
	S.E. ± (rij -rKL)	0.470	0.420	1.580	0.022	2.600	0.063	0.240	0.240	0.006	0.023

• Significant at 5 % level ** Significant at 1 % level for length of capsules. Reciprocal cross VRI-1 x JLT-54 showed the highest (0.26) and crosses TKG-21 x Tapi and VRI-1 x RT-46 exhibited the lowest (0.15) significant values for this character.

Highly significant positive reciprocal effects were recorded in seven reciprocal crosses and in two reciprocal crosses recorded significant positive reciprocal effects for number of seeds per capsule. Among these, JLT-54 x OS sel.2 possessed the highest (7.30) and OS sel.2 x TKG-21 had the lowest (0.30) positive significant values for this character. Ten reciprocal crosses recorded highly significant positive reciprocal effects and two crosses recorded significant positive reciprocal effects for seed yield per plant. The reciprocal cross JLT-54 x Tapi was having the highest (6.80) and the lowest value (0.43) was exhibited by the reciprocal cross OS sel. 2 x TKG-21 for seed yield per plant.

Eighteen reciprocal for 1000 seed weight registered highly significant positive reciprocal effects. The reciprocal JLT-54 x Tapi showed the highest (0.40) and JLT-54 x TKG-21 the lowest (0.042) positive significant values for 1000 seed weight. Thirteen reciprocals exhibited highly significant positive reciprocal effects for oil content. Among these reciprocals VRI-1 x RT-46 was having the highest (4.64) and JLT-54 x TKG-21 the lowest (0.088) significant values for this character.

4.4 Gene action

The analysis of combining ability in Table 9 revealed that both general and specific combining ability variances were highly significant for almost all the characters under study.

The s.c.a. variances for number of seeds per capsule, yield per plant and oil content was higher than g.c.a. variance suggesting the non-additive genetic control of the characters under study. The analysis further indicated that g.c.a. variances for the characters *viz.,* days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of capsule per plant, length of capsule and 1000 seed weight were higher than their corresponding s.c.a. variances suggesting the additive genetic control of the characters under study.

4.5 Correlations studies

Correlation coefficients at both phenotypic and genotypic levels were worked out for all the possible combinations among the variables under study and they are presented in Table 13.

4.5.1 Phenotypic correlations

a. Days for 50 per cent flowering

Days for 50 per cent flowering had highly significant positive correlation with days to maturity (0.9637), number of capsules per plant (0.3750) and number of branches per plant (0.3093). It also had a highly significant negative association (--0.3304) with 1000 grain weight and non-significant negative association with length of capsule and oil content. It had a positive but non-significant correlation with plant height (0.2219), number of seeds per capsule (0.0073) and yield per plant (0.2367).

b. Days to maturity

It had highly significant positive correlation with number of branches per plant (0.3292), number of capsules per plant

Table 13. Genotypic and Phenotypic correlation coefficients in sesamum

Sr. No.		Characters									
		Days to 50% flowering	Days for maturity	Plant height (cm)	No. of branches per plant	No. of capsules per plant	Length of capsule (cm)	No. of seeds per capsules	1000 seed weight (g)	Oil content (%)	Yield per plant (g)
1. Days to 50 % flowering	G	-	0.9939**	0.2261	0.3209**	0.3952**	-0.0546	0.0076	-0.3432**	-0.0657	0.2465*
	P	-	0.9637**	0.2219	0.3093*	0.3750**	-0.0495	0.0073	-0.3304**	-0.0629	0.2367
2. Days to maturity	G	-	-	0.2552*	03320**	0.4000**	-0.1013	0.0245	-0.3462**	-0.0283	0.2716*
	P	-	-	0.2427	0.3292**	0.3881**	-0.0940	0.0244	-0.3433	-0.0279	0.2677*
3. Plant height	G	-	-	-	0.3890**	0.5473**	0.1640	0.1944	0.2485*	-0.0349	0.4794**
	P	-	-	-	0.3698**	0.5083**	0.1483	0.1794	0.2332	-0.0331	0.4486**
4. No. of branches/plant	G	-	-	-	-	0.7099**	-0.1532	0.0700	-0.0263	0.0569	0.5830**
	P	-	-	-	-	0.6896**	-0.1358	0.0699	-0.0261	0.0568	0.5798**
5. No. of capsule/plant	G	-	-	-	-	-	0.0024	0.1615	-0.0380	0.1287	0.7923**
	P	-	-	-	-	-	-0.0028	0.1567	-0.0367	0.1248	0.7636**
6. Length of capsule	G	-	-	-	-	-	-	0.3735**	0.4365**	0.0163	0.0173
	P	-	-	-	-	-	-	0.3203**	0.3850**	0.0148	0.0146
7. No. of seeds/capsule	G	-	-	-	-	-	-	-	0.2299	0.1051	0.2019
	P	-	-	-	-	-	-	-	0.2289	0.1045	0.2003
8. 1000 grain weight	G	-	-	-	-	-	-	-	-	0.0801	0.1177
	P	-	-	-	-	-	-	-	-	0.0799	0.1170
9. Oil content	G	-	-	-	-	-	-	-	-	-	0.1199
	P	-	-	-	-	-	-	-	-	-	0.1194
10. Yield	G	-	-	-	-	-	-	-	-	-	-
	P	-	-	-	-	-	-	-	-	-	-

* Significant at 5 % level

** Significant at 1 % level

(0.3881), yield per plant (0.2677). It had highly significant negative correlation with 1000 grain weight and non-significant negative correlation with length of capsule and oil content. It had a positive but non-significant correlation with plant height, number of seeds per capsules.

c. Plant height

Plant height had highly significant positive correlation with number of branches (0.3698), number of capsule per plant (0.5083) and yield per plant (0.4486). It had non-significant negative correlation with oil content. It had positive but non-significant association with length of capsules (0.1483), number of seeds per capsule (0.1794), 1000 grain weight (0.2332).

d. Number of branches per plant

Number of branches per plant showed a positive and highly significant correlation with number of capsules per plant (0.6896) and yield per plant (0.5798). It had non-significant negative correlation with length to capsule, 1000 grain weight and it had a positive but non-significant association with number of seeds per capsule, oil content.

e. Number of capsules per plant

This character was found to have a positive and highly significant correlation with yield per plant (0.7636). It had non-significant negative correlation with length of capsule, 1000 grain weight and non-significant positive association with number of seeds per capsule and oil content.

f. Length of capsule

This character showed a positive and highly significant correlation with number of seeds per capsule (0.3203) and 1000 grain weight (0.3850). It had a positive but non-significant association with oil content (0.0148) and yield per plant (0.0146).

g. Number of seeds per capsule

Number of seeds per capsule had a positive but non-significant correlation with 1000 grain weight, oil content and yield per plant.

h. 1000 grain weight

This character was found to have a positive but non-significant correlation with oil content and yield per plant.

i. Oil content

Oil per cent was found to have a positive but non-significant correlation with yield per plant.

j. Yield per plant

Yield per plant had a positive and highly significant correlation with number of branches (0.5798), number of capsules per plant (0.7636), plant height (0.4486) and significant positive correlation with days to maturity (0.2677). It had positive but non-significant correlation with days to 50 per cent flowering, length of capsule, number of seeds per capsule, 1000 grain weight and oil content.

