Selection indices and character association in three segregating generations of sesame (*Sesamum indicum* L.)

BY

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CERTIFICATE

Miss. P. JYOSHNA DEVI has satisfactorily prosecuted the course of research and that the thesis "**SELECTION INDICES AND CHARACTER ASSOCIATION IN THREE SEGREGATING GENERATIONS OF SESAME (*Sesamum indicum* L.)**" submitted is the result of original research work and of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part there of has not been previously submitted by her for a degree of any university.

Date:

Place:

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CERTIFICATE

This is to certify that the thesis entitled "**SELECTION INDICES AND CHARACTER ASSOCIATION IN THREE SEGREGATING GENERATIONS OF SESAME (*Sesamum indicum* L.)**" submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** in the major field of **Genetics and Plant Breeding** of the Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bona fide research work carried out by **Miss. P. JYOSHNA DEVI** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma or has been published. The published part has been fully acknowledged. All the assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

(Dr. P.V. RAMA KUMAR)
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List of Symbols and Abbreviations

%	:	Percent
*	:	Significant at 5% level
**	:	Significant at 1% level
ANOVA	:	Analysis of Variance
CD	:	Critical Difference
Cm	:	Centimeter
Cv	:	Coefficient of variation
d.f	:	Degree of freedom
et al.	:	And other workers
F_2	:	Second generation of cross
F_3	:	Third generation of cross
F_4	:	Fourth generation of cross
g	:	Gram
GA	:	Genetic Advance
GAM	:	Genetic Advance as per cent of Mean
GCV	:	Genotypic Coefficient of Variance
PCV	:	Phenotypic Coefficient of Variance
h^2(b)	:	Heritability (broad sense)
SEd	:	Standard error of difference
Viz.,	:	Namely

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Date : **(P. JYOSHNA DEVI)**

DECLARATION

I, Miss. P. JYOSHNA DEVI, here by declare that the thesis entitled "**SELECTION INDICES AND CHARACTER ASSOCIATION IN THREE SEGREGATING GENERATIONS OF SESAME (*Sesamum indicum* L.)**" submitted to the Acharya N.G. Ranga Agricultural University for the degree of Master of Science in Agriculture in the major field of **Genetics and Plant Breeding** is the result of the original research work done by me. It is further declared that the thesis or any part there of has not been published earlier in any manner.

Place:

Date : **(P. JYOSHNA DEVI)**

ABSTRACT

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The present investigation was carried out during *rabi*, 2005-2006 at Agricultural College Farm, Bapatla, to study the genetic variability, heritability, expected genetic advance, character association, path coefficient analysis and selection indices in seventeen genotypes of sesamum for the characters, plant height, days to 50% flowering, days to maturity, number of primaries, number of capsules per plant, number of seeds per capsule, 1000-seed weight, oil content and seed yield per plant.

The analysis of variance revealed significant differences among seventeen genotypes for many of the characters studied except number of primaries and 1000-seed weight indicating the presence of sufficient amount

of variability in the material. The characters like, number of seeds per capsule, oil content, seed yield per plant and plant height were found to be highly heritable characters.

The correlation studies indicated significant positive association of seed yield with number of capsules per plant and plant height but a significant negative association with number of primaries.

The path coefficient analysis revealed that the characters, plant height, number of capsules per plant and oil content had positive direct effect with seed yield.

The selection indices showed that the functions including number of seeds per capsule as one of the components recorded high expected genetic advance as well as relative efficiency. An index in which seven characters viz*.,* plant height, days to 50% flowering, days to maturity, number of capsules per plant, number of seeds per capsule, oil content and seed yield per plant showed maximum genetic advance as well as relative efficiency, suggesting that simultaneous selection of all these characters would be better over straight selection for seed yield.

Among the seventeen genotypes of sesamum, the selection criterion values are more for the genotypes Gowri, Madhavi, Vinayak, Madhavi x Vinayak (F_2) and Gowri x SO-12-2154 (F_3) and were found to be better based on selection criterion values. In restricted selection indices highest genetic advance value was recorded by number of seeds per capsule, when each character was restricted separately.

CHAPTER – I

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oil seed crop, native to India and its nativity has been confirmed by Simmonds (1976). In India the annual production of sesame is 0.62 million tonnes with a productivity of 0.35 tonnes/ha compared to world production (2.89 million tonnes) and productivity (0.41 t/ha). The average seed yields of sesame are low due to non-availability of high yielding varieties with wider adaptability. In order to overcome the low productivity of sesamum, plant breeding programme with special emphasis on the development of high yielding varieties of sesamum is important.

Breeding for higher yield is the major objective in any crop improvement programme. Yield is a complex character governed by a large number of additive and non-additive genes and is quantitatively inherited.

Direct selection for yield is not effective as yield is a complex character with low heritability. Therefore, indirect selection could be made through component characters contributing to yield. Correlations provide information about the association of characters with each other and with yield. Path coefficient analysis provides information on the direct and indirect effects of each character on yield. These two aid in the selection to a greater extent for yield improvement.

Selection indices are useful in understanding the extent of improvement that can be brought in yield by combination of characters. It forms the basis in considering the correlated characters for higher efficiency in selection for yield.

Discriminant function affords an efficient method for simultaneous selection (Smith, 1936). Construction of selection indices using discriminant function technique will be highly helpful to discriminate desirable genotypes on the basis of their phenotypic performance. Selection index is a tool which utilizes the appropriate weightage to the phenotypic values of each of two or more component characters to be used simultaneously for selection based on their genotypic contribution. Thus, construction of selection indices using discriminate function technique solves the problem of apportioning the total effect by discriminating environmental effect. Hence, it will be highly helpful in selection of several characters simultaneously and also discriminate desirable genotypes from undesirable on the basis of phenotypic performance.

Taking the above aspects into consideration for selecting desirable genotypes and for formulating better selection criteria the present investigation was carried out with the following objectives;

1. To find out the extent of genetic variation, heritability and genetic advance for the yield and yield attributing characters.
2. To study the character association among yield and yield components through correlations.
3. To assess the direct and indirect effects of yield component characters through path coefficient analysis.
4. To study the simultaneous improvement of characters by constructing selection indices using discriminant function technique and also restriction selection indices.

CHAPTER – II

REVIEW OF LITERATURE

A review of work done in sesamum and other crops relevant to the present investigation is furnished under the following headings.

2.1 Genetic variability, heritability and genetic advance

2.2 Character association

2.3 Path coefficient analysis

2.4 Selection indices

2.1 GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE

The information on the nature and magnitude of variability for different quantitative and qualitative traits in any crop species plays a vital role while formulating the efficient breeding programmes. Yield being a complex character, is influenced by a number of other traits, which are polygenically inherited and such characters are influenced by several environmental factors. Hanson *et al.* (1956) defined heritability in broad sense as the ratio of genotypic variance to the total genetic in the non-segregating populations. Heritability measures the relative amount of the heritable portion of variability while the genetic advance helps to measure the amount of progress that could be expected with selection in a character. Estimates of heritability along with estimates of genetic advance are more useful in choice of selection method rather than heritability or genetic advance alone (Johnson *et al.,* 1955). Superior genotypes can be isolated by selection if considerable genetic variation exists within the population. It is essential to partition the overall variability into heritable and non-heritable components with the genetic parameters like, genotypic and phenotypic coefficients of variation.

Li (1988) reported high heritability for 1000 seed weight and seeds per capsule and low heritability for plant height, high genotypic variation and expected genetic advance for number of capsules per plant and yield per plant and low for plant height, number of branches and 1000 seed weight.

Kandaswamy *et al.* (1990) observed high heritability with high genetic advance in yield per plant, high heritability and low genetic advance in days to 50% flowering and low heritability and low genetic advance in number of capsules on main stem, number of capsules on branches and total number of capsules per plant.

Govindarasu *et al.* (1990) recorded high GCV values, heritability estimate and genetic advance for seed yield, capsules on primaries, capsules on secondaries and number of secondaries.

Janardhanam and Subhash Chandra Bose (1991) reported that the yield per plant showed high heritability and high genetic advance with high degree of disparity of phenotypic and genotypic coefficient of variance indicating the environmental influence.

A wide range of variation for plant height, days to maturity and number of capsules per plant and low variation for number of primary branches, 1000-seed weight and seed yield per plant was noticed by Raut *et al.* (1991).

Shinde *et al.* (1991) observed a significant variability for plant height, number of capsules per plant and seed yield per plant.

Pathak and Dixit (1992) revealed wide range of variability for plant height, branches per plant, seed yield and capsules per plant and high heritability for protein and oil content, days to maturity, days to 50% flowering and high genetic advance for plant height, branches per plant, seed yield, days to 50% flowering, capsules per plant and protein content.

Shadakshari *et al.* (1992) obtained high PCV and GCV values for total number of branches, total number of capsules, seed yield per plant and node of first flowering. Heritability and genetic advance were high for seed yield per plant, total number of capsules and total number of branches.

According to Baruah and Goud (1993) higher estimates of GCV coupled with high heritability and expected genetic advance were observed for seed yield per plant, seed weight per capsule, height of branching, plant height and number of capsules per plant in both the generations.

John *et al.* (1993) observed highest phenotypic and genotypic coefficients of variation for number of capsules on branches followed by seed yield per plant and number of capsules on main stem. Heritability value was highest for seed oil content. Highest genetic advance was recorded for seed yield per plant followed by the number of capsules on the main stem.

High estimates of heritability for number of capsules per plant, number of seeds per capsule, 1000 seed weight were recorded by Fendel and Penso (1994).

High heritability coupled with high genetic advance was recorded for branch number per plant, number of fruiting nodes per plant, capsule number per plant and seed yield in the reports of Mishra *et al.* (1995).

Shadakshari *et al.* (1995) observed high PCV and GCV values for number of capsules per axil, total number of capsules, total number of branches, seed yield per plant and node of first flowering and low values for days to 50% flowering, days to first branching, days to second branching, capsule length, capsule girth, oil content and days to maturity. Heritability and genetic advance were high for number of capsules per axil, seed yield per plant, number of locules per capsule, total number of capsules and total number of branches. Days to first branching, days to second branching, capsule length and oil content showed high heritability with low genetic advance.

Mishra and Yadav (1996) reported higher variability for days to maturity, number of capsules per plant, number of seeds per capsule and 1000-seed weight.

John Joel and Thangavelu (1997) revealed close resemblance between GCV and PCV estimates for 1000-seed weight, capsule length, capsule breadth, oil content, days to 50 per cent flowering, days to maturity and seed number per capsule, and also high heritability indicating that selection for these characters would be much effective.

Low heritability coupled with low genetic advance was observed by Kavitha and Sethupathi Ramalingam (1997) for 1000-seed weight and oil content which revealed that the characters were very much influenced by environment and would not respond to selection with efficiency.

Backiyarani *et al.* (1997 b) recorded high heritability estimates along with high genetic advance for plant height, primary branches, capsule number and single plant yield, while high heritability and low to moderate genetic advance was observed for number of seeds per capsule by their studies in F_2 and F_3 generations of sesame.

High heritability with high genetic advance for number of branches and high heritability with low genetic advance for days to 50% flowering and days to maturity were observed in studies of ten parental lines and 45 F_3 populations of sesame conducted by Jayalakshmi *et al.* (1998).

Shanmugavalli and Vannirajan (1998) reported high genotypic coefficients of variation and high heritability combined with high genetic advance for number of capsules per plant and single plant yield. Hence, these traits are the most suitable for improvement through selection.

High heritability for days to maturity, plant height, branches per plant, capsules per plant, seeds per capsule and 1000-seed weight and moderate to low heritability for seed yield per plant were observed by Kamala (1999).

Govindarasu *et al.* (1998) observed high genetic variability, heritability and genetic advance in the F_2 populations for seed yield, branch number and plant height than their parents.

Parameswari and Muralidharan (1999) revealed higher estimates of heritability in intermating progenies of sesame compared to F_2. Selection of intermated progenies is desirable over F_3 due to their superior mean performance, higher GCV and heritability coupled with high genetic advance.

Saravanan *et al.* (2000) reported high heritability and moderate genetic advance as per cent of mean for plant height, number of capsules per plant and seed yield per plant.

Mothilal (2000) revealed high heritability estimates for plant height, fruiting stem length, number of capsules and seed yield. Seed yield per plant and number of capsules recorded high genetic advance.

High GCV and PCV for seed yield per plant, total capsules per plant, plant height and oil yield per plant were observed by Ashoka *et al.* (2001).

According to Mukhekar *et al.* (2002) estimates of genotypic coefficient of variation, heritability and genetic gain revealed that the variability in 1000-seed weight, plant height and seed yield was heritable.

Krishnaiah *et al.* (2002) observed high GCV and heritability coupled with high genetic advance for number of capsules and plant height suggesting that simple selection is effective to improve these traits.

High phenotypic and genotypic coefficients of variation for number of branches per plant, number of seeds per capsule, high variability for seed yield per plant, high heritability and genetic advance for number of capsules and seed yield per plant were revealed by Kumar *et al.* (2002), with different crosses of sesame.

Sharma and Mandal (2001) reported significant variability in all the quantitative characters studies and high heritability values were recorded for number of capsules per plant followed by days to 50% flowering. The character, plant height showed maximum GA followed by number of capsules per plant.

Solanki and Deepak Gupta (2003) noticed high magnitude of variation in the experimental material was neglected by high values of mean and range for almost all the characters. High heritability combined with high genetic advance (as per cent of mean) was observed for seed yield, branches per plant and capsules per plant.

Higher estimates of PCV and GCV in biparental matings (BIPS) were noticed by Gangappa *et al.* (2003) for number of branches per plant, number of capsules per plant and capsule width in all the three crosses studied. Heritability estimates were higher for all the characters coupled with genetic advance as per cent of mean.

Saravanan *et al.* (2003) recorded high heritability and genetic advance for single plant yield, plant height, photosynthetic rate, leaf area index and harvest index and high heritability with low genetic advance for days to 50% flowering suggesting that improvement could be brought about by direct selection for these traits in advance generation.

Tamina Begum and Dasgupta (2003) observed high PCV and GCV and heritability for seed yield, number of capsules per plant, number of branches per plant and plant height. Genetic advance was highest for 1000-seed weight.

Wide range of variation was recorded for all the characters, except for capsule length under study. High heritability along with high magnitude of genetic advance in percentage of mean was recorded for capsules per plant and grain yield in the studies of Singh and Singh (2004). Days to maturity exhibited high heritability and low genetic advance.

Ved Narain *et al.* (2004) reported highest GCV for seed yield followed by harvest index, number of capsules per plant and primary branches per plant. High heritability and genetic advance were recorded for number of capsules per plant, seed yield and harvest index.

Ganesan (2005) obtained highest coefficient of variation, high heritability coupled with high genetic advance as percentage of mean for number of capsules per plant. Plant height, number of seeds per capsule and 1000-seed weight were also recorded high heritability estimates and moderate level of genetic advance as percentage of mean.

Velu and Shunmugavalli (2005) reported high phenotypic and genotypic variances for number of capsules, plant height and number of seeds per capsule indicating a wide range of variability in these characters.