4.5.2 Genotypic correlations

a. Days for 50 per cent flowering

This character showed positive and highly significant association with days to maturity (0.9939), number of branches per plant (0.3209), number of capsules per plant (0.3952) and significant positive correlation with yield per plant (0.2465). It had highly significant negative correlation with 1000 grain weight. It had positive but non-significant correlation with plant height, number of seeds per capsule. It had negative but non-significant correlation with length of capsule and oil content.

b. Days to maturity

This character had highly significant association with number of branches per plant (0.3320), number of capsules per plant (0.4000) and significant positive correlation with plant height (0.2552), yield per plant (0.2716). It had highly significant negative correlation with 1000 grain weight and non-significant negative correlation with length of capsule and oil content. It had positive but non-significant association with number of seeds per capsule.

c. Plant height

The association of plant height was fond to be positive and highly significant with number of branches per plant (0.3890), number of capsules per plant (0.5475), yield per plant (0.4794) and significant positive correlation with 1000 grain weight (0.2485). It had non-significant negative correlation with oil content and positive but non-significant association with length of capsules, number of seeds per capsule.

d. Number of branches per plant

Branches per plant showed positive and highly significant correlation with number of capsules per plant (0.7099) and yield per plant (0.5830). It had non-significant negative association with length of capsule, 1000 grain weight and positive but non-significant correlation with number of seeds per capsule and oil content.

e. Number of capsules per plant

There was positive and highly significant correlation with yield per plant (0.7923). It had negative non-significant association with 1000 grain weight and positive but non-significant correlation with length of capsule, number of seeds per capsule and oil content.

f. Length of capsule

It was found to have positive and highly significant correlation with number of seeds per capsule (0.3735) and 1000 grain weight (0.4365). It had positive but non-significant correlation with oil content and yield per plant.

g. Number of seeds per capsule

It had positive but non-significant association with 1000 grain weight, oil content and yield per plant.

h. 1000 grain weight

This character showed positive but non-significant correlation with oil content and yield per plant.

i. Oil content

It had non-significant positive correlation with yield per plant.

j. Yield per plant

It had positive and highly significant correlation with number of branches per plant, number of capsules per plant and positive significant correlation with plant height, days to 50 per cent flowering, days to maturity. It had positive but non-significant correlation with length of capsule, number of seeds per capsule, 1000 grain weight and oil content.

DISCUSSION

5. DISCUSSION

The concept of heterosis was first definitely recognised by Shull (1914) in his work with hybrid corn by the end of 1907. Prior to this the plant breeders *viz.,* Kolereuter (1763). Thomas (1956) etc., noted some impressive examples of excessive luxariance in various crops. But they were unable to give explanation for the heterosis concept. The attention of biological world on problems of heredity and hybrid vigour as one phase of quantitative inheritance was focussed only after the rediscovery of Mendel's law in 1900. During twentieth century many workers including Shull (1908 and 1914), East (1909), Bruce (1910) and Crow (1948) put forth different hypotheses justifying the manifested effects of 'heterosis'. Although the acceptance of most of these hypothesis precluded on various objections, they provided beyond doubt the way of thinking to reach the appropriate justification of the phenomenon.

In the modern plant breeding, the conventional method of plant selection has been supplemented by hybridization. In the beginning this method was mostly applied to cross fertilizing species such as maize, sugar beat, onion etc but later on, it was proved to be equally good even to the self fertilizing species for bringing about improvement in them. Attempts were made to create artificial variability through hybridization to act as a base population for further selection while going through the literature on self pollinating crop species, it was observed that limited work on quantitative aspects of sesamum has been done in India.

The present investigation on sesamum using eight diverse cultivars was therefore attempted to study heterosis, combining ability, gene action and correlation for ten metrical traits including developmental and yield attributes. The results thus obtained are discussed in this section.

5.1 Mean performance

The data on mean performance of the parents are presented in Table 2. From this table it can be seen that each of the parental lines used in present investigations had some desirable attributes. The parents Tapi and JLT-54 were found to be early in flowering (41.33) as well as in maturity (89.33 and 90.33), respectively. Parental line JLT-54 was observed superior in plant height (110.42 cm) and 1000 seed weight while parents VRI-1 appeared to be better for plant height (109.20 cm) and number of branches per plant. The parental lines Tapi and RT-46 were found to be superior in number of capsules per plant (68.62 and 63.25) and yield per plant (12.22 g and 9.90 g), respectively. Parent Gopi was the better in 1000 grain weight. Parental lines TKG-21 and RT-46 was observed superior in length of capsules (3.30 cm) and number of seeds per capsule (66.20 and 70.33), respectively. The parental line TKG-21 and OS sel.2 had maximum oil percentage (49.90 and 49.14), respectively.

5.2 Analysis of variance (ANOVA)

The data presented in Table 1 indicated that the difference due to treatments (i.e. parents vs hybrids) were highly significant for all the characters under study. Similar results were obtained by Murthy (1975), Krishnodoss *et al.* (1987), Gupta (1981), Tyagi and Singh (1981), Shrivas and Singh (1981), Chaudhari *et al.* (1984a) Pawar (1987), Goyal and Sudhirkumar (1991), Reddy and Haripriya (1993), Fatteh *et al.* (1995), Thakare *et al.* (1999), Zhao Yingzhong (1999), Jayalakshmi *et al.* (2000), Krishnaiah *et al.* (2002), Rajaravindram et al (2000), Saravanan *et al.* (2000), Devasena *et al.* (2001), Ganeshan et al (1993) Puspha *et al.* (2002).

5.3 Heterosis

The results of heterosis, revealed consistently higher amount of heterosis for yield per plant, number of capsule per plant, number of branches per plant, 1000 seed weight, plant height, number of seeds per capsule, oil per cent was present in both direct and reciprocal crosses (Table 14). An appreciable amount of heterosis over mid and superior parents was observed for almost all the ten characters which is shown in Table 3 to 7 (A). The range of the percentage of heterosis over superior parents and mid parents recorded for different characters has been presented in Table 8. The same results for grain yield and its attributes studied in both direct and reciprocal crosses of sesamum has been discussed in brief and presented below.

Fourteen direct crosses and four reciprocal crosses showed significant negative heterosis over superior parent for days to 50 per

Table 14. Sesame crosses showing maximum beneficial heterosis over superior parent

Sr. No.	Characters	Direct crosses	Heterosis (%)	Reciprocal crosses	Heterosis (%)
1.	No. of days for 50 % flowering	Tapi x VRI-1	-14.39	VRI-1 x JLT-54	-6.47
2.	Days to maturity	Tapi x VRI-1	-14.33	VRI-1 x JLT-54	-7.96
3.	Plant height	Tapi x OS sel.2	13.07	OS sel.2 x Sekhar	23.67
4.	No. of branches per plant	Tapi x JLT-54	25.65	VRI-1 x Tapi	33.60
		TKG-21 x OS sel.2	24.75	Gopi x TKG-21	29.79
		Sekhar x VRI-1	11.80	Gopi x RT-46	29.48
5.	No. of capsule per plant	Sekhar x VRI-1	66.46	VRI-1 x Sekhar	164.72
		TKG-21 x OS sel.2	58.95	OS sel.2 x Sekhar	58.8
		Sekhar x Gopi	43.11	VRI-1 x Tapi	48.64
6.	Length of capsule	Sekhar x OS sel.2	7.37	OS sel. 2 x Sekhar	5.26
7.	Number of seeds/capsules	OS sel.2 x JLT-54	39.32	Gopi x OS sel.2	14.75
		JLT-54 x VRI-1	19.40	Gopi x JLT-54	13.74
		JLT-54 x Gopi	17.84	JLT-54 x OS sel.2	13.10
8.	Yield per plant	RT-46 x VRI-1	118.18	VRI-1 x Sekhar	189.47
		TKG-21 x OS sel.2	102.47	Gopi x VRI-1	155.88
		Tapi x JLT-54	67.92	Gopi x TKG-21	132.79
9.	1000 seed weight	OS sel.2 x VRI-1	21.43	Gopi x VRI-1	15.26
		Tapi x VRI-1	15.38	RT-46 x Tapi	12.82
		JLT-54 x VRI-1	9.94	VRI-1 x OS sel.2	8.21
10.	Oil content	RT-46 x Gopi	19.99	Sekhar x Tapi	16.15
		Sekhar x JLT-54	17.11	JLT-54 x Sekhar	15.80
		RT-46 x VRI-1	15.60	JLT-54 x RT-46	15.05

cent flowering. The negative heterosis is of interest to the breeders as it indicates earliness. The hybrid Tapi x VRI-1 (-14.39) and VRI-1 x JLT-54 (-6.47) exhibited maximum negative heterosis in direct and reciprocal crosses, respectively. Magnitude of heterosis was found to range from -14.39 to -0.71 per cent in direct crosses, while it ranged from -6.47 to -0.71 per cent in reciprocal crosses. Among the different hybrids Tapi x VRI-1, RT-46 x Gopi, TKG-21 x Gopi in straight crosses and their reciprocals VRI-1 x JLT-54, RT-46 x TKG-21, Gopi x JIT-54 were early in flowering. The negative heterosis for days for flowering was previously reported by Riccelli and Mazzani (1964), Murty (1975), Dixit (1976a) Yermanos and Kotecha (1978), Chavan *et al.* (1982), Chaudhari *et al.* (1984) Pawar (1987), Anitha and Dorairaj (1991), Ray and Sen (1992), Navodiya *et al.* (1995), Ragiba and Reddy (2000), Solanki and Deepak Gupta (2000) and Kar *et al.* (2001).

Fifteen direct crosses and eight reciprocal crosses showed significant negative heterosis over superior parents for days to maturity. The hybrid Tapi x VRI-1 (-14.33) and VRI-1 x JLT-54 (-7.96) exhibited maximum negative heterosis in direct and reciprocal crosses, respectively. Magnitude of heterosis for days to maturity ranged from -14.33 to -1.39 per cent in direct crosses while it ranged from -7.96 to -1.39 per cent in reciprocal crosses. Among the different hybrids Tapi x VRI-1, RT-46 x Gopi, RT-46 x VRI-1 in direct crosses and VRI-1 x JLT-54, Gopi x JLT-54, VRI-1 x RT-46 in reciprocal crosses were found to be early maturing. The negative heterosis for days to maturity was also previously reported by Riccelli and Mazzani (1964), Murty (1975), Dixit (1976a) Yermonos and Kotecha (1978), Chavan *et al.* (1982), Chaudhari *et al.* (1984a) Pawar (1987), Sashikumar and Saradhani (1990), Anitha and Doriraj (1991), Ray and Sen (1992), Navodiya *et al.* (1995), Ragiba and Reddy (2000), Solanki and Gupta (2000) and Kar *et al.* (2001).

Eleven direct crosses and eight reciprocal hybrids were heterotic over superior parents for plant height. The magnitude of heterosis for plant height ranged from 4.85 to 13.07 per cent in the set of direct crosses while it was 4.43 to 23.67 per cent in the set of reciprocal crosses. The maximum beneficial positive heterosis was found in hybrid Tapi x OS sel.2 and OS sel.2 x Sekhar in direct and reciprocal crosses, respectively for the plant height. Among the different crosses Tapi x OS sel.2, Tapi x JLT-54, OS sel.2 x JLT-54 in direct crosses and OS sel.2 x Sekhar, TKG-21 x Tapi, Gopi x VRI-1 in reciprocal set had a higher magnitude of per cent positive heterosis for plant height. The positive heterosis for plant height was also observed by Riccelli and Mazzani (1964), Salazar and Onoro (1975), Murty (1975), Dixit (1976a) Sarafi (1976), Yermones and Kotecha (1978), Tyagi and Singh (1981), Paramasivan *et al.* (1982), Djigma (1983), Chaudhari *et al.* (1984a) Shivaprakash (1986), Pawar (1987), Ray and Sen (1992), Mishra *et al.* (1994), Ananda Kumar (1995), Navodiya *et al.* (1995), Kamla (1999), Solanki and Gupta (2000).

In respect of number of branches per plant, eight direct crosses and ten reciprocal crosses exhibited highly significant positive heterosis over superior parents ranging from 2.49 to 25.65 per cent and 1.20 to 33.60 per cent, respectively. The crosses Tapi x JLT-54, TKG-21 x OS sel.2, Sekhar x VRI-1 in the set of direct crosses and VRI-1 x Tapi, Gopi x TKG-21, Gopi x RT-46 in reciprocal set had higher magnitude of per cent positive heterosis for this attributes. The positive heterosis for number of branches was also observed by Murty (1975), Dixit (1976a), Tyagi and Singh (1981), Dora and Kamala (1986), Shivaprakash (1986), Pawar (1987), Anitha and Dorairaj (1991), Yadav and Mishra *et al.* (1991), Navodiya *et al.* (1995), Fatteh *et al.* (1995), Baviskar (1998), Govindrasu *et al.* (1999), Kamla (1999), Dixit and Swain (2000), Ragiba and Reddy (2000), Solanki and Gupta (2000).

For the number of capsules per plant thirteen direct crosses and fourteen reciprocal crosses showed significant positive heterosis over superior parent with the range 13.96 to 66.45 per cent in direct crosses while 15.48 to 164.72 per cent in reciprocals. The crosses Sekhar x VRI-1, TKG-21 x OS sel.2, Sekhar x Gopi in the set of direct crosses and VRI-1 x Sekhar, OS sel.2 x Sekhar, VRI-1 x Tapi in reciprocal set had maximum positive heterosis over superior parents, while fourteen direct crosses and nineteen reciprocal crosses showed positive heterosis over mid parent and range was from 16.11 to 74.49 and 10.92 to 177.49 per cent in direct and reciprocal crosses, respectively. Positive and significant heterosis for the number of capsules per plant was previously observed by Sarathe and Dabral (1969), Salazar and Onoro (1975), Murty (1975), Dixit (1976a), Uzo (1977), Nafie (1980), Tyagi and Singh (1981), Chavan *et al.* (1982), Djigma (1983), Pawar (1987), Sasikumar and Sardani (1990), Zhan *et al.* (1990), Yadav and Mishra (1991), Ray and Sen (1992), Padamavati *et al.* (1993), Mishra *et al.* (1994), Anandakumar (1995), Navodiya *et al.* (1995), Fatteh *et al.* (1995), Baviskar *et al.* (1998), Govindrasu *et al.* (1999), Dixit and Swain (2000), Ragiba and Reddy (2000), Solanki and Gupta (2000).

Four direct crosses and four reciprocal crosses exhibited highly significant positive heterobeltiosis for length of capsule. The range in direct crosses was 6.96 to 7.37 per cent. The cross Sekhar x OS sel.2 (7.37) and its reciprocal cross OS sel.2 x Sekhar (5.26) showed maximum positive heterosis over superior parent while eight direct crosses and seven reciprocal crosses exhibited significant positive heterosis over mid parent which ranged from 7.38 to 21.58 and 6.21 to 13.33 per cent in direct and reciprocals, respectively. This was in conformity with the previous studies of Dixit (1976a) Nafde (1980), Tyagi and Singh (1981), Sivaprakash (1986), Pawar (1987), Mishra *et al.* (1994).

Of the twenty eight direct crosses sixteen hybrids produced significant and positive heterosis and ranged between 1.44 to 39.32 per cent over superior parent, twenty two hybrids over mid parents with range of 1.59 to 40.12 per cent for number of seeds per capsule. Among the twenty eight reciprocal crosses nine hybrids showed significant positive heterobeltiosis in the range between 3.13 to 14.75 per cent and eighteen hybrids showed significant positive heterosis over mid parent in the range between 3.18 to 18.96 per cent. The crosses OS sel.2 x JLT-54, JLT-54 x VRI-1, JLT-54 x Gopi, in a set of direct crosses and the crosses Gopi x OS sel.2, Gopi x JLT-54, JIT-54 x OS sel.2 in a set of reciprocal cross exhibited maximum heterosis for number of seeds per capsule. Similar results were also reported by Nafie (1980), Paramasivan *et al.* (1982), Dora and Kamla (1986), Pawar (1987), Zhan *et al.* (1990), Anitha and Dorairaj (1991), Padmavati *et al.* (1993).