Babu *et al.* (2005) noticed high estimates of heritability for all the characters, while genetic advance as per cent of mean was high for seed yield per plant, number of seeds per capsule, number of primaries, number of capsules per plant and 1000-seed eight. Medium genetic advance as per cent of mean was recorded by days to 50% flowering and plant height. Oil content and days to maturity had a low genetic advance as per cent of mean. This indicated that simple selection could be effective for improving majority of characters including seed yield per plant.

Singh (2005) observed wide range of variation for all the characters, except for pod length and pod width.

Raghuwanshi (2005) recorded a wide range of variability for yield and its component characters. High variability was observed for all characters, except for 1000-seed weight, which showed low to moderate variability.

Sreedhar *et al.* (2005) noticed high heritability coupled with high genetic advance as percent of mean for number of primaries, number of capsules per plant in both F_2 and F_3 generations and 1000 seed weight in F_2 generation suggesting that these characters respond well to simple selection.

2.2 CHARACTER ASSOCIATION

Correlation studies are useful in developing an effective basis of phenotypic selection in plant populations. Study of character association has considerable use in plant breeding because selection for one character may bring about simultaneous effect on other characters depending on the intensity of association between the two traits under consideration.

Yield is polygenically controlled character and highly influenced by the environment. Selection merely based on yield is not effective. Selection based on its components increases yield as they are influenced much less due to environmental deviations. Unfavourable associations between the desired attributes under selection may limit genetic advance. Hence, a sound knowledge of associations between the yield components is essential for planning effective selection programme.

2.2.1. Plant height

Significant positive association of plant height with seed yield was revealed by Biswas and Akbar (1995), Patil and Sheriff (1996), Thiyagarajan and Ramanathan (1996), Backiyarani *et al.* (1999), Siddiqui *et al.* (1998), Alam *et al.* (1999), Backiyarani *et al.* (1999), Mukhekar *et al.* (2002), Ramireddy and Sundaram (2002), Deepasankar and Anandakumar (2003), Ratnababu *et al.* (2004), Siddiqui *et al.* (2005) and Sreedhar *et al.* (2005). Non significant positive association of seed yield with plant height was reported by Backiyarani *et al.* (1999) in F3 generation. Negative association of plant height with seed yield was observed by Shukla and Verma (1976).

2.2.2 Days to 50% flowering

Kandaswamy *et al.* (1990), Shadakshari *et al.* (1992), Vadharani *et al.* (1992), Chauhan and Gurjar (1998), Manivannan (1998), Siddiqui *et al.* (1998), Alam *et al.* (1999), Mukhekar *et al.* (2002) and Siddiqui *et al.* (2005), revealed significant positive association of days to 50% flowering with seed yield. Kumaresan and Nadarajan (2002) and Ramireddy and Sundaram (2002) noticed positive but non-significant association of this character with seed yield. Shukla (1983), Amaresha (1997) and Kavitha and Sethupathiranalingam (1999) in segregating populations of sesame observed negative association of days to 50% flowering with seed yield.

2.2.3. Days to maturity

Shadakshari *et al.* (1992), Ranganatha *et al.* (1994) in F_3 and F_4 generations of sesame, Subramanian and Subramanian (1994), Biswas and Akbar (1995), Padmavathi and Thangavelu (1996), Patil and Sheriff (1996), Subbalakshmi (1996), Tak (1997), Kavitha and Sethupathiramalingam (1999), Alam *et al.* (1999) and Siddiqui *et al.* (2005) revealed significant positive correlation of seed yield with days to maturity. Significant negative association of days to maturity with seed yield was reported by Kandaswamy *et al.* (1990).

2.2.4. Number of primaries

Significant positive association of seed yield with number of primaries was noticed by Ranganatha *et al.* (1994), Biswas and Akbar (1995), Patil and Sheriff (1996), Backiyarani *et al.* (1997a), Manivannan (1998), Alam *et al.* (1999), Kavitha and Sethupathiramalingam (1999), Solanki and Deepak (2000), Kumaresan and Nadarajan (2002), Ramireddy and Sundaram (2002), Deepasankar and Anandakumar (2003), Tamina Begum and Dasgupta

(2003), Ratnababu *et al.* (2004), Siddiqui *et al.* (2005) and Sreedhar *et al.* (2005).

2.2.5. Number of capsules per plant

Shadakshari *et al.* (1992), Ranganatha *et al.* (1994), Biswas and Akbar (1995), Patil and Sheriff (1996), Thiyagarajan and Ramanathan (1996), Govindarasu and Ramamoorthi (1998) in irradiated and non irradiated segregating populations, Manivannan (1998), Alam *et al.* (1999), Ramireddy and Sundaram (2002), Yingzhong and Yishou (2002), Deeepasankar and Ananda Kumar (2003), Tamina Begum and Dasgupta (2003), Ratnababu *et al.* (2004) and Siddiqui *et al.* (2005) revealed significant positive association of seed yield with number of capsules per plant. Vanisri *et al.* (1994) and Backiyarani *et al.* (1999) in F_2 and F_3 generations showed positive association of number of capsules with seed yield. Sharma and Asaw (1977) also reported the significant association of pod yield per plant with seed yield in redgram.

2.2.6. Number of seeds per capsule

Significant positive correlation between number of seeds per capsule and seed yield were reported by Pathak and Dixit (1992), Subramanian and Subramanian (1994), Tak (1997), Manivannan (1998), Alam *et al.* (1999), Backiyarani *et al.* (1999), Solanki and Deepak (2000), Ramireddy and Sundaram (2002), Tamina Begum and Dasgupta (2003), Ratnababu *et al.* (2004) and Sreedha *et al.* (2005). Backiyarani *et al.* (1999) in their F_3 generation studies recorded negative association of seed yield with number of seeds per capsule.

2.2.7. 1000-seed weight

Patil and Sheriff (1996), Backiyarani *et al.* (1999), Solanki and Deepak (2000), Kumaresan and Nadarajan (2002), Yingzhong and Yishou (2002), Deepasankar and Anandakumar (2003), Ratnababu *et al.* (2004) and Siddiqui *et al.* (2005) reported positively significant association of 1000-seed weight with seed yield. Yingzhong and Yishou (2002) observed negative and significant association of number of capsules per plant with 1000-seed weight. Shadakshari *et al.* (1992), Biswas and Akbar (1995), Thiyagarajan and Ramanathan (1996), Tamina Begum and Dasgupta (2003) showed negatively significant association of seed yield with 1000-seed weight. Manivannan (1998) observed no association between 1000-seed weight and seed yield.

2.2.8. Oil content

Significant positive correlation of seed yield with oil content was reported by Pathak and Dixit (1992), Shadakshari *et al.* (1992), Ramireddy and Sundaram (2002). Reddy and HariPriya (1991) noticed significant and positive correlations of branches per plant, capsules per plant and seed yield per plant with oil content. Pathak and Dixit (1992) observed significant and positive genotypic correlations of days to 50% flowering, days to maturity, plant height and number of capsules per plant with oil content. Non significant positive correlations of seed yield with oil content was observed by Ranganatha *et al.* (1994), Vanisri *et al.* (1994), Babu (2000) and Kumaresan and Nadarajan (2002). Negatively significant correlation of oil content with seed yield was recorded by Backiyarani *et al.* (1999) in their studies on both F_2 and F_3 generations.

2.2.9. Seed yield per plant

Seed yield per plant has significant positive association with other characters like plant height, number of primary branches, number of capsules per plant, number of seeds per capsule as reported by Backiyarani *et al.* (1997a), Alam *et al.* (1999), Ramireddy and Sundaram (2002) and Ratnababu *et al.* (2004). Positive correlations of seed yield with characters viz., 1000-seed weight and oil content was showed by Backiyarani *et al.* (1997a) and Kumaresan and Nadarajan (2002). Negative association of seed yield per plant with 1000-seed weight was reported by Thiyagarajan and Ramanathan (1996) and with oil content by Backiyarani *et al.* (1999).

2.3 PATH COEFFICIENT ANALYSIS

Selection based on the magnitude and direction of association between yield components and yield, will be useful in identifying important traits, which can be exploited profitably in a short time to achieve the desired level of improvement in yield. Path coefficient analysis devised by Wright (1921) is a standardized partial regression coefficient, which helps in partitioning the correlation coefficient into direct and indirect effects of independent variables on the dependent variable. The path analysis further helps to elucidate the intrinsic nature of the observed associations and imparts a degree of confidence in the selection scheme adopted for a given situation. It may also help to minimise the number of attributes for which simultaneous selection must be exercised (Dewey and Lu, 1959).

Correlation studies in conjunction with path coefficient analysis will give a better picture of the cause and effect relationship between pairs of characters.

2.3.1. Plant height

Positive direct effect of plant height on seed yield was reported by Singh *et al.* (1997), Siddiqui *et al.* (1998), Veena (1998), Kavitha and Sethupathiramalingam (1999), Yingzhong and Yishou (2002), Ratnababu *et al.* (2004) and Siddiqui *et al.* (2005). Direct effect of plant height was positive and higher in biparental progenies than F_3 bulk population as reported by Sudharani *et al.* (1996).

Negative direct effect of plant height on seed yield was reported by Reddy and HariPriya (1991) in both parents and F_1 hybrids and Subbalakshmi (1996).

2.3.2. Days to 50% flowering

Days to 50% flowering had direct positive effect on seed yield was observed by Mishra *et al.* (1995), Siddiqui *et al.* (1998) and Siddiqui *et al.* (2005). Indirect positive effect through plant height, number of capsules per plant, 1000-seed weight and oil content was noticed by Thiyagarajan and Ramanathan (1996) through number of capsules per plant and days to maturity was reported by Siddiqui *et al.* (1998) via primary branches by Kavitha and Sethupathiramalingam (1999). Low indirect effect through number of capsules per plant with negligible direct effect was reported by Deepasankar and Anandakumar (2003).

A negative direct effect of days to 50% flowering with seed yield was revealed by Thiyagarajan and Ramanathan (1996) and Kavitha and Sethupathiramalingam (1999). Negative indirect effect via number of capsules per plant, plant height and 1000-seed weight was reported in segregating populations of sesame by Kavitha and Sethupathiramalingam (1999).

2.3.3. Days to maturity

Pathak and Dixit (1992), Siddiqui *et al.* (1998), Alam *et al.* (1999) and Ratnababu *et al.* (2004) reported positive direct effect of days to maturity on seed yield.

Sudharani *et al.* (1996) observed a shift from positive direct effect of days to maturity to a negative direction in F_3 bulk population in biparental progenies. Kaushal *et al.* (1977) and Thangavelu and Rajasekharan (1983) revealed negative direct effect of days to maturity on seed yield. Indirect negative effect of days to maturity on seed yield was reported by and Siddiqui *et al.* (2005).

2.3.4. Number of primaries

Positive direct effect of number of primary branches on seed yield was noticed by Thangavelu and Rajasekharan (1983). A shift from positive direct effect of number of primary branches on seed yield in F_3 bulk population to negative direction in biparental progenies was observed by Sudharani *et al.* (1996). Tak (1997) recorded highest positive direct effect of number of primary branches on seed yield. Govindarasu and Ramamoorthi (1998) reported high positive direct effect of number of primaries on seed yield in segregating populations of sesame. Backiyarani *et al.* (1999) reported that number of primaries had high direct effect on seed yield in F_2 and low direct effect in F_3 generation, while Kavitha and Sethupathiramalingam (1999) reported negative direct effect of number of primary branches on seed yield. Indirect negative effect of number of primaries on seed yield was reported by and Siddiqui *et al.* (2005).

2.3.5. Number of capsules per plant

Subbalakshmi (1996), Sudharani *et al.* (1996), Govindarasu and Ramamoorthi (1998) in segregating populations, Manivannan (1998), Kavitha and Sethupathiramalingam (1999), Tomar *et al.* (1999), Yingzhong and Yishou (2002), Deepasankar and Anandakumar (2003), Ratnababu *et al.* (2004) and Sreedhar *et al.* (2005) reported that number of capsules per plant had direct positive effect on seed yield per plant. Sharma and Asaw (1977) indicated the importance of pods per plant in selection of high yield in genotypes. Days to flower, primary branches and secondary branches do not affect yield independently but, mainly via., pods per plant. While negative direct effect of number of capsules per plant on seed yield was recorded by Thiyagarajan and Ramanathan (1996). Indirect negative effect of number of capsules per plant on seed yield was reported by and Siddiqui *et al.* (2005).

2.3.6. Number of seeds per capsule

Vanisri *et al.*(1994), Alam *et al.* (1999), Tomar *et al.* (1999) and Karuppaiyan and Ramaswamy (2000) revealed number of seeds per capsule had positive direct effect on seed yield. Maximum direct effect on seed yield was exerted by number of seeds per capsule according to Ratnabbu *et al.* (2004).

Rai *et al.* (1997) indicated that the number of seeds per capsule had negative direct effects on seed yield coupled with positive indirect effects via capsule number and days to 50% flowering and negative indirect effects via primary branches and 1000-seed weight. Manivannan (1998) noticed negative indirect effect on seed yield via capsules on branches.

2.3.7. 1000-seed weight

Positive direct effect of 1000-seed weight on seed yield was given by Thiyagarajan and Ramanathan (1996), Sudharani *et al.* (1996), Tak (1997), Tomar *et al.* (1999), Solanki and Deepak (2000) and Ratnababu *et al.* (2004). Positive indirect effect through number of primary branches was reported by Kavitha and Sethupathiramalingam (1999) in segregating populations of sesame. Tomar *et al.* (1999) reported positive indirect effects via capsules per plant and seeds per capsule.

Negative direct effect of 1000-seed weight on seed yield was noticed by Rai *et al.* (1997) and Kavitha and Sethuapthiramalingam (1999). Backiyarani *et al.* (1999) revealed that direct effect was low and negative in both F_2 and F_3 generations of sesame. Negative indirect effect through plant height, number of capsules per plant was recorded by Kavitha and Sethupathiramalingam (1999).

2.3.8. Oil content :

Positive direct effect of oil content on seed yield per plant was reported by Thiyagarajan and Ramanathan (1996), Solanki and Deepak (2000) and Ratnababu *et al.* (2004). Positive indirect effect via plant height, 1000-seed weight was reported by Thiyagarajan and Ramanathan (1996). Negative direct effect of oil content on seed yield was reported by Kavitha and Sethupathiramalingam (1999). Backiyarani *et al.* (1999) reported that the direct effect of oil content on seed yield was negative and low both in F_2 and F_3 generations of sesame. Thiyagarajan and Ramanathan (1996) indicated negative indirect effect via days to 50% flowering.

2.4. SELECTION INDEX :

The formulation of selection index for measuring the merit of any breeding material is as old as the art of breeding (Hazel, 1943). Advances in genetics, plant breeding and biometry have shown that formulation of a selection index utilizing Fisher's (1936) concept of discriminant function is an important measure for efficient selection of breeding material and this was first employed by Smith (1936). Since, then it is being applied by many workers in different crops to know the genotypic value of a plant or a line.

Hazel (1943) reported that selection index gave the maximum genetic progress as it is based on law of regression. According to Stephans (1942) the interaction of yield components with in the plant and with in the population served as index for yielding ability. Sikka and Gupta (1949) were of the opinion that when the morphological characters are available, they may still be the best indication of yield and their relationship can be suggestive of a selection index. Manning (1956) has stated that selection index provides an objective basis for determining optimum relative weights to be given to characters based on quantitative measurement. Panse (1957) reported selection index to be indicative of the genotype of the individual characters for the reason that it can discriminate environmental variation in the total phenotype and also represents the heritable proportion of the same. Kempthorne and Nordskog (1959) constructed restricted selection indices which enable restriction of a particular character.

2.4.1 Discriminant function :

Selection based on correlation represents only the phenotypic relationship of the components to the yield. Abraham *et al.* (1954) reported in rice, that the discriminant function may be useful where selection for a combination of characters was a case. He stated that selection for any other single character was not efficient than selection on yield alone. He also stated that the discriminant function score based on yield components was not a better index of the genotypic value of a strain than the yield itself. Panse (1957) has stressed the need for the differentiation of heritable and non heritable variation in the phenotype and that selection would be more effective based on heritable characters which show least fluctuations to the environmental influence which in turn is due to stability of the genotype. Therefore, if the characters based on their correlation with yield are taken into account in exercising selection it may not be sound, as the relative genotype contribution of each of these character is not known. The adoption of discriminant function analysis solves this problem of apportioning the total effect by discriminating environmental effect and also by assigning relative weights to each of the yield components based on its genotypic contribution. Goulden (1959) has pointed out that the discriminant function gives an indication of the concentration of yield genes on the yield components. Smith (1936) explained the hypothetical premises from which the discriminant equation was derived.

They are :

1. That the genotypic and environmental effects are additive to give the observed magnitude of characters.
2. That they are independent and
3. That the genotypic yield follows the normal distribution.

Thus the equation provides the genotypic assessment of the complex yield from its components.

Narasimha Reddy (1985) revealed that a selection index with plant height, girth of stem, number of branches, number of capsules and 100-seed weight was more efficient in sesamum than the index without yield. Both the indices were superior to straight selection based on yield alone.

Lee and Chang (1986) concluded that the best selection indices in sesamum is by combining capsule weight and capsule number per plant, even though all the characters together will give good yield.

Number of seeds per capsule, 1000-seed weight, days to maturity and number of capsules per plant exhibited positive correlation in sesamum as reported by Khorgade *et al.* (1998). Selection indices studies indicated that there was a marginal but consistent increase in the selection efficiency. The index comprising of number of capsules per plant, 1000-seed weight and seed yield per plant was found more useful.

In the studies of 36 genotypes Khorgade *et al.* (1998) revealed that none of the single character indices showed higher efficiency over straight selection for yield alone.

Surekha and Ramakumar (2005) studied selection indices in 27 genotypes of sesamum using discriminant function technique and revealed that the functions including number of seeds per capsule as one of the components recorded high expected genetic advance and relative efficiency, the index which consisted of all the 9 characters viz., plant height, days to 50% flowering, days to maturity, number of primaries, number of capsules per plant, number of seeds per capsule, 1000 seed weight, oil content and seed yield per plant showed maximum genetic advance as well as relative efficiency suggesting that simultaneous selection for all these characters was better over straight selection for seed yield.

CHAPTER – III

MATERIALS AND METHODS

The present investigation was carried out during *rabi*, 2005-2006 at Agricultural College Farm, Bapatla, Andhra Pradesh, which is located at an altitude of 5.4 mt MSL, $15^0$54' north latitude and $80^0$90' east longitude.

3.1 MATERIAL

The experimental material for this study consisted of three generations of four crosses of sesame, alongwith their five parents. Four crosses were done among five parents to produce F_1 generation, further, F_2, F_3 and F_4 generations of these crosses were produced by selfing.

The details of parents and crosses used in the study are furnished here under.

Sl.No.	Experimental material	Pedigree	Source of origin
1.	Madhavi	Pureline selection	Andhra Pradesh
2.	Vinayak	Local variety	Orissa
3.	SO-12-2154	Germplasm line	Andhra Pradesh
4.	Tanukubrown	Pureline selection	Andhra Pradesh
5.	Gowri	Pureline selection	Andhra Pradesh

Crosses :

Cross 1 : Madhavi x SO-12-2154

Cross 2 : Madhavi x Vinayak

Cross 3 : Gowri x SO-12-2154

Cross 4 : Tanukubrown x Vinayak

3.2 METHODS

The detailed experimental technique for the present investigation is furnished hereunder.

Season	:	*Rabi,* 2005-2006
Design	:	Randomized block design
Replications	:	3 (Three)
Number of entries	:	17 (Five parents and F_2, F_3 and F_4 of four crosses)
Length of the row	:	4m

Number of rows per entry per replication :

Parents = single row

F_2, F_3 and F_4 = 5 rows

Number of plants per row	:	40
Spacing	:	30 cm x 10 cm
Fertilizer dose	:	40 N + 40 P_2O_5 + 20 K_2O kg ha^{-1}

3.3 OBSERVATIONS RECORDED

Observations were recorded on 10 randomly selected plants per treatment per replication in parents and on 50 randomly selected plants per treatment per replication in F_2, F_3 and F_4 generations and their mean values were used for statistical analysis. However, days to 50% flowering, days to maturity, 1000 seed weight and oil percentage were recorded on plot basis. The observations were recorded on the following nine yield and yield component characters.

3.3.1 Plant Height (cm)

The length of fully matured plant from the base of the plant to the tip was measured in centimetres.

3.3.2 Days to 50% Flowering

The number of days taken from sowing to the day when 50 per cent of the plants in a plot were seen flowering in the population.

3.3.3 Days to Maturity

When more than 50 per cent of capsules turned to yellow colour in plants is the symptom of maturity. The days from sowing to that particular date of maturity symptom is counted as days to maturity.

3.3.4 Number of Primaries

It was recorded as number of branches arising from the main stem.

3.3.5 Number of Capsules per Plant

Total number of capsules obtained from particular plant is counted and regarded as number of capsules per plant.

3.3.6 Number of Seeds per Capsule

Ten capsules randomly taken from each plant and number of seeds in each capsule is counted. The average seed number of 10 capsules was considered as number of seeds per capsule.

3.3.7 1000-seed Weight (g)

The weight of 1000 healthy random seeds from each entry was taken and was expressed in grams.

3.3.8 Oil Percentage

Oil content was recorded at National Seed Project, Rajendranagar with NMR spectrometer for each entry at the rate of three samples per replication.

3.3.9 Seed Yield per Plant (g)

The weight of dried, cleaned and threshed seed from individual plant is measured and expressed in grams.

3.4 STATISTICAL ANALYSIS

The data collected on different characters in RBD with three replications were subjected to the following statistical analysis.

3.4.1 Analysis of Variance

The analysis of variance for each of the characters was performed by using the standard statistical procedure. This was done as follows;

$$Y_{ij} = \mu + t_i + b_j + e_{ij}$$

Where,

Y_{ij} = Performance of i^{th} genotype in j^{th} block

μ = General mean

t_i = i^{th} genotype effect

b_j = j^{th} block effect

e_{ij} = random error

The structure of analysis of variance was as follows :

ANOVA table for Randomised Block Design:

Source	Degree of freedom (df)	Mean sum of squares (MSS)	'F' calculated value
Replications	(r-1)	Mr	Mr/Me
Treatments	(t-1)	Mt	Mt/Me
Error	(r-1) (t-1)	Me	

Where,

r = Number of replications

t = Number of treatments (genotype)

Mr = Mean sum of squares of replications

Mt = Mean sum of squares of treatments

Me = Mean sum of squares of error

The test of significance for variance was carried out referring to the 'F' table value (Snedecor and Cochran, 1994).

3.4.2 Phenotypic and Genotypic Coefficients of Variation

Phenotypic and genotypic variances were estimated according to the method given by Lush (1940).

σ^2p = Phenotypic variance = $\sigma^2g + \sigma^2e$

σ^2g = Genotypic variance = Mt-Me/r

σ^2e = Environmental variance = Me/r

$$\text{Coefficient of variation (CV\%)} = \frac{\sqrt{EMSS}}{\text{Grand mean}} \times 100$$

Where, EMSS = Error mean sum of squares

Phenotypic and genotypic co-efficients of variation were computed according to the formula given by Burton (1952).

$$\text{Phenotypic coefficient of variation} = \frac{\sqrt{\text{Phenotypic variance}}}{\text{Grand mean}} \times 100$$

$$\text{Genotypic coefficient of variation} = \frac{\sqrt{\text{Genotypic variance}}}{\text{Grand mean}} \times 100$$

3.4.3 Heritability (Broad sense) (H)

Heritability was calculated by the formula given by Lush (1940).

$$H = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

Where H = heritability in broad sense

σ^2_g = Genotypic variance

σ^2_p = Phenotypic variance

As suggested by Johnson et al. (1955), heritability estimates were categorized into

Low : 0 – 30 %

Moderate : 31 – 60 %

High : 61 % and above

Genetic Advance

Genetic advance was calculated based on formula given by Johnson *et al.* (1955).

Genetic advance (GA) = σ_p x H x K

Where, σ_p = phenotypic standard deviation

H = heritability (Broad sense)

K = selection differential at 5% selection intensity (2.06)

$$\text{Genetic advance as per cent of mean} = \frac{GA}{\text{Grand mean}} \times 100$$

GA = Genetic advance

3.4.4 Correlations

The phenotypic and genotypic correlation coefficients were worked out according to the formula suggested by Falconer (1964).

Phenotypic coefficient of correlation

$$r\,(xy)_p = \frac{CoV(xy)p}{\sqrt{[Var(x)p.Var(y)p]}}$$

where $r(xy)_p$ = Phenotypic correlation between x and y characters

$Cov\,(x,y)_p$ = Phenotypic covariance between x and y characters

$Var(x)_p$ = Phenotypic variance of x character

$Var(y)_p$ = Phenotypic variance of y character

Genotypic coefficient of correlation

$$r(xy)_g = \frac{CoV(xy)g}{\sqrt{[Var(x)g.Var(y)g]}}$$

where,

$r(xy)_g$ = Genotypic correlation between x and y characters

$Cov(x,y)_g$ = Genotypic covariance between x and y characters

$Var(x)_g$ = Genotypic variance of x character

$Var(y)_g$ = Genotypic variance of y character

Test of significance

The correlation coefficients were compared with the table values (Fisher and Yates, 1963) at (n-2) degrees of freedom at 1% and 5% level of significance where 'n' denotes the number of genotypes under study (Number of paired observations).

3.4.5 Path Coefficient Analysis

Phenotypic correlation coefficients were utilized for path coefficient analysis. The direct and indirect contribution of various traits were calculated through path coefficient analysis as suggested by Wright (1921) and later elaborated by Dewey and Lu (1959).

The following simultaneous equations were formed and solved for estimating various direct and indirect effects on yield.

$r_{1y} = P_{1y} + r_{12}P_{2y} + r_{13}\, P_{3y} + \ldots. + r_{ii}P_{iy}$

$r_{2y} = r_{21}P_{2y} + P_{2Y} + r_{23}P_{3y} + \ldots. + P_{iy}$

……………………..

$r_{iy} = r_{i1}P_{1y} + r_{i2}P_{2y} + r_{i3}P_{3y} + \ldots\ldots\ldots + P_{iy}$

Where,

r_{1y} to r_{iy} = coefficient of correlation between causal factors I to i and dependent character Y.

r_{i2} to $r_i i_1$ = coefficient of correlation among causal factor

P_{1Y}, to P_{iY} = Direct effects of character 1 to i on character Y

The above equations were written in a matrix form as follows

$$\underset{A}{\begin{pmatrix} r_{1Y} \\ r_{2Y} \\ . \\ . \\ . \\ . \\ r_{iY} \end{pmatrix}} = \underset{C}{\begin{pmatrix} I & r_{12} & \ldots & r_{1i} \\ r_{21} & I & \ldots & r_{2i} \\ & & & \\ r_{i1} & r_{i2} & \ldots & I \end{pmatrix}} \quad \underset{B}{\begin{pmatrix} P_{1Y} \\ P_{2Y} \\ \\ P_{iY} \end{pmatrix}}$$

Then $B = [C]^{-1}A$

Where

$$[C]^{-1} = \begin{pmatrix} C_{11} & C_{12} & C_{13} & .. & .. & C_{1i} \\ C_{21} & C_{22} & C_{23} & .. & .. & C_{2i} \\ C_{i1} & C_{i2} & C_{i3} & .. & .. & C_{ii} \end{pmatrix}$$

The direct effects were calculated as follows

$$P_{1Y} = \sum_{i=1}^{k} \quad = \quad C_{1i}r_{iY}$$

$$P_{2Y} = \sum_{i=1}^{k} \quad = \quad C_{2i}r_{iY}$$

.
.
.

$$P_{iY} = \sum_{i=1}^{k} \quad = \quad C_{1i}r_{iY}$$

3.4.6 Discriminant Function

This was given by Fisher (1936) with a purpose to discriminate the individuals belonging to two different populations showing some degree of overlapping. The function, Z is defined as

$$Z = b_1x_1 + b_2X_2 + \ldots + b_nX_n$$

Where X_1, X_2, $X_3 \ldots X_n$ are variables measured and b_1, b_2, $b_3 \ldots b_n$ are their weighing coefficients.

3.4.6.1 Classical selection indices

Application of discriminant function as a basis for making selection on several characters simultaneously is aimed at discriminating the desirable genotypes from undesirable ones on the basis of their phenotypic performance.

The genotype worth (H) of an individual as defined by Smith (1936) was $H = a_1G_1 + a_2G_2 + \ldots + a_n G_n$

Where, G_1, G_2, G_3 ………. G_n are the genotypic values of individual characters and a_1, a_2, a_3 … a_n are their relative economic importance.

Another function (I) based on the phenotypic performance of various characters is defined as

$$I = b_1p_1 + b_2p_2 + \ldots\ldots + b_np_n$$

Where, b_1, b_2 .. bn are to be estimated such that the correlation between H and I *i.e.,* r(H,I) becomes maximum, when once such function is obtained, discrimination of good genotype from the undesirable one will be possible on the basis of phenotypic performance *i.e.,* p_1, p_2 …p_n directly.

The maximization of r (H, I) leads to a set of simultaneous equations which upon solving give the desired estimates of values. Considering nine characters, the simultaneous equations are as follows;

$$b_1x_{11}+b_2x_{12} + \ldots\ldots + b_ix_{1n} = a_1G_{11} + a_1G_{12} + \ldots + a_iG_{1n}$$

$$b_1x_{21}+b_2x_{22} + \ldots\ldots + b_ix_{2n} = a_1G_{21} + a_1G_{22} + \ldots + a_iG_{2n}$$

$$b_1x_{31}+b_2x_{32} + \ldots\ldots + b_ix_{3n} = a_1G_{31} + a_1G_{32} + \ldots + a_iG_{3n}$$

.

.

$$b_1x_{m1}+b_2x_{m2} + \ldots\ldots + b_ix_{mn} = a_1G_{m1} + a_1G_{m2} + \ldots + a_iG_{m-n}$$

The weights *i.e.,* a_i values used in the study were the reciprocals of the means of the nine characters respectively. The reciprocals of means of each character was used as relative weights of corresponding character by Ramakumar *et al.* (1981).