Twenty one direct crosses and nineteen reciprocal crosses were heterotic over superior parents for yield per plant. The magnitude of heterosis for yield per plant ranged from 4.46 to 118.18 per cent in a set of direct crosses while 17.88 to 189.47 per cent in the set of reciprocal crosses. The significant positive heterosis over mid parents (9.24 to 162.77 %) for yield per plant was noticed in twenty four crosses and twenty reciprocal crosses exhibited heterotic effect (12.82 to 214.94 %) over mid parent for yield per plant. In general, the combinations RT-46 x VRI-1 (118.18), TKG-21 x OS sel.2 (102.47), Tapi x JLT-54 (67.92) produced very high heterotic effects in respect of this trait. In addition, the heterotic effects for yield per plant in the reciprocal crosses of hybrids VRI-1 x Sekhar (189.47), Gopi x VRI-1 (155.88) and Gopi x TKG-21 (132.79) were also appreciable in magnitude. These crosses may be useful for producing hybrids by hand pollination. The heterotic effects for this character were also observed in the previous studied conducted by Sarathe and Dabral (1969), Murty (1975), Sarafi (1976), Shrivastava and Prakash (1977), Paramasivan *et al.* (1982), Sharma and Chavan (1983), Desai *et al.* (1984), Dora and Kamala (1986), Pawar (1987), TU LC *et al.* (1988), Osman (1989), Sasikumar and Saradana (1990), Sodani and Bhatnagar (1990), Reddy and Haripriya (1990), Zhan *et al.* (1990), Anitha and Dorairaj (1991), Dingh *et al.* (1991), Yadav and Mishra

(1991), Bridha and Shivsubramanan (1992), Rey and Sen (1992), Reddy *et al.* (1992), Padmavati *et al.* (1993), Reddy and Haripriya (1993), Ananda Kumar (1995), Navodiya *et al.* (1995), Fatteh *et al.* (1995), Baviskar *et al.* (1998), Govindrasu *et al.* (1999), Kamala (1999), Dixit and Swain (2000), Ragiba and Reddy (2000), Solanki and Gupta (2000) and Kar *et al.* (2001).

These crosses having high heterotic effect for various yield attributes and also higher grain yield could be tested at different locations for their performance under different environmental conditions. While selecting a particular hybrid, it is therefore necessary to consider the per se performance in addition to its heterotic effect for grain yield.

The heterotic effects for yield per plant in the direct and reciprocal crosses were found to be mostly influenced by heterosis for either one or more of the yield attributing traits like plant height, number of branches per plant, capsules per plant, length of capsules, number of seeds per capsule and 1000 seed weight.

Eleven direct crosses and eight reciprocal crosses showed high significant positive heterobeltiosis for 1000 seed weight ranging from 0.68 to 21.43 per cent and 1.70 to 15.26 per cent, respectively. Sixteen and ten hybrids showed highly significant positive heterosis over mid parent in direct and reciprocal crosses, respectively. The range in respective crosses was found to be 1.03 to 24.54 per cent and 3.44 to 26.28 per cent. The hybrids OS sel. 2 x VRI-1 (21.43 %), Tapi x VRI-1 (15.38 %), JLT-54 x VRI-1 (9.94 %) in direct crosses and Gopi x VRI-1 (15.26 %), RT-46 x Tapi (12.82 %) and VRI-1 x OS sel.2

(8.21 %) in reciprocal set showed heterosis over superior parent. In the previous studies similar results were reported by Shrivastava and Prakash (1977), Tyagi and Singh (1981), Paramasivan *et al.* (1982), Djigma (1983), Pawar (1987), Zhan *et al.* (1990), Ray and Sen (1992), Padmavathi *et al.* (1993), Navodiya *et al.* (1995), Solanki and Gupta (2000).

Solanki and Gupta noticed higher percentage (44.9 %) of heterosis for the 1000 seed weight. These data indicate the need of giving due weightage to the parents showing substantial heterosis for grain weight in different cross combinations for exploiting hybrid vigour for grain yield per plant.

In respect of oil content twenty direct crosses (0.44 to 19.99) and sixteen reciprocal crosses (0.24 to 16.15) showed highly significant positive heterosis over superior parent while twenty two crosses of F_1's set (0.83 to 23.83) and twenty two crosses of reciprocals (1.25 to 16.19) exhibited highly significant positive heterosis over mid parent. Hybrids RT-46 x Gopi (19.99 %), Sekhar x JLT-54 (17.11 %) and RT-46 x VRI-1 (15.60 %) showed higher heterosis in direct crosses while Sekhar x Tapi (16.15 %), JIT-54 x Sekhar (15.80 %), JIT-54 x RT-46 (15.05 %) showed beneficial heterosis in reciprocal crosses. The positive and significant heterosis for oil content in this crop was previously observed by Murty (1975), Tyagi and Singh (1981), Chaudhari *et al.* (1984a) Desai *et al.* (1984), Pawar (1987), Anitha and Dorairaj (1991), Reddy *et al.* (1992), Navodiya *et al.* (1995).

On the basis of *per se* performance and heterobeltiosis the direct cross RT-46 x VRI-1 appeared to be promising. Similarly the reciprocal cross VRI-1 x Sekhar was best on the basis of *per se* performance and heterobeltiosis.

5.4 ANOVA for combining ability

The analysis of variance for combining ability as presented in Table 9 indicated the existence of significant differences for general combining ability, specific combining ability and reciprocal effects among the hybrids for all the characters. the magnitude of g.c.a. variance was higher as compared to s.c.a. variance for all the character except number of seeds per capsule and oil content. The general combining ability variances were found to be highly significant and higher than specific combining ability for the characters *viz.,* Days to 50 per cent flowering, days to maturity, plant height, number of capsules per plant, yield per plant, length of capsule and 1000 seed weight. Similar results were also reported by Murti (1975), Kotecha and Yermonos (1978), Nafie (1980), Gupta (1981), Chandraprakash (1987), Chandramani and Nayar (1988), Shinde *et al.* (1991), Rajavindram *et al.* (2000) and Devasena *et al.* (2001).

While for number of seeds per capsule and oil content s.c.a. variance were higher than g.c.a. variance such higher magnitude of s.c.a. effects than g.c.a. effects for these characters were also reported by Murty (1975), Dixit (1978), Shrivas and Singh (1981), Sharma and Chauhan (1985), Krishnodoss *et al.* (1987), Chandraprakash (1987), Dora and Kamala (1986), Kumar *et al.*

(1987), Ramalingam *et al.* (1990), Ding *et al.* (1991), Reddy *et al.* (1992), Thiyangarajan and Ramanathan (1995), Ragiba and Reddy (2000b) in their studies.

The magnitude of s.c.a. variance when compared with variance due to reciprocal effect was highly significant and higher for the characters *viz.,* length of capsule, number of seeds per capsule, yield per plant and oil content.

While the magnitude of r.c.a. variance was highly significant and higher than s.c.a. variance for the characters *viz.,* days to maturity, plant height, number of branches per plant, number of capsules per plant, yield per plant and 1000 seed weight. Thus indicating presence of reciprocal effects for these characters.

This may be due to the influence of maternal effect or cytoplasmic influence which could be well ascertained in the later segregating generations such higher magnitude of r.c.a. effect than s.c.a. effects for these character also noticed by Yermonos and Kotecha (1979), Dora and Kamala (1986), Brindha and Shivasubramanan (1992), Krishnadevi *et al.* (2002).

5.5 General combining ability

The parent showing best general combining ability effects are given in Table 15.