The above equations were written in matrix form as follows;

$$\begin{pmatrix} x_{11}\ x_{12}\ \ldots\ x_{1n} \\ x_{21}\ x_{22}\ \ldots\ x_{2n} \\ . \\ . \\ x_{n1}\ x_{m2}\ \ldots\ x_{mn} \end{pmatrix} . \begin{pmatrix} b_1 \\ b_2 \\ \\ \\ b_i \end{pmatrix} = \begin{pmatrix} G_{11}\ G_{12}\ \ldots\ G_{1n} \\ G_{21}\ G_{22}\ \ldots\ G_{2n} \\ \\ \\ G_{m1}\ G_{m2}\ \ldots\ G_{mn} \end{pmatrix} \begin{pmatrix} a_1 \\ a_2 \\ \\ \\ a_i \end{pmatrix}$$

where M = n = number of characters (9)

The solution of this equation gave the estimate of bi values as $b = x^{-1}$ Ga.

Where,

b = Column vector

x^{-1} = Inverse of phenotypic variance and covariance

G = Genotypic variance

a = Column vector for economic weights

Expected genetic advance

The expected genetic advance, by constructing different discriminant functions was calculated and relative efficiency of each discriminant function was estimated as per Brim *et al.* (1959).

$$\Delta G_i = K \frac{\Sigma_j b_j g_{ij}}{\Sigma_i b_i g_i}$$

Where

ΔG_i = Expected genetic advance in i^{th} character

K = Selection differential (2.06 at 5% level)

B_i and b_j = Weighing coefficient

g_i and g_{ij} = Genotypic variance and covariance

The relative efficiency of the discriminant function which includes seed yield per plant alone, was taken as 100% and the relative efficiencies of other functions were estimated with reference to this.

3.4.6.2 Restricted selection indices

The restricted selection indices as per Kempthorne and Nordskog (1959) were computed following single restriction case in case of seed yield per plant, 1000-seed weight and oil per cent.

When a character was restricted *i.e.,* the genetic gain is zero ($\Delta G=0$), the maximization of the correlation between H and I was obtained using the following formula.

$$b = [I_{nn}-P^{-1}GC\ (C^{1}GP^{-1}GC)^{-1}\ C^{1}G]\ P^{-1}Ga$$

where,

Inn = n x n unit matrix

P^{-1} = Inverse of phenotypic variance and covariance matrix

G = Genotypic variance and covariance matrix

C = Coefficient vector matrix

C^1= Transposed coefficient vector matrix

For eg :

(i) for $G_1 = 0$ and G_2 to G_{11} were unrestricted

$C^1 = (1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$ is a vector

(ii) for $G_2 = 0$ and G_1, G_3 to G_{11} were unrestricted

$C^1 = (0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0)$ is a vector

Genetic advance

The genetic advance (ΔG_1) was calculated using the following formula

$$\Delta G_1 = \frac{Gb}{\sqrt{a^{'}Gb}}$$

Where

$a^{'}Gb$ = Standard deviation of b (restricted)

ΔG_1 = Genetic advance in ith character

G = genotypic variance and covariance matrix

b = Weighing coefficients

a’ = Transposed vector of economic weights

CHAPTER – IV

RESULTS

The present investigation was carried out during *rabi* 2005-06 at Agricultural College Farm, Bapatla. The data on plant height, days to 50% flowering, days to maturity, number of primaries, number of capsules per plant, number of seeds per capsule, 1000-seed weight, oil content and seed yield per plant from F_2, F_3 and F_4 generation of four crosses and their parents of sesame was subjected to statistical analysis. The results obtained are described hereunder.

4.1 VARIABILITY, HERITABILITY, GENETIC ADVANCE AND GENETIC ADVANCE AS PER CENT OF MEAN

The replication mean squares were non significant for all the characters i.e., plant height, days to 50% flowering, days to maturity, number of primaries, number of capsules per plant, 1000 seed weight, oil percentage and seed yield per plant except for number of seeds per capsule. The analysis of variance revealed significant differences among the genotypes for all characters except for characters, number of primaries and 1000-seed weight. The details are furnished in Table 1.

The mean performance of four crosses and their parents of sesame for nine characters in F_2, F_3 and F_4 generation is presented in Table 2. The genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance as per cent of mean were calculated for nine characters studied and the results are presented in Table 3.

4.1.1 Plant Height (cm)

The plant height ranged from 87.50 cm to 92.78 cm with a mean of 90.55. The GCV and PCV were 1.36 and 1.77 respectively. The heritability recorded for this character was 58.9 per cent. Genetic advance recorded was 1.95 and GA as per cent of mean was 2.15%.

4.1.2 Days to 50% Flowering

The observed variation for this character ranged from 35.66 to 40.66 with a mean of 38.21. The genotypic and phenotypic coefficients of variation were 3.19 and 5.13. The heritability was 38.6 % with genetic advance 1.56 and genetic advance as per cent of mean 4.08 per cent.

4.1.3 Days to Maturity

The number of days to maturity ranged from 81.33 to 86.00 with a mean of 83.90. The GCV and PCV were 0.93 and 2.18 per cent respectively. The heritability recorded was 18.3 per cent with genetic advance 0.68 and genetic advance as per cent of mean 0.82 per cent.

4.1.4 Number of Primaries

A range of 2.73 to 3.16 was observed for this trait with a mean value of 2.92. The GCV and PCV recorded were 2.39 and 6.54 per cent, respectively. The heritability was 13.4%, genetic advance 0.05 and genetic advance as per cent of mean 1.80 per cent were registered.

4.1.5 Number of Capsules per plant

The number of capsules per plant varied from 37.38 to 42.08 with a mean of 40.30, GCV 1.22 per cent and PCV 5.13 per cent. This character recorded 5.7 per cent heritability with a genetic advance of 0.24 and genetic advance as per cent of mean 0.60 per cent.

4.1.6 Number of Seeds per Capsule

The range of number of seeds per capsule was 34.76 to 45.98 with a mean of 38.70. The estimates of GCV and PCV were 6.95 and 8.57 respectively. The heritability observed was 65.8 per cent, with 4.50 genetic advance and 11.62 per cent genetic advance as per cent of mean.

4.1.7 1000-Seed Weight

The observed range of variation for this trait was 2.61 to 3.22 with a mean of 2.82. The GCV and PCV were 3.42 and 8.20 respectively. The heritability recorded as 17.4 per cent. The genetic advance was 0.08 and genetic advance as per cent of mean was 2.94 per cent.

4.1.8 Oil Percentage (%)

The percentage of oil content ranged from 43.61 to 50.95 with a mean of 48.15. The GCV and PCV estimates were 4.08 and 5.21, respectively. The heritability recorded was 61.4 per cent. The genetic advance as 3.17 and genetic advance as per cent of mean as 6.59 per cent.

4.1.9 Seed Yield per Plant (g)

A range of 7.50 to 12.01 with a mean of 10.06 was observed for this trait. The GCV and PCV were 10.89 and 13.44 respectively. The character was having 65.6 per cent heritability, 1.83 genetic advance and 18.17 per cent genetic advance as per cent of mean.

4.2 CHARACTER ASSOCIATION (CORRELATIONS)

4.2.1 Plant Height (cm)

The character recorded highly significant positive correlations with number of capsules per plant (0.6172) and seed yield per plant (0.9272) and highly significant negative correlation with number of primaries (-0.6510). Non significant positive and negative correlations were recorded for the characters days to 50% flowering (0.0280), number of seeds per capsule (0.2027) and oil content (0.1569) and days to maturity (-0.0707) and 1000-seed weight (-0.0629), respectively.

4.2.2 Days to 50% Flowering

The character had non significant positive correlation with days to maturity (0.3892), number of primaries (0.1091), number of seeds per capsule (0.2280), 1000-seed weight (0.0367) and non significant negative correlation with number of capsules per plant (-0.0153), oil content (-0.2134) and seed yield per plant (-0.0584).

4.2.3 Days to Maturity

This character showed non significant positive association with number of primaries (0.1499) and number of seeds per capsule (0.1378) and non significant negative association with number of capsules per plant (-0.0427), 1000-seed weight (-0.0515), oil content (-0.0097) and seed yield per plant (-0.1813).

4.2.4 Number of Primaries

This character recorded highly significant association with seed yield per plant (-0.7105) in negative direction, non significant positive correlations with 1000-seed weight (0.0284) and non significant negative correlation with number of capsules per plant (-0.3975), number of seeds per capsule (-0.0223) and oil content (-0.0893).

4.2.5 Number of Capsules per plant

This character exhibited significant positive association with seed yield per plant (0.6091) and non significant positive association with number of seeds per capsule (0.0647), 1000-seed weight (0.0304) and oil content (0.0875).

4.2.6 Number of Seeds per Capsule

This character showed non significant positive correlation with 1000-seed weight (0.0812), oil content (0.2756) and seed yield per plant (0.1290).

4.2.7 1000-seed Weight

This character recorded non significant positive correlation with oil content (0.0917) and non significant negative correlation with seed yield per plant (-0.1294), plant height (-0.0629) and days to maturity (-0.0516).

4.2.8 Oil Content (%)

Oil content showed non significant positive association with seed yield per plant (0.1783), plant height (0.1569), number of capsules per plant (0.0875), number of seeds per plant (0.2756) and 1000-seed weight (0.0917) and non significant negative association with days to 50% flowering (-0.2134), days to maturity (-0.0097) and number primaries (-0.0893).

4.2.9 Seed Yield per Plant

This character exhibited highly significant positive correlation with plant height (0.9272), number of capsules per plant (0.6091) and number of primaries (-0.7105) in negative direction. Non significant positive and negative correlations were recorded for the characters number of seeds per capsule (0.1290), oil content (0.1783) and days to 50% flowering (-0.0584), days to maturity (-0.1813) and 1000-seed weight (-0.1294) respectively.

4.3 PATH COEFFICIENT ANALYSIS

Path coefficient analysis was carried out for partitioning the correlation coefficients of yield and yield contributing characters into direct and indirect effects. The results of path coefficient analysis of yield and yield components are presented in Table 6.

4.3.1 Plant Height (cm)

This character had a positive direct effect on seed yield per plant (0.7618). It had indirect effects on seed yield in positive direction through days to 50% flowering (0.0213), number of capsules per plant (0.4701), number of seeds per capsule (0.1544) and oil content (0.1195) and indirect effects in negative direction via days to maturity (-0.0539), number of primaries (-0.4959) and 1000-seed weight (-0.0479). This trait had positive association with seed yield per plant (0.9272).

4.3.2 Days to 50% Flowering

The direct contribution of this character on seed yield per plant was positive (0.0015). It exerted its indirect effects via days to maturity (-0.0006), number of primaries (-0.0002), number of seeds per capsule (-0.0003), 1000-seed weight (-0.0001) in negative direction and oil content (0.0003) in a positive direction. This character had negative correlation with seed yield per plant (-0.0584).

4.3.3 Days to Maturity

This trait had a negative direct effect on seed yield per plant (-0.0993). The indirect effects were in positive direction via plant height (0.0070), number of capsules per plant (0.0042), 1000-seed weight (0.0051) and oil content (0.0010). The indirect effects through days to 50% flowering (-0.0387), number of primaries (-0.0149) and number of seeds per capsule (-0.0137) were in negative direction. Days to maturity showed non significant negative correlation with seed yield per plant (-0.1813).

4.3.4 Number of Primaries

The direct contribution of number of primaries to seed yield per plant was negative (-0.1657). It exerted indirect positive effects via plant height (0.1079),number of capsules per plant (0.0659), number of seeds per capsule (0.0037) and oil content (0.0148) and indirect negative effects through days to 50% flowering (-0.0181), days to maturity (-0.0248) and 1000-seed weight (-0.0047). This character had highly significant negative phenotypic correlation with seed yield per plant (-0.7105).

4.3.5 Number of Capsules per plant

The character had a positive direct effect on seed yield per plant (0.0687). The indirect effects on seed yield per plant through plant height (0.0424), number of seeds per capsule (0.0044), 1000-seed weight (0.0021) and oil content (0.0060) were observed positive and through days to 50%

flowering (-0.0011), days to maturity (-0.0029) and number of primaries (-0.0273) negative. This trait had a significant positive association with seed yield per plant (0.6091).

4.3.6 Number of Seeds per Capsule

The direct contribution of this character on seed yield per plant was negative (-0.0268). It exerted its negative indirect effects via plant height (-0.0054), days to 50% flowering (-0.0061), days to maturity (-0.0037), number of capsules per plant (0.0017), 1000-seed weight (-0.0022) and oil content (-0.0074), 1000-seed weight (-0.0022) and oil content (-0.0074) and positive indirect effect through number of primaries (0.0006). This character had positive association with seed yield per plant (0.1290).

4.3.7 1000-seed Weight

This character recorded negative direct effect on seed yield per plant (-0.0865). The indirect effect via days to 50% flowering (-0.0032), number of primaries (-0.0025), number of capsules per plant (-0.0026), number of seeds per capsule (-0.0070) and oil content (-0.0079) were negative and plant height (0.0054) and days to maturity (0.0045) were positive. This trait had non-significant negative correlation with seed yield per plant (-0. 1294).

4.3.8 Oil Content (%)

The direct contribution of this character on seed yield per plant was positive (0.0520). This trait exerted positive indirect effects via plant height (0.0082), number of capsules per plant (0.0046), number of seeds per capsule (0.0143) and 1000-seed weight (0.0048) and negative indirect effects through days to 50% flowering (-0.0111), days to maturity (-0.0005) and number of primaries (-0.0046). This trait possessed positive correlation with seed yield per plant (0.1783).

4.4 SELECTION INDICES

The results of selection indices constructed based on the Fisher's discriminant function in 17 sesamum genotypes are described.

4.4.1 Classical selection indices

The economic weights (ai values) allotted for each character alongwith weighing coefficients (bi values) are presented in Table 7. Inverse of mean value for respective characters were considered as economic weight. Among the characters 1000-seed weight (0.35) got the highest weightage followed by number of primaries (0.34), seed yield per plant (0.09), days to 50% flowering, number of capsules per plant, number of seeds per capsule and oil content (0.01) and for remaining characters *viz.,* plant height and days to maturity. In the weighing coefficient values number of primaries showed high value (0.2594) followed by seed yield per plant (0.0486), 1000-seed weight (0.0307), number of capsules per plant (0.0247), number of seeds per capsule (0.0198), plant height (0.0120), oil per cent (0.0047), days to maturity (0.0014) and days to 50% flowering (0.0100).

Higher values of selection criteria were observed for the genotypes Gowri (4.339), Madhavi (4.215), Vinayak (4.148), Madhavi x Vinayak (F_2) (4.017), Gowri x So-12-2154 (F_3) (3.878), etc. while the lowest was observed for the genotype Tanuku brown (3.354).

The inclusion of characters one by one in the function resulted in the increased efficiency of selection.

The selection indices for different character combinations are presented alongwith its genetic advance and relative efficiencies in Table 9.

Among the two component character indices alongwith seed yield, number of seeds per capsule showed highest genetic advance (0.25) with a relative efficiency of (139.17%).

The other component characters that exhibited higher values of genetic advance and relative efficiency in combination with seed yield were number of capsules per plant (0.22 and 121.03) and plant height (0.21 and 113.36).

Like wise, three character combinations showed still higher genetic advance (0.29) *i.e.,* for the function with characters seed yield per plant, number of capsules per plant and number of seeds per capsule with a relative efficiency of 159.48%.

The other three character combinations that exhibited higher values of genetic advance and relative efficiency in combination with seed yield were plant height and number of seeds per capsule (0.28 and 151.53%).

The maximum genetic advance of 0.35 and relative efficiency of 194.42% was showed when all the seven characters *i.e.,* plant height, days to 50% flowering, days to maturity, number of capsules per plant, number of seeds per capsule and oil content were included in the index.

The other indices with different combinations involving six characters, five characters and four characters gave values of genetic advance and relative efficiency in a relatively descending order.

4.4.2 Restricted Selection Indices

Restricted selection indices using single case restriction of nine characters *viz*., plant height, days to 50% flowering, days to maturity, number of primaries, number of capsules per plant, number of seeds per capsule, 1000-seed weight, oil content and seed yield per plant were calculated separately. The character-wise weighing coefficient (bi) values and genetic advance (ΔGi) values in each restriction are embodied in Tables 10 and 11.

4.4.2.1 Plant height

By restricting plant height, positive weighing coefficient values were observed for characters days to 50% flowering (0.55), days to maturity (0.43), number of capsules per plant (0.38), number of seeds per capsule (0.83), oil content (0.39) and seed yield per plant (0.12). Highest value of genetic advance was observed for number of seeds per capsule (1.99) and low value for seed yield per plant (-0.02).

4.4.2.2 Days to 50% flowering

By restricting days to 50% flowering, positive weighing coefficient values were observed for days to maturity (0.64), number of seeds per capsule (0.98), oil content (0.42) and seed yield per plant (2.95). Highest value of genetic advance was observed for number of seeds per capsule (1.80) followed by plant height (0.89). Number of primaries recorded least genetic advance (-0.07).

4.4.2.3 Days to maturity

By restricting days to maturity, positive weighing coefficient values were observed for days to maturity (0.65), number of primaries (1.86), number of seeds per capsule (0.91), 1000-seed weight (0.99), oil content (0.34) and seed yield per plant (2.69). Highest value of genetic advance was observed for number of seeds per capsule (1.68) followed by plant height (0.44). 1000-seed weight recorded least genetic advance (-0.007).

4.4.2.4 Number of primaries

By restricting number of primaries, days to 50% flowering (0.60), number of capsules per plant (0.65), number of seeds per capsule (0.77) and oil content (0.18) recorded positive weighing coefficient values. Number of seeds per capsule (2.00) and plant height (-0.008) recorded highest and lowest genetic advance values respectively.

4.4.2.5 Number of capsules per plant

By restricting number of capsules per plant, positive weighing coefficient values were observed for days to 50% flowering (0.74), days to maturity (0.04), number of capsules per plant (0.85), number of seeds per capsule (0.72) and oil content (0.36). High genetic advance was observed for number of seeds per capsule (1.94). Number of primaries recorded least genetic advance (-0.01).

4.4.2.6 Number of seeds per capsule

By restricting number of seeds per capsule, positive weighing coefficient values were observed for days to maturity (0.57), number of primaries (2.89), oil content (0.51) and seed yield per plant (3.29). The genetic advance was high for plant height (0.93) followed by oil content (0.83). Number of primaries recorded least genetic advance (-0.08).

4.4.2.7 1000-seed weight

By restricting 1000-seed weight, positive weighing coefficient values were observed for days to maturity (0.58), number of capsules per plant (0.02), number of seeds per capsule (1.11), oil content (0.45) and seed yield per plant (3.55). High genetic advance was observed for number of seeds per capsule (1.92) followed by oil content (0.79) and number of primaries recorded least genetic advance (-0.07).

4.4.2.8 Oil content

By restricting oil content, positive weighing coefficient values were observed for days to maturity (0.81), number of seeds per capsule (1.10) and seed yield per plant (3.16). Number of seeds per capsule recorded high genetic advance (1.93) and number of primaries recorded least genetic advance (-0.06).

4.4.2.9 Seed yield per plant

By restricting seed yield per plant, positive weighing coefficient values were observed for days to 50% flowering (0.51), days to maturity (0.30), number of capsules per plant (0.40), number of seeds per capsule (0.95), oil content (0.33) and seed yield per plant (0.74). High genetic advance was recorded by number of seeds per capsule (2.03) and number of primaries recorded least genetic advance (-0.02).

Table 1: Analysis of variance for yield and yield components in sesamum (*Sesamum indicum* L.).

		Mean sum of squares								
Source	**Degrees of freedom**	**Plant height**	**Days to 50% flowering**	**Days to maturity**	**Number of primaries**	**Number of capsules per plant**	**Number of seeds per capsule**	**1000-seed weight**	**Oil content (%)**	**Seed yield per plant**
Replications	2	1.345	4.843	0.843	0.007	5.576	8.905**	0.064	0.009	0.215
Treatments	16	5.632**	6.830**	4.573**	0.046	4.773**	25.517**	0.072	14.050**	4.237**
Error	32	1.062	2.363	2.738	0.031	4.043	3.767	0.044	2.436	0.630

***, ** Significant at 5% and 1% level of probability**

Table 2 : Mean performance of 17 genotypes of sesamum (*Sesamum indicum* L.).

S. No.	Genotypes	Plant height	Days to 50% flowering	Days to maturity	Number of primaries	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content (%)	Seed yield per plant
1.	Madhavi	90.14	39.66	84.00	3.01	39.09	43.44	3.00	50.95	9.50
2.	Vinayak	91.76	39.33	86.00	2.83	42.03	36.81	2.82	5032	11.34
3.	Tanuku Brown	89.53	36.00	84.66	2.95	40.14	38.06	2.63	49.28	9.06
4.	SO-12-2154	89.24	35.66	81.33	3.04	39.04	34.76	3.22	49.12	9.06
5.	Gowri	91.78	39.33	85.33	2.79	41.28	45.98	2.80	19.90	10.93
6.	F_2 Madhavi x SO-12-2154	91.80	36.66	82.66	2.73	40.59	39.50	2.94	49.16	11.05
7.	F_2 Madhavi x Vinayak	92.78	37.66	83.33	2.76	40.80	37.78	2.66	49.22	12.01
8.	F_2 Gowri x SO-12-2154	90.91	37.33	83.66	2.88	41.81	40.64	2.88	49.25	10.50
9.	F_2 Tanuku Brown x Vinayak	91.21	36.33	81.33	2.97	41.27	38.37	2.82	49.20	10.80
10.	F_3 Madhavi x SO-12-2154	91.20	38.00	84.33	2.78	40.62	40.80	2.89	44.73	10.92
11.	F_3 Madhavi x Vinayak	91.69	38.66	83.66	3.03	41.29	37.23	2.63	43.61	10.71
12.	F_3 Gowri x SO-12-2154	90.51	40.33	84.00	2.97	41.19	40.64	2.86	46.53	9.66
13.	F_3 Tanuku Brown x 88.51Vinayak	91.27	37.33	83.66	2.91	40.24	37.57	2.67	49.90	10.52
14.	F_4 Ma9014dhavi x SO-12-2154	88.51	38.33	84.66	3.11	39.17	36.89	2.84	46.57	8.06

S. No.	Genotypes	Plant height	Days to 50% flowering	Days to maturity	Number of primaries	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content (%)	Seed yield per plant
15.	F_4 Madhavi x Vinayak	90.14	39.33	84.33	2.83	38.56	34.95	2.61	46.08	9.86
16.	F_4 Gowri x SO-12-2154	87.50	40.66	84.66	3.16	37.38	38.88	2.84	45.56	7.50
17.	F_4 Tanuku Brown x Vinayak	89.46	39.00	84.66	2.94	40.65	36.12	2.93	48.82	9.61
	Mean	90.55	38.21	83.90	2.92	40.30	38.70	2.82	48.15	10.06
	CV	1.13	4.02	1.97	6.09	4.98	5.01	7.45	3.24	7.88
	SE	0.59	0.88	0.95	0.10	1.16	1.12	0.12	0.90	0.45
	CD	1.71	2.55	2.75	0.29	3.34	3.22	0.35	2.59	1.32

Table 3 : Mean, variability, heritability, genetic advance and genetic advance as per cent of mean for yield and yield components in sesamum (*Sesamum indicum* L.).

S.No.	Character	Range		Mean	GCV (%)	PCV (%)	Heritability (%)	Genetic advance (%)	Genetic advance as % of mean
		Minimum	Maximum						
1.	Plant height	87.50	92.78	90.55	1.36	1.77	58.9	1.95	2.15
2.	Days to 50% flowering	35.66	40.66	38.21	3.19	5.13	38.6	1.56	4.08
3.	Days to maturity	81.33	86.00	83.90	0.93	2.18	18.3	0.68	0.82
4.	Number of primaries	2.73	3.16	2.92	2.39	6.54	13.4	0.05	1.80
5.	Number of capsules per plant	37.38	42.03	40.30	1.22	5.13	5.7	0.24	0.60
6.	Number of seeds per capsule	34.76	45.98	38.70	6.95	8.57	65.8	4.50	12.62
7.	1000-seed weight	2.61	3.22	2.82	3.42	8.20	17.4	0.08	2.94
8.	Oil content (%)	43.61	50.95	48.15	4.08	5.21	61.4	3.17	6.59
9.	Seed yield per plant	7.50	12.01	10.06	10.89	13.44	65.6	1.83	18.17

Table 4 : Phenotypical correlation coefficients among yield and yield components of sesame (*Sesamum indicum* L.)

Characters	Days to 50% flowering	Days to maturity	Number of primaries	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content (%)	Seed yield per plant
Plant height	0.0280	-0.0707	-0.6510**	0.6172**	0.2027	-0.0629	0.1569	0.9272**
Days to 50% flowering	-	0.3892	0.1091	-0.0153	0.2280	0.0367	-0.2134	-0.0584
Days to maturity	-	-	0.1499	-0.0427	0.1378	-0.0516	-0.0097	-0.1813
Number of primaries	-	-	-	-0.3975	-0.0223	0.0284	-0.0893	-0.7105**
Number of capsules per plant	-	-	-	-	0.0647	0.0304	0.0875	0.6091**
Number of seeds per capsule	-	-	-	-	-	0.0812	0.2756	0.1290
1000-seed weight	-	-	-	-	-	-	0.0917	-0.1294
Oil content (%)	-	-	-	-	-	-	-	0.1783

*** Significant at 5 per cent level**
**** Significant at 1 per cent level of probability**

Table 5 : Genotypical correlation coefficients among yield and yield components of sesame (*Sesamum indicum* L.)

Characters	Days to 50% flowering	Days to maturity	Number of primaries	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content (%)	Seed yield per plant
Plant height	-0.4260	-0.1654	-1.1436**	1.5581	0.3361	0.6949**	0.3116	1.0231**
Days to 50% flowering	-	1.1803**	0.3608	-0.8432**	0.3254	-0.4615	-0.4333	-0.3803
Days to maturity	-	-	-0.8736**	0.4386	0.3795	-1.2425	-0.2298	-0.0090
Number of primaries	-	-	-	-1.2950**	-0.6475**	0.8062**	-0.6885**	-1.1806**
Number of capsules per plant	-	-	-	-	0.9018**	-1.0558**	0.7673**	1.5965**
Number of seeds per capsule	-	-	-	-	-	0.1362	0.1961	0.2620
1000-seed weight	-	-	-	-	-	-	0.5441	-0.4547
Oil content (%)	-	-	-	-	-	-	-	0.3265

*** Significant at 5 per cent level**
**** Significant at 1 per cent level of probability**

Table 6 : Path coefficients of yield and yield components of sesame

Characters	Plant height	Days to 50% flowering	Days to maturity	Number of primaries	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content (%)	Phenotypic correlation with Seed yield per plant
Plant height	**0.7618**	0.0213	-0.0539	-0.4959	0.4701	0.1544	-0.0479	0.1195	0.9272
Days to 50% flowering	0.0000	**0.0015**	-0.0006	-0.0002	0.0000	-0.0003	-0.0001	0.0003	-0.0584
Days to maturity	0.0070	-0.0387	**-0.0993**	-0.0149	0.0042	-0.0137	0.0051	0.0010	-0.1813
Number of primaries	0.1079	-0.0181	-0.0248	**-0.1657**	0.0659	0.0037	-0.0047	0.0148	-0.7105
Number of capsules per plant	0.0424	-0.0011	-0.0029	-0.0273	**0.0687**	0.0044	0.0021	0.0060	0.6091
Number of seeds per capsule	-0.0054	-0.0061	-0.0037	0.0006	-0.0017	**-0.0268**	-0.0022	-0.0074	0.1290
1000-seed weight	0.0054	-0.0032	0.0045	-0.0025	-0.0026	-0.0070	**-0.0865**	-0.0079	-0.1294
Oil content (%)	0.0082	-0.0111	-0.0005	-0.0046	0.0046	0.0143	0.0048	**0.0520**	0.1783

*** Significant at 5 per cent level**
**** Significant at 1 per cent level of probability**

Residual effect 0.315
Values in bold face type are direct effects

Table 7: Weighing coefficients (bi) and economic weights (ai) for different characters in sesamum(*Sesamum indicum* L.).

Character	bi value	ai value
Plant height	0.0120	0.01
Days to 50% flowering	0.0100	0.02
Days to maturity	0.0014	0.01
Number of primaries	0.2594	0.34
Number of capsules per plant	0.0247	0.02
Number of seeds per capsule	0.0198	0.02
1000-seed weight	0.0307	0.35
Oil content	0.0047	0.02
Seed yield per plant	0.0486	0.09

Table 8 : Selection criterion values for 17 genotypes of sesamum (*Sesamum indicum* L.). in classical selection indices

Sl. No	Genotype	Selection criteria
1.	Madhavi	4.215
2.	Vinayak	4.148
3.	Tanuku brown	3.354
4.	SO-12-2154	3.775
5.	Gowri	4.339
6.	F_2 Madhavi x SO-12-2154	3.873
7.	F_2 Madhavi x Vinayak	4.017
8.	F_2 Gowri x SO-12-2154	3.814
9.	F_2 Tanuku brown x Vinayak	3.867
10.	F_3 Madhavi x SO-12-2154	3.778
11.	F_3 Madhavi x Vinayak	3.795
12.	F_3 Gowri x SO-12-2154	3.878
13.	F_3 Tanuku brown x Vinayak	3.736
14.	F_4 Madhavi x SO-12-2154	3.606
15.	F_4 Madhavi x Vinayak	3.728
16.	F_4 Gowri x SO-12-2154	3.688
17.	F_4 Tanuku brown x Vinayak	3.710

Table 9 : Selection indices for different character combinations in sesamum (*Sesamum indicum* L.).