Parent RT-46 was the best general combiner for days to 50 per cent flowering and days to maturity. The other parents *viz.,* Tapi, TKG-21, JLT-54 and Sekhar exhibited good g.c.a. effects for days to 50 per cent flowering and days to maturity. Parents OS sel.2 and VRI-1 were the best general combiner for plant height and

Table 15. Parents showing best general combining ability effects in sesamum

Sr. No.	Parents	No. of characters	Name of characters
1.	Tapi	6	Days to 50 % flowering, Days to maturity, Number of branches, Number of capsules per plant, yield per plant, oil content
2.	TKG-21	4	Days to 50 % flowering, Days to maturity, 1000 grain weight, Oil content
3.	RT-46	6	Days to 50 % flowering, Days to maturity, Number of branches, Number of capsule, Number of seeds per capsule, yield per plant,
4.	Sekhar	4	Days to 50 % flowering, Days to maturity, 1000 grain weight, Oil content
5.	OS sel.2	7	Plant height, Number of branches, Number of capsule, length of capsule, Number of seeds per capsule, yield per plant, oil content
6.	JLT-54	6	Days to 50 % flowering, Days to maturity, Length of capsule, Number of seeds per capsule, 1000 seed weight, oil content
7.	VRI-1	5	Plant height, Number of branches, Number of capsule, yield per plant, Oil content
8.	Gopi	2	Length of capsule, 1000 seed weight

number of capsules per plant while parents Tapi and RT-46 exhibited good g.c.a. effects for number of capsules per plant. The parental lines VRI-1, RT-46, OS sel.2 and Tapi were the best combiners in descending order for number of branches per plant.

The parents JLT-54, OS sel.2 and Gopi were the best general combiners for the length of capsule, highly significant positive g.c.a. effects were displayed by the parental line RT-46, OS sel. 2 and JLT-54 for number of seeds per capsule in descending order.

The parents Tapi, VRI-1, OS sel.2 and RT-46 appeared to be the best general combiners for the yield per plant. The best general combining ability effects for 1000 seed weight were showed by the parental lines JLT-54, Sekhar, Gopi and TKG-21. The parents TKG-21 and Tapi appeared to be the best general combiners for oil content.

The parents Tapi, RT-46, OS sel.2, JLT-54, VRI-1 appeared to be average general combiners for most of the developmental and yield contributing characters. Murty (1975), Dixit (1978), Gupta (1981), Shrivas and Singh (1981), Fatteh *et al.* (1982), Chaudhari *et al.* (1984b),Krishnodoss *et al.* (1987), Goyal and Kumar (1988), Khorgade *et al.* (1988), Khorgade *et al.* (1989), Goyal *et al.* (1991), Shinde *et al.* (1991), Kadu *et al.* (1992),Shinde *et al.* (1993), Mishra *et al.* (1994), Mcharo *et al.* (1995), Mishra and Yadav (1997), Baviskar *et al.* (1998), Das *et al.* (1999), Thakare *et al.* (1999), Zhao Yingzhog (1999), Jayalakshmi *et al.* (2000), Rajavindram *et al.* (2000), Ragiba and Reddy (2000), Sakila. *et al.* (2000b),Saravanan *et al.* (2000), Devasena *et al.* (2001), Krishnadevi *et al.* (2002), Krishnaiah *et al.* (2002), Pushpa *et al.* (2002), Senthil Kumar and Ganeshan (2002) also reported good general combiners for various yield related components in sesamum.

5.6 Specific combining ability effects reciprocal effects and gene action

The best combinations for various characters are given in Table 16.

Four direct crosses exhibited highly significant negative s.c.a. effect and two crosses exhibited significant negative s.c.a. effect for days to 50 per cent flowering and nine crosses for days to maturity showed highly significant negative s.c.a. effects, thus suggesting their best specific combining ability for earliness.

Among these the crosses TKG-21 x RT-46, JLT-54 x VRI-1, OS sel.2 x Gopi and Tapi x RT-46 showed highest negative values for s.c.a. effects for days to 50 per cent flowering while the crosses TKG-21 x RT-46, JLT-54 x VRI-1, Tapi x RT-46 and TKG-21 x Sekhar showed significant negative s.c.a. effects for days for maturity.

The parents RT-46, TKG-21, Tapi, JLT-54 and Sekhar proved to be the good general combiners for days to 50 per cent flowering and days to maturity, while VRI-1, OS sel.2 and Gopi were poor general combiner for days to 50 per cent flowering and days to maturity. This suggested that the character days to 50 per cent flowering and days to maturity in these crosses was under the influence of non-additive and additive gene action. The general combining ability variances play major part in the inheritance of flowering and maturity. These results indicated that additive as well

Table 16. The crosses showing best specific combining ability effect in sesamum

Sr. No.	Name of characters	Specific combinations	
		Direct crosses	Reciprocal crosses
1.	Days to 50 % flowering	TKG-21 x RT-46, JLT-54 x VRI-1 and OS sel.2 x Gopi	VRI-1 x Tapi, Gopi x RT-46 and TKG-21 x Tapi
2.	Days to maturity	TKG-21 x RT-46, JLT-54 x VRI-1 and Tapi x RT-46	Gopi x RT-46, VRI-1 x Tapi and TKG-21 x Tapi
3.	Plant height	Sekhar x VRI-1, Tapi x RT-46 and Sekhar x OS sel.2	JIT-54 x Tapi, VRI-1 x TKG-21 and Sekhar x TKG-21
4.	No. of branches per plant	TKG-21 x Gopi, RT-46 x Gopi and Sekhar x VRI-1	JIT-54 x Tapi, Gopi x Sekhar and OS sel.2 x TKG-21
5.	Number of capsule per plant	Sekhar x VRI-1, TKG-21 x OS sel.2 and RT-46 x JLT-54	JLT-54 x Tapi, Gopi x Tapi and JLT-54 x OS sel.2
6.	Length of capsule	JLT-54 x VRI-1, Tapi x TKG-21 and OS sel.2 x VRI-1	VRI-1 x JLT-54, JLT-54 x Sekhar and JLT-54 x OS sel.2
7.	Number of seeds per capsule	OS sel.2 x JLT-54, JLT-54 x Gopi and Tapi x OS sel.2	JLT-54 x OS sel.2, Sekhar x TKG-21 and VRI-1 x JLT-54
8.	Yield per plant	TKG-21 x OS sel.2, Sekhar x VRI-1 and RT-46 x JLT-54	JLT-54 x Tapi, VRI-1 x RT-46 and Shekhar x Tapi
9.	1000 seed weight	OS sel.2 x VRI-1, VRI-1 x Gopi and JLt-54 x VRI-1	JLT-54 x Tapi, Gopi x Sekhar and VRI-1 x Tapi
10.	Oil content	OS sel.2 x Gopi, Shekhar x JLT-54 and RT-46 x Tapi	VRI-1 x RT-46, OS sel.2 x TKG-21 and OS sel.2 x RT-46

as non-additive gene action played a major role in the inheritance of earliness. These findings are in agreement with the finding of Murty (1975), Dixit (1976b), Solanki and Paliwal (1981), Chaudhari *et al.* (1984b), Sharma and Chauhan (1984), Chandraprakash (1987), Krishnodoss *et al.* (1987), Khorgade *et al.* (1988), Goyal *et al.* (1991), Shinde *et al.* (1993), Fatteh *et al.* (1995), Mcharo *et al.* (1995), Mishra and Yadav (1997), Das *et al.* (1999), Zhao Yingzhog (1999), Jayalakshmi *et al.* (2000), Saravan *et al.* (2000), Kar *et al.* (2001), Solanki and Gupta (2001), Krishnaiah *et al.* (2002).

Highly significant negative effect were observed in eighteen reciprocal crosses for days to 50 per cent flowering and nineteen reciprocal showed highly significant negative reciprocal effect for days to maturity. The reciprocal crosses VRI-1 x Tapi, Gopi x RT-46 and TKG-21 x Tapi for days for 50 per cent flowering and Gopi x RT-46, VRI-1 x Tapi and TKG-21 x Tapi for days for maturity were found to be promising. These reciprocal effects were also previously reported by Yermones and Kotecha (1978), Sharma and Chauhan (1985) and Bridha and Sivasubramanian (1992).