Character combination	Genetic advance	Relative efficiency (%)
Plant height (x_1)	0.02	11.86
Days to 50% flowering (x_2)	0.04	22.50
Days to maturity (x_3)	0.01	4.51
Number of primaries (x_4)	0.02	9.92
Number of capsules per plant (x_5)	0.01	3.30
Number of seeds per capsule (x_6)	0.12	63.96
1000-seed weight (x_7)	0.03	16.21
Oil content (x_8)	0.07	36.28
Seed yield per plant (x_9)	0.18	100.00
$x_9 + x_1$	0.21	113.36
$x_9 + x_2$	0.16	88.87
$x_9 + x_3$	0.19	102.43
$x_9 + x_4$	0.14	75.22
$x_9 + x_5$	0.22	121.03
$x_9 + x_6$	0.25	139.17
$x_9 + x_7$	0.16	85.79
$x_9 + x_8$	0.22	122.33
$x_9 + x_1 + x_6$	0.28	151.54
$x_9 + x_5 + x_6$	0.29	159.48
$x_9 + x_1 + x_5 + x_6$	0.31	172.20
$x_9 + x_5 + x_6 + x_8$	0.32	177.56
$x_9 + x_1 + x_5 + x_6 + x_8$	0.35	190.19
$x_9 + x_1 + x_3 + x_5 + x_6 + x_8$	0.35	193.18
$x_9 + x_1 + x_2 + x_3 + x_5 + x_6 + x_8$	0.35	194.42

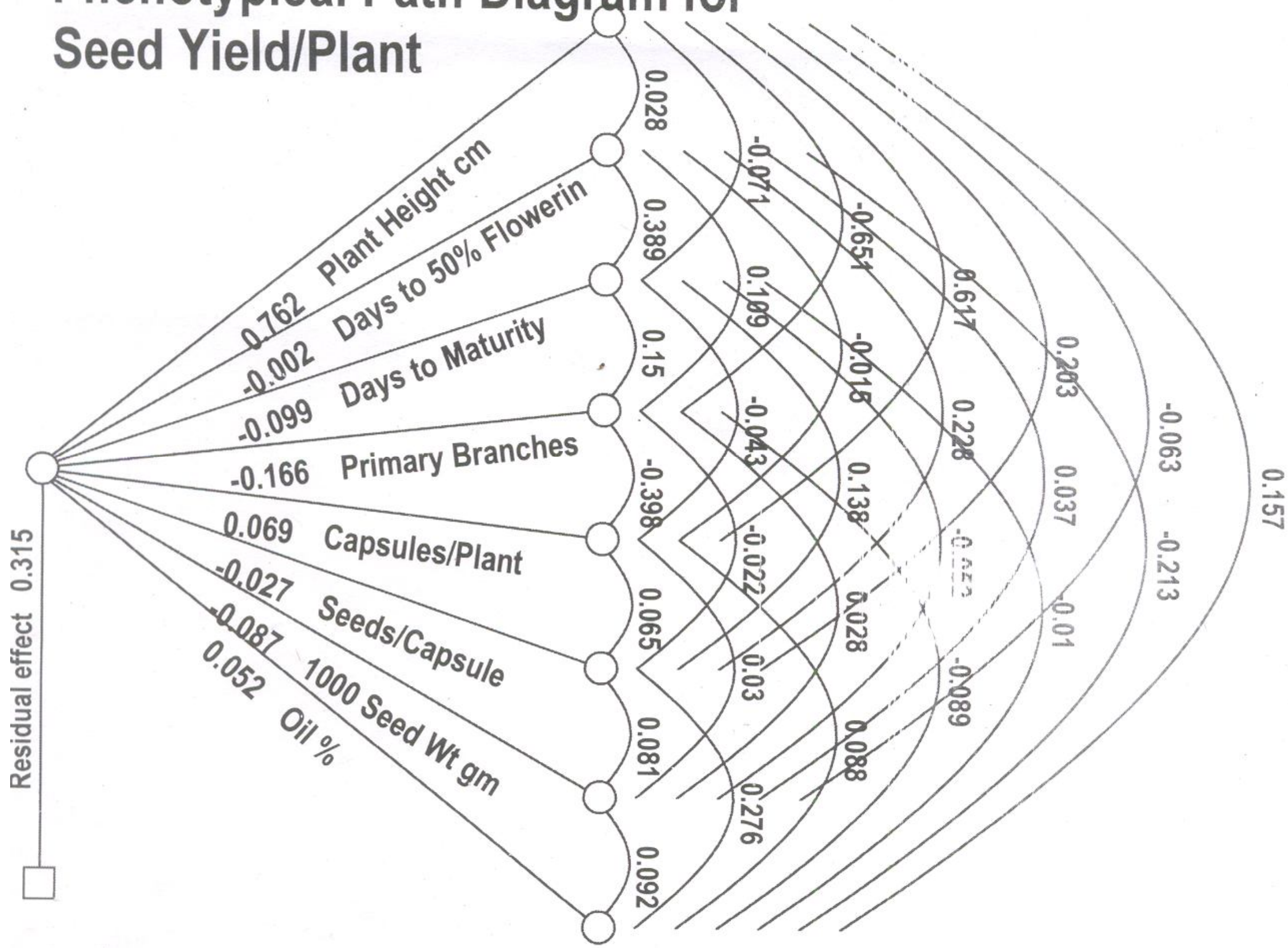
Table 10 : Genetic advance (ΔGi) values in case of restricted selection indices in 17 genotypes of sesamum (*Sesamum indicum* L.).

Characters	Plant height	Days to 50% flowering	Days to maturity	Number of primaries	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content (%)	Seed yield per plant
Plant height	0.00	0.89	0.94	-0.0008	0.06	0.93	0.76	0.73	0.06
Days to 50% flowering	0.60	0.00	-0.16	0.46	0.51	-0.30	0.12	0.44	0.61
Days to maturity	0.62	0.22	0.00	0.62	0.69	0.009	0.31	0.49	0.65
Number of primaries	-0.01	-0.07	-0.08	0.00	-0.01	-0.08	-0.07	-0.06	-0.02
Number of capsules per plant	0.06	0.70	0.78	-0.05	0.00	0.72	0.62	0.59	0.11
Number of seeds per capsule	1.99	1.80	1.68	2.00	1.94	0.00	1.92	1.93	2.03
1000-seed weight	0.011	-0.01	-0.007	0.01	0.005	-0.02	0.00	-0.03	0.01
Oil content (%)	0.49	0.82	0.88	0.37	0.47	0.83	0.79	0.00	0.42
Seed yield per plant	-0.02	0.73	0.79	-0.04	0.02	0.80	0.61	0.56	0.00

Table 11 : Weighing coefficients (bi) in case of restricted selection indices in 17 genotypes of sesamum (*Sesamum indicum* L.).

Characters	Plant height	Days to 50% flowering	Days to maturity	Number of primaries	Number of capsules per plant	Number of seeds per capsule	1000-seed weight	Oil content (%)	Seed yield per plant
Plant height	-1.67	-1.02	-0.16	-0.98	-1.48	-0.99	-2.08	-1.53	-2.19
Days to 50% flowering	0.55	-0.33	-0.69	0.60	0.74	-0.12	-0.12	-0.02	0.51
Days to maturity	0.43	0.64	0.65	-0.34	0.04	0.57	0.58	0.81	0.30
Number of primaries	-11.69	-3.52	1.86	-14.16	-14.24	2.89	-4.51	-2.81	-10.94
Number of capsules per plant	0.38	-0.02	-0.28	0.65	0.85	-0.42	0.02	-0.05	0.40
Number of seeds per capsule	0.83	0.98	0.91	0.77	0.72	-0.18	1.11	1.10	0.95
1000-seed weight	-0.49	-1.89	0.99	-1.64	-1.98	-2.39	-1.57	-4.56	-2.00
Oil content (%)	0.39	0.42	0.34	0.18	0.36	0.51	0.45	-0.44	0.33
Seed yield per plant	0.12	2.95	2.69	-0.96	-0.36	3.29	3.55	3.16	0.74

Phenotypical Path Diagram for Seed Yield/Plant



CHAPTER – V

DISCUSSION

Sesame is one of the ancient oil seed crops grown in India. The crop is cultivated in almost all parts of the country. Sesame yields oil and protein of high quality and possesses tremendous potential for export. However, it has not contributed its best to the present oilseeds scenario. Sesame yields are generally low and vary considerably depending on the growing conditions and variation of genotypes. To improve the yields of sesame, plant breeder must possess an adequate knowledge about the nature and magnitude of genes controlling different traits, which provides useful guideline in the crop improvement programme.

An effective selection depends on the extent of genetic variability for different characters present in the available germplasm. Economic characters are mostly polygenically controlled and having complex inheritance are often influenced by environment. Hence, an understanding of the nature and magnitude of genetic variation present in the available material is necessary before initiating a breeding programme and aiming at developing high yielding varieties. The correlation and path coefficient analysis further help in establishing the extent of association between yield and yield contributing characters, so that these yield components form additional selection criteria.

The results obtained for nine quantitative characters in seventeen genotypes of sesamum discussed character-wise are presented hereunder with the following headings.

1. Variability, heritability, genetic advance and genetic advance as per cent of mean
2. Correlations
3. Path coefficient analysis and
4. Selection indices.

5.1 VARIABILITY, HERITABILITY, GENETIC ADVANCE AND GENETIC ADVANCE AS PER CENT OF MEAN

The knowledge of genetic variability present in any crop species plays an important role in planning any breeding programme. The genotypic coefficient of variation gives the range of variability available in a crop species and enables the comparison of amount of variability present in different characters. The phenotypic expression of a character is the resultant of interaction between the genotype and environment. The measure of transmission of a character from parent to progeny is termed as heritability. Thus, the information on heritability is a pre-requisite for planning a good breeding programme based on selection, as it would be useful to estimate the genetic gain obtained by selection. Burton (1952) indicated that genetic variability together with heritability would give a better idea on the amount of genetic advance expected from selection.

High heritability coupled with high genetic advance estimates indicate that the genotypic variance for the characters is probably owing to additive gene effect Johnson *et al.* (1955a). The results obtained are discussed as follows :

5.1.1. Plant Height

The extent of variability in plant height was found to be low. This trait exhibited moderate heritability estimates with low genetic advance and genetic advance as per cent of mean. The difference between GCV and PCV was narrow suggesting that there is less influence of environment in the expression of this character. This character recorded moderate to high heritability with low genetic advance as per cent of mean indicating predominance of non-additive gene action. Li (1988) reported low heritability, low GCV and low expected genetic advance while Backiyarani *et al.* (1997b), Kamala (1999) and Saravanan *et al.* (2000) reported high heritability and moderate genetic advance as per cent of mean.

5.1.2. Days to 50% flowering

This trait recorded low genotypic and phenotypic coefficients of variation among genotypes as reported by Shadakshari *et al.* (1995) in sesamum genotypes. The narrow difference between genotypic and phenotypic coefficients of variation is in accordance with Baruah and Goud (1993). This character recorded moderate heritability with low genetic advance as per cent of mean.

5.1.3. Days to maturity

This trait possessed low GCV and PCV indicating less variation among the genotypes studies and it had a narrow difference between genotypic and phenotypic coefficients of variation, which indicate the lesser influence of environment on expression of this character. The results are in accordance with Shadakshari *et al.* (1995). Days to maturity recorded low heritability with low genetic advance as per cent of mean and therefore unsuitable for improvement through direct selection as reported by Kandaswamy *et al.* (1990).

5.1.4. Number of primaries

Low genotypic and phenotypic coefficients of variation were observed for this character. Low heritability coupled with low genetic advance and genetic advance of mean were observed. The difference between GCV and PCV was low which indicates that the phenotypic variability is the direct measure of genetic variability.

5.1.5. Number of Capsules Per Plant

The genotypic and phenotypic coefficients of variation were low. The heritability was moderate coupled with low genetic advance and genetic advance as per cent of mean.

Low genotypic and phenotypic coefficients of variation were recorded for this trait indicating less variability among genotypes studied, thus giving less scope for selection. The difference between GCV and PCV was narrow indicating lesser influence of environment on expression of this character. This trait recorded low heritability with low genetic advance as per cent of mean. These results were in accordance with Kandaswamy *et al.* (1990).

5.1.6. Number of Seeds Per Capsule

This character exhibited low GCV and PCV. Heritability estimates were high coupled with moderate genetic advance as per cent of mean as reported by Backiyarani *et al.* (1997a).

Low to moderate genotypic and phenotypic coefficients of variation indicate lesser variation among genotypes studied. The difference between

GCV and PCV was narrow and therefore indicate that phenotypic variability is the direct measure of genetic variability. These results are in accordance with Raut *et al.* (1991). High heritability coupled with moderate genetical advance as per cent of mean was observed indicating the predominance of both additive and non additive gene actions and therefore desired results may not be obtained with simple selection. While, high heritability and high genetic advance as per cent of mean were reported by Li (1988), Fendel and Penso (1994) and Kamala (1999).

5.1.7 1000-seed Weight

1000-seed weight exhibited low GCV and PCV values indicating less variability among genotypes studied. Similar results were reported by Li (1988) and Raut *et al.* (1991). Heritability estimates were low coupled with low genetic advance as per cent of mean suggesting that this trait may not be useful for selection in segregating generations.

5.1.8 Oil Content

Oil content exhibited low values of genotypic and phenotypic coefficients of variation indicating less range of variability thereby less scope for selection. Narrow difference between GCV and PCV indicated negligible influence of environment on the inheritance of this character. High heritability with low to moderate genetic advance as per cent of mean was recorded for this trait. However, high heritability coupled with moderate genetic advance as per cent of mean for this character was reported by Pathak and Dixit (1992), Baruah and Goud (1993) and Shadakshari *et al.* (1995).

5.1.9 Seed Yield Per Plant

Seed yield per plant exhibited moderate genotypic and phenotypic coefficients of variability, which indicate a moderate to wide range of variability. Therefore, there exists a scope for improvement of this character through selection. The difference between GCV and PCV was narrow suggesting significant role of genetic factors influencing expression of this character. The estimate of heritability was high with moderate genetic advance as per cent of mean which shows that genotypic variance for this character may be as a result of high additive gene effect. Hence, this trait can be improved through selection. These results are in confirmity with Govindarasu *et al.* (1990), Shadakshari *et al.* (1995), Backayarani *et al.* (1997 b) and Kumar *et al.* (2002). High heritability was reported by Govindarasu *et al.* (1998), Mothilal (2000), Solanki and Deepak Gupta (2003) and Saravanan (2003).

5.2. CORRELATIONS

Yield is a complex polygenic inherited character resulting from multiplicative interaction of its contributing characters. The cumulative effect of such characters determine the yield. These characters play an important role in modification of yield as a whole in magnitude as well as in direction. Hence, direct selection for yield is not effective as it is much influenced by environment.

Correlation studies test the strength of association of yield components with yield, which inturn helps the plant breeder during selection (Robinson *et al.,* 1951).

The association between two traits can be ascertained by phenotypic correlations, which is determined from measurement of two characters on a number of individuals of the segregating population.

Sharma and Asaw (1977) opined that the study of character association in segregating generation would be of special importance since more genotypes are available.

In the present investigation, phenotypic and genotypic correlation estimates were obtained from 17 genotypes *i.e.,* five parents, F_2, F_3 and F_4 generations of four crosses of sesame for yield and yield attributing characters. The character-wise results of phenotypic correlations are discussed hereunder.

5.2.1 Plant Height

Plant height recorded significant positive association with seed yield per plant and the same was reported by Patil and Sheriff (1996), Backiyarani *et al.* (1999) and Deepasankar and Anandakumar (2003), Ratnababu *et al.* (2004) and Siddiqui *et al.* (2005). Plant height exhibited positive correlation with number of capsules per plant which had positive correlation with seed yield. An increase in plant height would simultaneously increase the number of capsules per plant which brings about an increase in seed yield per plant.

5.2.2 Days to 50% Flowering

Days to 50% flowering showed non significant negative association with seed yield and the same was recorded by Shukla (1983) and Kavitha and Sethupathiramalingam (1999) in segregating populations of sesame. This character had non significant positive correlation with all other characters under study except number of capsules per plant and oil content.

5.2.3 Days to Maturity

Days to maturity recorded non significant negative correlation with seed yield per plant. The result was in accordance with Kandaswamy *et al.* (1990). The trait had non significant negative correlation with number of capsules per plant, 1000-seed weight and oil content. Therefore, days to maturity may not be one of the selection criteria in choosing better segregants, aimed at crop improvement with respect to seed yield per plant.

5.2.4 Number of Primaries

This character exhibited significant correlation with seed yield per plant in negative direction. It had non significant negative association with number of capsules per plant and oil content. Therefore, number of primaries per plant may not be one of the selection criteria in choosing parental combinations in any hybridization programme aimed at improvement of seed yield per plant.

5.2.5 Number of Capsules Per Plant

Number of capsules per plant exhibited highly significant positive association with seed yield per plant and had positive association with number of seeds per capsule, 1000-seed weight and oil content. These results suggest that selection for this character may improve the seed yield directly. These results are in accordance with those of Govindarasu and Ramamoorthi (1998), Backiyarani *et al.* (1999), Yingzhong and Yishou (2002), Deepasankar and Anandakumar (2003), Ratnababu *et al.* (2004) and Siddiqui *et al.* (2005).

5.2.6 Number of Seeds Per Capsule

This trait exhibited non significant positive correlation with seed yield per plant, 1000-seed weight and oil content. A non significant correlation was observed indicating that more number of capsules resulted in less number of seeds due to competition during capsule development.

5.2.7 1000-seed Weight

This character showed non significant negative correlation with seed yield per plant. It has positive association with oil content. Similar results were reported by Thiyagarajan and Ramanathan (1996).

5.2.8 Oil Content

Oil content exhibited positive correlation with seed yield per plant. Non significant positive correlation of seed yield with oil content was observed by Ranganatha *et al.* (1994) and Kumaresan and Nadrajan (2002). Oil content had positive correlation with plant height, number of capsules per plant, number of seeds per capsule and 1000-seed weight indicating that 1000-seed weight and oil content are inherited together and selection of any one of the two characters may cause corresponding improvement in other trait finally resulting in increased seed weight with good oil percentage. Similar results were reported by Singh *et al.* (1997), Alam *et al.* (1999), Solanki and Deepak Gupta (2000) and Pawar *et al.* (2002).

5.3 PATH COEFFICIENT ANALYSIS

Seed yield in sesamum is a complex character and influenced by number of components, which present a complex situation for making selection. Thus, direct selection based on correlations may not be effective.

Therefore, it is necessary to split the total correlation coefficients into direct and indirect effects on the given character. This can be achieved by path coefficient analysis, a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects.

If the correlation is positive, but the direct effect is negative, the indirect effect may be the cause of correlation. Correlation coefficient may be negative but the direct effect is positive and high. Then a restricted simultaneous selection model is to be followed. The total correlations between yield and a component character may sometimes be misleading as it might be an over estimate or under estimate because of its interdependence with other characters which are also correlated with yield. Hence, direct selection based on correlated response may sometimes be unworthy when many characters are affecting a given character. Correlation in combination with path coefficient analysis gives a better understanding into cause and effect relationship between different pairs of characters (Singh and Chaudhary, 1999).

Based on the above importance of cause and effect relationship, path coefficient analysis was worked out for eight characters with seed yield in the parents and segregating generations to get the information on direct and indirect contribution of yield contributing characters on yield. The character-wise results are discussed hereunder.

5.3.1 Plant Height

This trait exhibited positive direct effect on seed yield per plant and also this trait exhibited positive correlation coefficient. These results are in accordance with Vanisri *et al.* (1994), Thiyagarajan and Ramanathan (1996), Singh *et al.* (1997), Siddiqui *et al.* (1998), Yingzhong and Yishou (2002), Ratnababu *et al.* (2004) and Siddiqui *et al.* (2005).

5.3.2 Days to 50% Flowering

Days to 50% flowering had low negative direct effect and negative non significant correlation with seed yield. It has positive indirect effects through number of capsules per plant, plant height and oil content. By selecting these characters, improvement in yield can be brought about.

5.3.3 Days to Maturity

Days to maturity exhibited low and negative direct effect with seed yield per plant. It also had negative correlation with seed yield per plant. The negative direct effect of days to maturity on seed yield revealed the possibility of selection of early segregants coupled with high yield. Similar results were reported by Kaushal *et al.* (1977), Thangavelu and Rajasekharan (1983) and Sudharani *et al.* (1996).

5.3.4 Number of Primaries

This trait recorded negative direct effect and significant negative correlation with seed yield per plant. It has its positive indirect effects through plant height, number of capsules per plant, number of seeds per capsule and oil content. Therefore selection for these characters could be effective in the segregating populations in improving seed yield per plant. Kavitha and Sethupathiramalingam (1999) reported negative direct effect of number of primaries on seed yield per plant.

5.3.5 Number of Capsules Per Plant

Number of capsules per plant had a positive direct effect and positive correlation with seed yield per plant. It had positive indirect effects through plant height, number of seeds per capsule, 1000-seed weight and oil content. High positive correlation with seed yield indicated that selection for this trait will be rewarding for yield improvement. These results are in agreement with those of Subbalakshmi (1996), Govindarasu and Ramamoorthi (1998), Deepasankar and Anandakumar (2003) and Ratnababu *et al.* (2004).

5.3.6 Number of Seeds Per Capsule

This trait possessed negative direct effect on seed yield per plant and it had positive correlation with seed yield per plant. Negative direct effect of this trait on seed yield was reported earlier by Rai *et al.* (1997).

5.3.7 1000-seed Weight

This character exhibited negative direct effect with seed yield per plant. It had negative correlation coefficient. The results are in accordance with Rai *et al.* (1997), Kavitha and Sethupathiramaligam (1999) and Backiyarani *et al.* (1999) in segregating populations.

5.3.8 Oil Content

Oil content had a positive direct effect and positive correlation with seed yield per plant. This trait had positive indirect effects through plant height, number of capsules per plant, number of seeds per capsule and 1000-seed weight. The positive indirect effects nullify the negative indirect effects. These results are in accordance with those of Thiyagarajan and Ramanathan (1996), Solanki and Deepak (2000) and Ratnababu *et al.* (2004).

5.4 SELECTION INDICES

When selection is applied for the improvement of economic value of a plant, it is generally applied to several characters simultaneously because economic value depends on more than one character. This is usually referred to as multiple trait selection. The method that is expected to give most rapid improvement of economic value, however is to apply selection simultaneously to all the component characters together by giving appropriate weights to each character acceding to its relative economic importance, its heritability and the genotypic and phenotypic correlations between different characters. The component characters have to be combined together into a score or index in such a way that selection applied to the index, as if the index were a single character which will yield the most rapid possible improvement of economic value (Falconer, 1964).

Smith (1936) proposed a selection model for making selection on several characters simultaneously using discriminant function of Fisher (1936). He explained the hypothetical promises from which discriminant function was derived. They are (i) the genotypic and environmental effects are additive to give the observed magnitude of characters (ii) they are independent and (iii) the genotypic yield as well as the phenotypic yield follow the normal distribution. Thus, the equation provides the genotypic assessment of complex yield from its components.

In affecting varietal improvement for yield and for other desirable combinations of characters, the plant breeder desires to select superior genotypes. But in actual practice he has to choose individuals based on their phenotypic expressions. Many of the plant characters of economic value are quantitatively inherited and are highly influenced by environmental condition. Selection made on the basis of such characters in the field are liable to be influenced by a large portion of non heritable variability and is therefore, likely to be less efficient. This suggests the need for studying the relative amounts of heritable and non heritable variability exhibited by individual characters. This could be estimated by individual characters and calculated either by (i) the correlation between the characters with the hope that the components are less susceptible to environmental fluctuations (ii) selection indices, which would give the most appropriate weightage to the phenotypic values of each of the two or more components to be used simultaneously for selection.

5.4.1 Classical Selection Indices

Inverse of mean of a character was considered as weightage given to that particular character in the present study. This procedure of allotting weightage to character might reduce the wide differences observed between the means of characters and may give better validity to the computed genetic advance values. High weighing coefficient values were observed for seed yield.

The effect of relative phenotypic and genotypic variances on the reliability of the indices is not straight forward. The possibility approach such as weighing each character according to its relative worth deserves consideration (Brim *et al.,* 1959). If the weighing character are not in money unit, they must express in some other way the relative importance to the breeder in one unit increase of each trait (Yamada *et al.,* 1975). The reciprocals of means of each character was used as relative weights of corresponding character by Ramakumar *et al.* (1981). But Pesek and Baker

(1969) modified the selection index theory by substituting for relative economic weights to traits by desired gains which was suited to the needs of practical breeder.

In general, the indices which include more than one character gave high genetic advance suggesting the utility of construction of selection indices for affecting joint improvement of several characters. For example a function involving majority of the characters *i.e.,* plant height, days to 50% flowering, days to maturity, number of capsules per plant, number of seeds per capsule and oil content alongwith seed yield gave highest genetic advance as well as highest relative efficiency over straight selection for yield alone.

Abraham *et al.* (1954) stated that discriminant function may be useful when selection for a combination of character was a case.

Khorgade *et al.* (1998) observed in sesamum that index consisted of 500 seed weight and seed yield exhibited highest genetic advance and relative efficiency. Further, addition of one more yield component resulted in increased efficiency, but the increase being very marginal.

In the present investigation, the genetic advance and relative efficiencies increased linearly with the inclusion of more number of characters in the index alongwith seed yield per plant. In the two component indices only one combination of seed yield with number of seeds per capsule showed 39.1% increase in relative efficiency over straight selection for seed yield alone.

The difference in relative efficiency between four component function and function involving seven characters was only 22.2%. The improvements in relative efficiencies from four components index to indices with inclusion of more characters one by one were considerably less. But all these functions were better than single character and two character indices for their genetic advance and relative efficiency.

The discriminant function alongwith index of genetic advance indicate that plant height, days to 50% flowering, days to maturity, number of capsules per plant, number of seeds per capsule and oil content are desirable traits for index construction in sesamum. The index with these characters gave efficient genetic advance values and may be useful for simultaneous improvement of these characters. Number of seeds per capsule looked to be valuable character and gave highest relative efficiency in the straight selection. All the indices involving this trait were also high in relative efficiency.

In the present study, the high selection criterion values were shown by the genotypes Gowri (4.339), Madhavi (4.215), Vinayak (4.148), Madhavi x Vinayak F_2 (4.017) and Gowri x SO-2-2154 F_3 (3.878) are productive genotypes. Inclusion of characters one by one in the function resulted in the increased efficiency of selection. Similar results were reported by Khorgade *et al.* (1998).

5.4.2 Restricted Selection Indices

Under certain situations the breeder might like to effect change in the means of some characters unlike keeping the means of other characters unchanged. This is the case of restricted selection *i.e.,* the breeder requires to maximize the correlation between the genetic worth value (H) of the genotype and the phenotypic performance value (I) of various characters of the genotype, such that the genetic advance in the restricted character becomes zero.

A solution to this problem of index construction was given by Kempthorne and Nordskog (1959) by using long range multiplier. Using single restriction case in respect of nine characters *viz.,* plant height, days to 50% flowering, days to maturity, number of primaries, number of capsules per plant, number of seeds per capsule, 1000-seed eight, oil content and seed yield per plant restricted selection indices were computed in the present study and the genetic advance was calculated for each character in each restriction according to Singh and Chaudhary (1979).

The genetic advance value for a particular character under restriction was negligible indicating successful cases of character restriction in the nine single case restriction.

In each restriction case, the character, number of seeds per capsule showed high genetic advance in all the cases except when that character was under restriction. Low values of genetic advance were observed in different characters in restricted selection indices.

By restricting plant height, the genetic advance value was high for number of seeds per capsule followed by days to maturity, days to 50% flowering and oil content. Hence, improvement can be anticipated in these characters by restricting plant height.

High genetic advance was recorded by number of seeds per capsule followed by plant height, oil content and seed yield per plant when days to 50% flowering was restricted. Gains in these characters through selection may be anticipated.

By restricting days to maturity, the genetic advance was high for number of seeds per capsule followed by plant height, oil content and seed yield per plant. Hence, improvement can be anticipated in these characters.

Improvement of number of seeds per capsule, days to maturity, days to 50% flowering and oil content can be anticipated as their genetic advance values were high when number of branches was restricted.

By restricting number of capsules per plant, the genetic advance value was high for number of seeds per capsule followed by days to maturity, days to 50% flowering and oil content which can be improved through selection.

High genetic advance was recorded by plant height, oil content and seed yield per plant when number of seeds per capsule was restricted. Gains in these characters through selection may be anticipated.

Number of seeds per capsule, oil content, plant height and number of capsules per plant can be improved through selection as they possessed high genetic advance value when 1000-seed weight was restricted.

Improvement in number of seeds per capsule, plant height, number of capsules per plant and seed yield per plant can be anticipated through selection due to their high genetic advance values when oil content was under restriction.

By restricting seed yield per pant, the genetic advance value was high for number of seeds per capsule, days to maturity and days to 50% flowering which can be improved through selection.

In all nine characters, restriction of seed yield per plant, number of primaries followed by number of capsules per plant are found to be successful cases of restriction. Hence, it is concluded that the means of economic characters can be improved by restricting the means of these traits individually.

In every single case restriction of each character, number of seeds per capsule recorded high genetic advance where as number of primaries recorded least genetic advance.

Conclusions

From the results and discussion on various aspects of the present investigation, the following conclusions are drawn.

1. Analysis of variance showed significant differences among the seventeen genotypes for all the characters except for number of primaries and 1000-seed weight.

2. Variability studies indicated that the material used in present investigation possessed some amount of variability which provides sufficient basis for selection by breeder.

3. The results of heritability revealed that the characters, number of seeds per capsule, seed yield per plant, oil percentage, plant height and days to 50% flowering exhibited moderate to high heritability estimates.

4. Character association indicated significant positive association of seed yield with plant height and number of capsules per plant.

5. Path coefficient analysis indicated that the characters plant height, number of capsules per plant and oil content had positive direct effects on seed yield. Hence, selection for these traits would be more effective

to bring improvement in yield and also evolve superior high yielding varieties in sesamum.

6. The discriminant function studies revealed that the indices involving number of seeds per capsule as one of the component character were more effective as they showed higher genetic advance and relative efficiency when compared to the other indices in which this trait was not included.