Eight crosses showed highly significant positive s.c.a. effects for plant height an fifteen crosses showed highly significant positive s.c.a. effects for number of branches per plant. The hybrids Sekhar x VRI-1, Tapi x RT-46 and Sekhar x OS sel.2 for plant height involved parents with low x high and high x high g.c.a. effect thus suggesting importance of non-additive as well as additive gene effects in these crosses. Similar results for plant height have been reported by Murty (1975), Gupta (1981), Chaudhari *et al.* (1984b), Sharma and

Chauhan *et al.* (1981), Krishnodoss *et al.* (1987), Shinde *et al.* (1993), Anandakumar (1995), Fatteh *et al* (1995), Rajavindram *et al.* (2000), Solanki and Gupta (2001), Krishnaiah *et al.* (2002), Senthil Kumar and Ganeshan (2002).

The crosses TKG-21 x Gopi, RT-46 x Gopi and Sekhar x VRI-1 involving parents with high x high and low x high g.c.a. effects for number of branches per plant showed significant s.c.a. effects. These results indicated that both additive as well as non-additive gene effects were important for this character. Sharma and Chauhan (1985), Kadaswamy (1985), Anandakumar (1995), Das *et al.* (1999), Rajavindram *et al.* (2000), Senthil Kumar and Ganeshan (2002) reported additive gene action while Murty (1975), Dixit (1976b), Shinde *et al.* (1993), Fatteh *et al.* (1995) and Jayalakshmi *et al.* (2000) reported non-additive genen action and Khorgade (1988) and Mishra and Yadav (1997) reported additive and non-additive gene action for the inheritance of number of branches per plant in sesame.

Among the reciprocal crosses eleven crosses showed highly significant positive s.c.a. effects for the plant height, while twelve reciprocal crosses registered highly significant positive s.c.a. effects for number of branches per plant. The reciprocal crosses JLT-54 x Tapi, VRI-1 x TKG-21 and Sekhar x TKG-21 for plant height and JLT-54 x Tapi, Gopi x Sekhar and OS sel.2 x TKG-21 for number of branches per plant exhibited highest reciprocal effect. Similar results for both the character have been reported by Fatteh *et al.* (1982), Yermonos and Kotecha (1978), Sharma and Chauhan (1985).

Nine crosses exhibited highly significant positive s.c.a. effects for number of capsule per plant. While four crosses showed highly significant positive s.c.a. effect and two crosses showed significant positive s.c.a. effect for length of capsule. The hybrids Sekhar x VRI-1, TKG-21 x OS sel.2 and RT-46 x JLT-54 showed high positive value of s.c.a. effects for number of capsule per plant and the crosses JLT-54 x VRI-1, Tapi x TKG-21 and OS sel.2 x VRI-1 showed high positive value of s.c.a. effects for length of capsule. These crosses involved the parents with low x high and high x high, high x low g.c.a. effects. It is thus evident that major portion of s.c.a. effects for these character was due to additive as well as non-additive genic control. Similar results have been reported for number of capsule by Murty (1975), Dixit (1978), Chaudhari *et al.* (1984b) Chavan *et al.* (1982), Sharma and Chavan (1984), Hu (1985), Krishnodoss *et al.* (1987), Khorgade *et al.* (1988), Shinde *et al.* (1993), Anandakumar (1995), Fatteh *et al.* (1995), Mcharo *et al.* (1995), Mishra and Yadav (1997), Das *et al.* (1999), Jayalakshmi *et al.* (2000), Rajavindram *et al.* (2000), Krishnaiah *et al.* (2002), Senthil Kumar and Ganeshan (2002) while for length of capsule Khorgade *et al.* (1988), Padmavathi *et al.* (1994), Fatteh *et al.* (1995), Mcharo *et al.* (1995), Mishra and Yadav (1997), Krishnaiah *et al.* (2002) reported similar results.

In the reciprocal effects, ten and five crosses showed highly significant positive reciprocal effects for number of capsule per plant and length of capsule, respectively. The reciprocal crosses JLT-54 x Tapi, Gopi x Tapi and JLT-54 x OS sel.2 showed highly significant positive reciprocal effects for number of capsule per plant while the reciprocal crosses VRI-1 x JLT-54, JLT-54 x Sekhar and JLT-54 x OS sel.2 appeared to be highly significant with positive reciprocal effects for length of capsules similar results were reported by Brindha and Sivasubramanan (1992).

Twelve crosses showed highly significant positive s.c.a. effects for number of seeds per capsule, while nine crosses exhibited highly significant positive s.c.a. effects and three crosses showed significant positive s.c.a. effect for yield per plant. The hybrids OS sel.2 x JLT-54, JLT-54 x Gopi and Tapi x OS sel.2 showed high positive value of s.c.a. effects for seeds per capsule. While the hybrids TKG-21 x OS sel.2, Sekhar x VRI-1 and RT-46 x JLT-54 showed highest significant positive values of s.c.a. effects for yield per plant and involved the parents with high x high, high x low, low x high s.c.a. effects. It is thus evident that both additive as well as non-additive genetic effects are important for this character. Similar results have been reported for yield per plant by Murty (1975), Dixit (1978), Chaudhari et al (1977), Chavan *et al.* (1982), Sharma and Chauhan (1985), Shivaprakash (1986), Krishnodoss *et al.* (1987), Reddy *et al.* (1992), Fatteh *et al.* (1995), Mcharo *et al.* (1995), Mishra and Yadav (1997), Thakare *et al.* (1999), Das *et al.* (1999), Zhao Yingzhog (1999), Jayalakshmi *et al.* (2000), Saravanan *et al.* (2000), Solanki and Gupta (2001), Krishnadevi *et al.* (2002) and Senthil Kumar and Ganesan (2002).

While for number of seeds per capsule similar results has been reported by Chavan *et al.* (1982), Hu (1985), Kandaswamy (1985), Fatteh *et al.* (1995), Mcharo *et al.* (1995), Mishra and Yadav

(1997), Rajavindram *et al.* (2000), Krishnadevi *et al.* (2002) and Senthil Kumar and Ganeshan (2002).

Among the reciprocal crosses seventeen crosses showed highly significant and two crosses showed only significant positive reciprocal effects for number of seeds per capsule while ten reciprocal crosses exhibited highly significant and two crosses showed only significant positive reciprocal effects for yield per plant. the crosses JLT-54 x OS sel.2, Sekhar x TKG-21 and VRI-1 x JLT-54 showed highly significant positive reciprocal effects for number of seeds per capsules, while the crosses JLT-54 x Tapi, VRI-1 x RT-46 and Sekhar x Tapi for yield per plant ranked in the decreasing order in magnitude and had highly significant positive reciprocal effects. Similar results have been reported by Dora and Kamala (1986).

Fifteen hybrids for 1000 seed weight and sixteen hybrids for oil percentage revealed highly significant positive s.c.a. effects. The crosses OS sel.2 x VRI-1, VRI-1 x Gopi and JLT-54 x VRI-1 had highly significant positive s.c.a. effects for 1000 seed weight, involving parents with low x high, high x low and high x high g.c.a. effects indicating that the character was controlled by non-additive and additive gene action. Similarly, the crosses OS sel.2 x Gopi, Sekhar x JLT-54 and RT-46 x Tapi showed highly significant positive s.c.a. effects for oil percentage with low x high and high x low g.c.a. effects indicating non-additive gene action for oil percentage. Similar results were reported by Reddy *et al.* (1992) and Mishra and Yadav (1997) for additive gene action Fatteh *et al.* (1982), Sharma and chauhan (1985), Padmavati *et al.* (1994), Thiyangarajan and

Ramanathan (1996) and Solanki and Gupta (2001) for non-additive gene action, while Fatteh *et al.* (1995), Das *et al.* (1999), Thakare *et al.* (1999), Saravanan (2000) for both additive and non-additive gene action.

Eighteen and thirteen reciprocal crosses showed highly significant positive reciprocal effect for 1000 seed weight and oil percentage, respectively. The reciprocal crosses JLT-54 x Tapi, Gopi x Sekhar and VRI-1 x Tapi had highly significant positive reciprocal effects for 1000 seed weight whereas the reciprocal crosses VRI-1 x RT-46, OS sel.2 x TKG-21 and OS sel.2 x RT-46 showed highly significant positive reciprocal effects for oil percentage.

Reciprocal effects were observed for all the characters, thus the significance of reciprocal effects for all the characters exhibited the presence of maternal effect. However, the magnitude of variance due to s.c.a. when compared with those due to reciprocal effect was higher for the character *viz.,* length of capsule, number of seeds per capsule, yield per plant and oil content suggested the predominant role of s.c.a. effects while the magnitude of r.c.a. variance was higher than s.c.a. variance for the character *viz.,* days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, 1000 seed weight for these character maternal effects played an important role than s.c.a. effects. The reciprocal effects for yield and most of the yield related components like plant height, number of branches, number of capsules per plant and earliness were also reported by Yermanos and Kotecha (1978), Fatteh *et al.* (1982), Sharma and Chauhan (1985), Dora and Kamla (1986), Bridha and Sivasubramanian (1992).

5.7 Correlations

The knowledge of inter relationship among the characters is useful to the plant breeder for improving the efficiency of selection programme. The phenotypic correlation indicates the extent of the observed relationship between two characters. This does not give a true genetic picture of the relationship because it indicates both heredity as well as environmental influence. Genotypic correlations provide an estimates of an inherent association between genes controlling any two characters. Hence, it is of greater significance and can be effectively utilized in formulating on effective selection scheme. The estimates of correlation coefficients may also help to identify the characters that prove to be or little or no importance in the selection programme.

In general, it was observed that genotypic correlation coefficients were higher than the phenotypic correlation coefficients between most of the characters studied (Table 13). This indicate that though there was a strong inherent association between the various characters studied, the genotypic expression of the correlation was comparatively less influenced by the environmental deviation. Chavan and Chopade (1981) in sesamum also observed higher genotypic correlation than phenotypic correlation between various pairs of characters which supported the present findings.

It was observed, that the grain yield per plant showed highly significant positive association with number of branches per plant, number of capsules per plant and significantly correlated with days to maturity and plant height at phenotypic levels while at genotypic level the grain yield per plant showed highly significant positive association with number of branches per plant, number of capsule per plant and positive significant correlated with days to 50 per cent flowering, days to maturity and plant height. The characters length of capsule and number of seeds per capsule showed non-significant positive correlation with grain yield at phenotypic level and genotypic level. The observations suggested that these characters are substantially affected by environment. It was interesting to note from the for going discussion that the character number of branches per plant, number of capsules per plant, 1000 seed weight, plant height, length of capsule, earliness characters are governed predominantly by additive gene action. Further the results on association between these characters indicated that simultaneous selection for these traits may bring about an improvement such correlation have also been reported by Shukla and Verma (1976), Gupta (1976), Rathnaswamy and Jagathesan (1984), Sharma and Chauhan (1984), Krishnodoss *et al.* (1986), Rong and Wu (1989), Osman (1989), Zhan *et al.* (1990), Pathak and Dixit (1992), Vadhavani *et al.* (1992), Reddy *et al.* (1993), Jarwal *et al.* (1998), Siddiqui *et al.* (1998), Ganesh and Sakila (1999), Sakila *et al.* (2000), Solanki and Gupta (2001), Kumaresan and Nadarajan (2002) Yingzhong and Yishou (2002).

The days for 50 per cent flowering showed positive but non-significant correlation while days to maturity had significant correlation with grain yield per plant at phenotypic level whereas at genotypic level both characters showed significant correlation with grain yield suggesting that early flowering and short duration varieties might be beneficial for higher grain yield in this crop. Similar result were noticed by Chavan and Chopade (1981), Jarwal *et al.* (1998), Siddiqui *et al.* (1998).

The character 1000 seed weight and oil content had positive but non-significant correlation with grain yield at both levels. A positive relationship among the yield attributes indicating that they had certain inherent relationship with grain yield. Similar results were reported by Chaudhari *et al.* (1977), Chauhan et al (1981), Ro and Wu (1989), Pathak and Dixit (1992), Solanki and Gupta (2001).

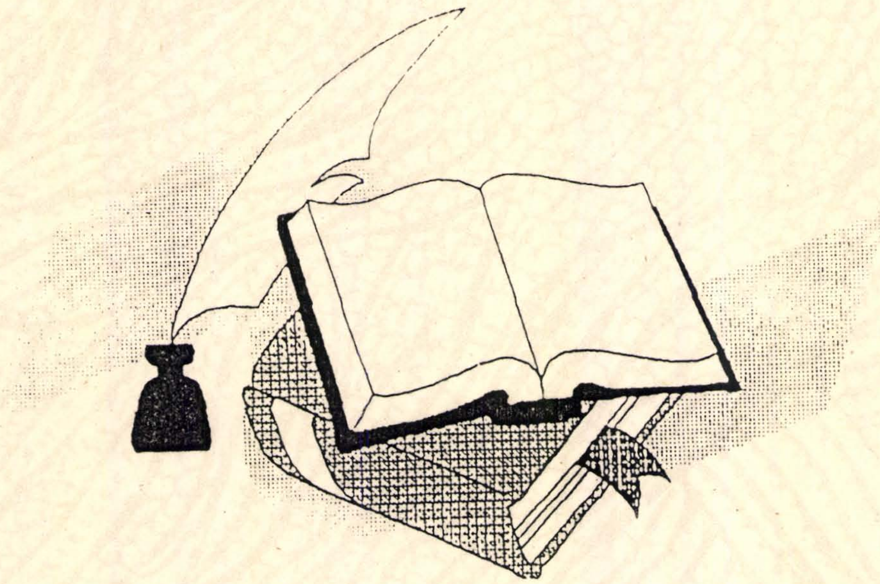
The days for 50 per cent flowering was highly significant positively correlated with days for maturity, number of capsules per plant and significantly positive correlated with number of branches per plant. It also had positive but non-significant correlation with plant height, number of seeds per capsule. Indicating that there is certain interrelationship among these characters. Days for 50 per cent flowering was positively correlated with days for maturity suggesting that days taken for maturity can be predicted by days taken for flowering. Similar results were observed by Kaushal *et al.* (1974), Jarwal *et al.* (1998) and Siddiqui *et al.* (1998).

The days for maturity had highly significant positive correlation with days to 50 per cent flowering, number of branches per plant, number of capsules per plant. It had highly significant negative correlation with 1000 grain weight and non-significant negative correlation with length of capsule and oil content, indicating that there is no association among these character. It had positive but non-significant correlation with plant height and number of seeds per capsules indicating there is certain relationship among these character. Similar results were reported by Krishnadoss ef *al*. (1986), Pathak and Dixit (1992), Siddiqui *et al*. (1998), Ganesh and Sakila (1999), Kumaressna and Nadarajan (2002).

Plant height had positive and highly significant correlation with number of branches, number of capsule indicating that number of branches and capsule increases with the increase in plant height. Plant height had positive but non-significant correlation with days for 50 per cent flowering, days for maturity, length of capsule, number of seeds per capsule, 1000 seed weight. It had non-significant negative correlation with oil content. Similar results were noticed by Krishnodoss ef *al*. (1986), Jarwal *et al*. (1998) and Ganesh and Sakila (1999).

The component characters *viz.,* days to 50 per cent flowering, days to maturity, number of branches, No. of capsules per plant were observed to be positively associated with each other at genotypic as well as phenotypic levels indicating grain yield in a function of these components. Further, length of capsules, no. of seeds/capsule of ICXX) grain weight also had positive significant correlation among them selves indicating inter linked with each other.

Thus the above observations suggested that a desirable plant type in sesamum for higher seed yield should have more number of branches, more number of capsules, more number of seeds per capsule and the large sized capsule selection based on these character would be more effective.



SUMMARY AND CONCLUSIONS

6. SUMMARY AND CONCLUSIONS

In the present investigation in sesamum (*Sesamum indicum* L.) conducted during 2002 an attempt has been made to study the heterosis, combining ability, gene action and correlation through a diallel analysis in respect of characters *viz.,* days for 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of capsules per plant, length of capsule (cm), number of seeds per capsule, yield per plant, 1000 seed weight, oil percentage. Eight parents *viz.,* Tapi, TKG-21, RT-46, Sekhar, OS sel.2, JLT-54, VRI-1 and Gopi and 56 F_1's including reciprocals were assessed in a randomised block design with three replications at the Post Graduate Research Farm of Mahatma Phule Agricultural University, Rahuri.

6.1 Summary

6.1.1 Mean performance

On the basis of mean performance the parents Tapi and JLT-54 were found to be early in flowering as well as in maturity. Parental line JLT-54 was observed superior in plant height and 1000 seed weight while parent VRI-1 appeared to be better for number of branches. The parental lines Tapi and RT-46 were found to be superior in number of capsules per plant and yield per plant. Parental line TKG-21 was observed superior in length of capsule and oil content. Parental line RT-46 was observed superior in number of seeds per capsule.

The crosses RT-46 x VRI-1 and Tapi x JLT-54 were the best considering mean performance for yield per plant. These hybrids were also good for number of capsules per plant and number of branches per plant. Similarly, the reciprocal hybrid VRI-1 x Sekhar was best on the basis of *per se* performance for yield per plant. This cross was also superior for number of capsules per plant and plant height.

6.1.2 Heterosis

Fourteen direct crosses and four reciprocal crosses showed significant negative heterosis over superior parents for days to 50 per cent flowering. The direct cross Tapi x VRI-1 and reciprocal cross VRI-1 x JLT-54 showed maximum beneficial heterosis over superior parents for days to 50 per cent flowering.

Fifteen direct crosses and eight reciprocal crosses showed significant negative heterosis over superior parents for days to maturity. The direct cross Tapi x VRI-1 and reciprocal cross VRI-1 x JLT-54 showed maximum beneficial heterosis over superior parents for days to maturity.

Eleven direct crosses and eight reciprocal hybrids showed significant heterosis over superior parents for plant height. The direct cross Tapi x OS sel.2 and reciprocal cross OS sel.2 x Sekhar showed maximum beneficial heterosis over superior parents for plant height.

In respect of number of branches per plant eight direct crosses and ten reciprocal crosses exhibited highly significant positive heterosis over superior parents. The direct cross Tapi x JLT-54 and reciprocal cross VRI-1 x Tapi showed maximum beneficial heterosis over superior parents for number of branches per plant.

For the number of capsules per plant thirteen direct crosses and fourteen reciprocal crosses showed significant positive heterosis over superior parents. The direct cross Sekhar x VRI-1 and its reciprocal cross VRI-1 x Sekhar exhibited maximum beneficial heterosis over superior parents for number of capsules per plant.

Four direct crosses and four reciprocal crosses exhibited highly significant positive heterobeltiosis for length of capsules. The direct cross Sekhar x OS sel.2 and its reciprocal cross OS sel.2 x Sekhar showed maximum beneficial heterosis over superior parents for length of capsules.

Sixteen direct crosses and nine reciprocal crosses showed significant positive heterobeltiosis for number of seeds per capsule. The direct cross OS sel.2 x JLT-54 and reciprocal cross Gopi x OS sel.2 showed maximum beneficial heterosis over superior parents for number of seeds per capsules.

Twenty one direct crosses and nine reciprocal crosses showed highly significant heterosis over superior parents for yield per plant. The direct cross RT-46 x VRI-1 and reciprocal cross VRI-1 x Sekhar showed maximum beneficial heterosis over superior parents for yield per plant.

Eleven direct crosses and eight reciprocal crosses showed highly significant positive heterobeltiosis for 1000 seed weight. The direct cross OS sel. 2 x VRI-1 and reciprocal cross Gopi x VRI-1 showed maximum beneficial heterosis over superior parents for 1000 seed weight.

In respect of oil content twenty direct crosses and sixteen reciprocal crosses showed highly significant positive heterosis over superior parents. The direct cross RT-46 x Gopi and reciprocal cross Sekhar x Tapi showed maximum beneficial heterosis over superior parents for oil content.

6.1.3 General combining ability

The parental line OS sel.2 was good general combiner for seven characters *viz.,* plant height, number of branches per plant, number of capsules per plant, length of capsule, number of seeds per capsule, yield per plant and oil content. Similarly parents Tapi and JLT-54 were good general combiners for six characters, parents VRI-1 for five characters and TKG-21 and Sekhar for four characters.

6.1.4 Specific combining ability

The cross Sekhar x VRI-1 was found to be good specific combination for plant height, number of branches per plant, number of capsules per plant and yield per plant. The reciprocal hybrid JLT-54 x Tapi was promising specific combination for traits *viz.,* yield per plant, plant height, number of branches per plant, number of capsules per plant and 1000 seed weight.

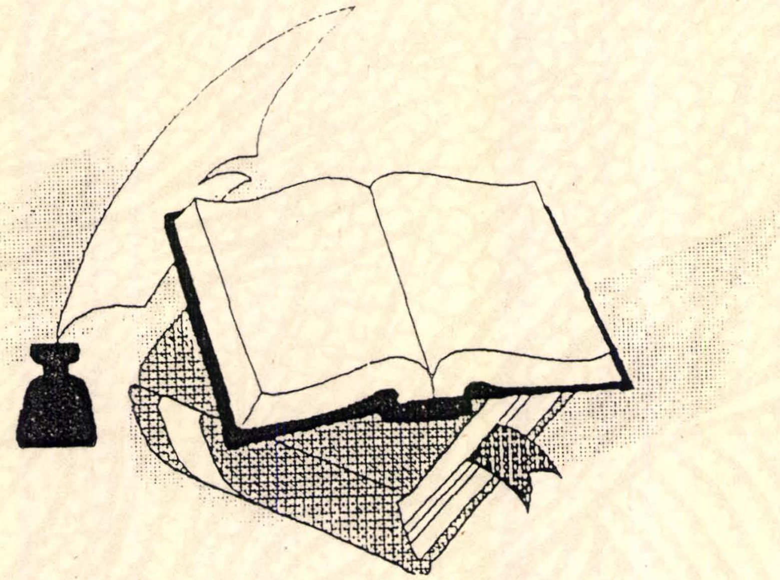
6.1.5 Correlation

Highly significant positive association of grain yield per plant was observed with traits *viz.,* number of branches per plant, number of capsules per plant and significance association with plant height, days to 50 per cent flowering and days to maturity. The characters length of capsule number of seeds per capsule, 1000 seed weight and oil content showed non significant positive correlation with grain yield. The characters *viz.,* days to 50 per cent flowering, days to maturity, number of branches, number of capsules were interrelated with each other at genotypic as well as phenotypic levels.

6.2 Conclusions

1. On the basis of mean performance the parental lines Tapi and RT-46 were found to superior for yield per plant, while Tapi and JLT-54 were promising for earliness.
2. The direct crosses *viz.,* RT-46 x VRI-1 and Tapi x JLT-54 and the reciprocal cross VRI-1 x Sekhar were promising for yield per plant on the basis of mean performance.
3. The direct cross RT-46 x VRI-1 and the reciprocal cross VRI-1 x Sekhar ranked top in respect of heterobeltiosis for yield per plant.
4. The lines *viz.,* Tapi, VRI-1, OS sel.2 and RT-46 were identified as best combiners for yield per plant.
5. On the basis of specific combining ability effects the crosses TKG-21 x OS sel.2 and Sekhar x VRI-1 were promising for yield per plant.
6. On the basis of reciprocal effects the crosses JLT-54 x Tapi and VRI-1 x RT-46 were promising for yield per plant.
7. The traits *viz.,* number of capsules/plant, number of branches/plant, plant height, days to maturity and days to 50 per cent flowering were significantly and positively correlated with yield/plant.

8. On the basis of *per se* performance and heterobeltiosis and sca effects the direct cross RT-46 x VRI-1 appeared to be promising for further confirmation and exploitation.



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Originals not seen

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