7. Among the seventeen genotypes studied, Gowri, Madhavi, Vinayak, Madhavi x Vinayak (F_2) and Gowri x SO-12-2154 (F_3) were good for selection based on the selection criterion values.

The function including the seven characters under study *viz*., plant height, days to 50% flowering, days to maturity, number of capsules per plant, number of seeds per capsule, oil content and seed yield per plant had highest genetic advance and relative efficiency.

8. In restricted selection indices, highest genetic advance value was recorded by number of seeds per capsule, when each character was separately restricted whereas the positive weighting coefficients differed each time when single character was restricted.

CHAPTER – VI

SUMMARY

The present investigation was carried out during *rabi,* 2005 at Agricultural College Farm, Bapatla with seventeen genotypes *i.e.,* five parents, *viz.,* Madhavi, Vinayak, Tanuku brown, SO-12-2154 and Gowri F_2, F_3 and F_4 generations of four crosses of sesamum (*Sesamum indicum* L.)

The four crosses were given the numbers as follows :

Cross 1	:	Madhavi x SO-12-2154
Cross 2	:	Madhavi x Vinayak
Cross 3	:	Gowri x SO-12-2154
Cross 4	:	Tanukubrown x Vinayak

The mean, variability, heritability, genetic advance, character association, path coefficient analysis and selection indices were studied for nine characters *viz.,* plant height, days to 50% flowering, days to maturity, number of primaries, number of capsules per plant, number of seeds per capsule, 1000-seed weight, oil content and seed yield per plant.

The analysis of variance indicated significant differences among seventeen genotypes for the characters which include plant height, days to 50% flowering, days to maturity, number of capsules per plant, number of seeds per capsule, oil content and seed yield per plant.

The results of heritability revealed that the characters number of seeds per capsule, oil content, seed yield per plant and plant height were highly heritable characters.

Correlation studies indicated that there is a significant positive association of seed yield with number of primaries, number of capsules per plant and plant height. Hence, selection for these traits may result in superior genotypes in sesamum.

The results of path coefficient analysis revealed that the characters, plant height, number of capsules per plant and oil content had positive direct effects on seed yield. The characters, number of capsules per plant and plant height exhibited positive correlation with seed yield per plant. Hence, selection for these traits would be more effective to bring simultaneous improvement of yield and yield attributes in sesamum.

The selection indices studies revealed that the genetic advance and relative efficiency increased with inclusion of more number of characters in the indices. All the functions including number of seeds per capsule as one of the components showed more relative efficiency and genetic advance. The function including all the seven characters viz., plant height, days to 50% flowering, days to maturity, number of capsules per plant, number of seeds per capsule, oil content and seed yield per plant had high genetic advance and relative efficiency over the straight selection. Hence, breeder has to apply multiple trait selection based on these characters for yield improvement.

Among the seventeen genotypes of sesamum, the selection criterion values are more for the genotypes Gowri, Madhavi, Vinayak, Madhavi x Vinayak F_2 and Gowri x SO-12-2154 (F_3) and hence these are proposed as better genotypes for selection.

In restricted selection indices, highest genetic advance values was recorded by number of seeds per capsule, when each character was restricted separately. But the positive weighing coefficients differed each time when single character was restricted.

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*** Original not seen**

APPENDICES

Discriminant function, expected genetic advance and relative efficiency over seed yield per plant in 17 Sesamum genotypes

Selection index	Discriminant function	Genetic advance	Relative efficiency
X_1	0.0120	0.02	11.86
X_2	0.0100	0.04	22.50
X_3	0.0014	0.01	4.51
X_4	0.2594	0.02	9.92
X_5	0.0247	0.01	3.30
X_6	0.0198	0.12	63.96
X_7	0.0307	0.03	16.21
X_8	0.0047	0.07	36.28
X_1X_2	$0.0120\ X_1 + 0.0100\ X_2$	0.03	18.44
X_1X_3	$0.0120\ X_1 + 0.0014\ X_3$	0.02	11.31
X_1X_4	$0.0120\ X_1 + 0.2594\ X_4$	0.02	13.24
X_1X_5	$0.0120\ X_1 + 0.0247\ X_5$	0.06	30.43
X_1X_6	$0.0120\ X_1 + 0.0198\ X_6$	0.13	70.70
X_1X_7	$0.0120\ X_1 + 0.0307\ X_7$	0.03	14.27
X_1X_8	$0.0120\ X_1 + 0.0047\ X_8$	0.08	43.45
X_2X_3	$0.0100\ X_2 + 0.0014\ X_3$	0.06	32.51
X_2X_4	$0.0100\ X_2 + 0.2594\ X_4$	0.06	30.86
X_2X_5	$0.0100\ X_2 + 0.0247\ X_5$	0.03	15.68
X_2X_6	$0.0100\ X_2 + 0.0198\ X_6$	0.14	76.81
X_2X_7	$0.0100\ X_2 + 0.0307\ X_7$	0.03	14.38
X_2X_8	$0.0100\ X_2 + 0.0047\ X_8$	0.05	28.57
X_3X_4	$0.0014\ X_3 + 0.2594\ X_4$	0.02	9.34
X_3X_5	$0.0014\ X_3 + 0.0247\ X_5$	0.02	8.53
X_3X_6	$0.0014\ X_3 + 0.0198X_6$	0.12	67.70
X_3X_7	$0.0014\ X_3 + 0.0307\ X_7$	0.03	18.91
X_3X_8	$0.0014\ X_3 + 0.0047\ X_8$	0.06	34.38
X_4X_5	$0.2594\ X_4 + 0.0247\ X_5$	0.01	5.27
X_4X_6	$0.2594\ X_4 + 0.0198\ X_6$	0.09	50.29
X_4X_7	$0.2594\ X_4 + 0.0307\ X_7$	0.06	32.69
X_4X_8	$0.2594\ X_4 + 0.0047\ X_8$	0.04	21.65

Selection index	Discriminant function	Genetic advance	Relative efficiency
X_5X_6	$0.0247 X_5 + 0.0198 X_6$	0.14	75.70
X_5X_7	$0.0247 X_5 + 0.0307 X_7$	0.02	12.16
X_5X_8	$0.0247 X_5 + 0.0047 X_8$	0.08	45.31*
X_6X_7	$0.0198 X_6 + 0.0307 X_7$	0.13	69.92
X_6X_8	$0.0198 X_6 + 0.0047 X_8$	0.14	77.33
$X_1X_2X_3$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3$	0.05	28.99
$X_1X_2X_4$	$0.0120 X_1 + 0.0100 X_2 + 0.2594 X_4$	0.07	37.34
$X_1X_2X_5$	$0.0120 X_1 + 0.0100 X_2 + 0.0247 X_5$	0.04	22.29
$X_1X_2X_6$	$0.0120 X_1 + 0.0100 X_2 + 0.0198 X_6$	0.14	79.74
$X_1X_2X_7$	$0.0120 X_1 + 0.0100 X_2 + 0.0307 X_7$	0.04	22.35
$X_1X_2X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.0047 X_8$	0.06	3091
$X_1X_3X_4$	$0.0120 X_1 + 0.0014 X_3 + 0.2594 X_4$	0.03	18.50
$X_1X_3X_5$	$0.0120 X_1 + 0.0014 X_3 + 0.0247 X_5$	0.05	29.46
$X_1X_3X_6$	$0.0120 X_1 + 0.0014 X_3 + 0.0198 X_6$	0.12	73.81
$X_1X_3X_7$	$0.0120 X_1 + 0.0014 X_3 + 0.0307 X_7$	0.04	21.15
$X_1X_3X_8$	$0.0120 X_1 + 0.0014 X_3 + 0.0047 X_8$	0.08	41.29
$X_1X_4X_5$	$0.0120 X_1 + 0.2594 X_4 + 0.0247 X_5$	0.01	5.40
$X_1X_4X_6$	$0.0120 X_1 + 0.2594 X_4 + 0.0198 X_6$	0.11	57.90
$X_1X_4X_7$	$0.0120 X_1 + 0.2594 X_4 + 0.0307 X_7$	0.07	38.56
$X_1X_4X_8$	$0.0120 X_1 + 0.2594 X_4 + 0.0047 X_8$	0.05	28.54
$X_1X_5X_6$	$0.0120 X_1 + 0.0247 X_5 + 0.0198 X_6$	0.15	85.22
$X_1X_5X_7$	$0.0120 X_1 + 0.0247 X_5 + 0.0307 X_7$	0.02	12.42
$X_1X_5X_8$	$0.0120 X_1 + 0.0247 X_5 + 0.0047 X_8$	0.11	58.77
$X_1X_6X_7$	$0.0120 X_1 + 0.0198 X_6 + 0.0307 X_7$	0.13	73.24
$X_1X_6X_8$	$0.0120 X_1 + 0.0198 X_6 + 0.0047 X_8$	0.16	86.05
$X_1X_7X_8$	$0.0120 X_1 + 0.0307 X_7 + 0.0047 X_8$	0.11	59.38
$X_2X_3X_4$	$0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4$	0.07	37.16
$X_2X_3X_5$	$0.0100 X_2 + 0.0014 X_3 + 0.0247 X_5$	0.05	29.13
$X_2X_3X_6$	$0.0100 X_2 + 0.0014 X_3 + 0.0198 X_6$	0.15	83.65
$X_2X_3X_7$	$0.0100 X_2 + 0.0014 X_3 + 0.0307 X_7$	0.04	20.13
$X_2X_3X_8$	$0.0100 X_2 + 0.0014 X_3 + 0.0047 X_8$	0.06	33.48

Selection index	Discriminant function	Genetic advance	Relative efficiency

$X_2X_4X_5$	$0.0100\ X_2 + 0.2594\ X_4 + 0.0247\ X_5$	0.04	24.49
$X_2X_4X_6$	$0.0100\ X_2 + 0.2594\ X_4 + 0.0198\ X_6$	0.12	67.59
$X_2X_4X_7$	$0.0100\ X_2 + 0.2594\ X_4 + 0.0307\ X_7$	0.06	34.53
$X_2X_4X_8$	$0.0100\ X_2 + 0.2594\ X_4 + 0.0047\ X_8$	0.04	20.88
$X_2X_5X_6$	$0.0100\ X_2 + 0.0247\ X_5 + 0.0198\ X_6$	0.15	84.95
$X_2X_5X_7$	$0.0100\ X_2 + 0.0247\ X_5 + 0.0307\ X_7$	0.03	14.67
$X_2X_5X_8$	$0.0100\ X_2 + 0.0247\ X_5 + 0.0047\ X_8$	0.06	33.85
$X_2X_6X_7$	$0.0100\ X_2 + 0.0198\ X_6 + 0.0307\ X_7$	0.14	78.75
$X_2X_6X_8$	$0.0100\ X_2 + 0.0198\ X_6 + 0.0047\ X_8$	0.15	83.10
$X_2X_7X_8$	$0.0100\ X_2 + 0.0307\ X_7 + 0.0047\ X_8$	0.08	44.15
$X_3X_4X_5$	$0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5$	0.01	5.24
$X_3X_4X_6$	$0.0014\ X_3 + 0.2594\ X_4 + 0.0198\ X_6$	0.10	54.10
$X_3X_4X_7$	$0.0014\ X_3 + 0.2594\ X_4 + 0.0307\ X_7$	0.07	38.65
$X_3X_4X_8$	$0.0014\ X_3 + 0.2594\ X_4 + 0.0047\ X_8$	0.04	22.20
$X_3X_5X_6$	$0.0014\ X_3 + 0.0247\ X_5 + 0.0198\ X_6$	0.14	79.72
$X_3X_5X_7$	$0.0014\ X_3 + 0.0247\ X_5 + 0.0307\ X_7$	0.03	15.31
$X_3X_5X_8$	$0.0014\ X_3 + 0.0247\ X_5 + 0.0047\ X_8$	0.08	43.82
$X_3X_6X_7$	$0.0014\ X_3 + 0.0198\ X_6 + 0.0307\ X_7$	0.13	73.23
$X_3X_6X_8$	$0.0014\ X_3 + 0.0198\ X_6 + 0.0047\ X_8$	0.14	79.40
$X_3X_7X_8$	$0.0014\ X_3 + 0.0307\ X_7 + 0.0047\ X_8$	0.10	56.96
$X_4X_5X_6$	$0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6$	0.11	61.52
$X_4X_5X_7$	$0.2594\ X_4 + 0.0247\ X_5 + 0.0307\ X_7$	0.05	26.19
$X_4X_5X_8$	$0.2594\ X_4 + 0.0247\ X_5 + 0.0047\ X_8$	0.06	30.55
$X_4X_6X_7$	$0.2594\ X_4 + 0.0198\ X_6 + 0.0307\ X_7$	0.11	59.81
$X_4X_6X_8$	$0.2594\ X_4 + 0.0198\ X_6 + 0.0047\ X_8$	0.11	62.60
$X_4X_7X_8$	$0.2594\ X_4 + 0.0307\ X_7 + 0.0047\ X_8$	0.09	51.56
$X_5X_6X_7$	$0.0247\ X_5 + 0.0198\ X_6 + 0.0307\ X_7$	0.04	78.99
$X_5X_6X_8$	$0.0247\ X_5 + 0.0198\ X_6 + 0.0047\ X_8$	0.17	91.36
$X_5X_7X_8$	$0.0247\ X_5 + 0.0307\ X_7 + 0.0047\ X_8$	0.11	63.10

Selection index	**Discriminant function**	**Genetic advance**	**Relative efficiency**
$X_1X_2X_3X_4$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4$	0.08	46.48
$X_1X_2X_3X_5$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.0247\ X_5$	0.06	32.05

$X_1X_2X_3X_6$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.0198\ X_6$	0.16	86.10
$X_1X_2X_3X_7$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.0307\ X_7$	0.05	28.15
$X_1X_2X_3X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.0047\ X_8$	0.06	34.59
$X_1X_2X_4X_5$	$0.0120\ X_1 + 0.0100\ X_2 + 0.2594\ X_4 + 0.0247\ X_5$	0.04	20.21
$X_1X_2X_4X_6$	$0.0120\ X_1 + 0.0100\ X_2 + 0.2594\ X_4 + 0.0198\ X_6$	0.14	77.07
$X_1X_2X_4X_7$	$0.0120\ X_1 + 0.0100\ X_2 + 0.2594\ X_4 + 0.0307\ X_7$	0.09	50.19
$X_1X_2X_4X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.2594\ X_4 + 0.0047\ X_8$	0.06	31.80
$X_1X_2X_5X_6$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0247\ X_5 + 0.0198\ X_6$	0.16	90.35
$X_1X_2X_5X_7$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0247\ X_5 + 0.0307\ X_7$	0.01	8.13
$X_1X_2X_5X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0247\ X_5 + 0.0047\ X_8$	0.08	43.50
$X_1X_2X_6X_7$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0198\ X_6 + 0.0307\ X_7$	0.15	83.94
$X_1X_2X_6X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0198\ X_6 + 0.0047\ X_8$	0.16	88.06
$X_1X_3X_4X_5$	$0.0120\ X_1 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5$	0.01	7.30
$X_1X_3X_4X_6$	$0.0120\ X_1 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0198\ X_6$	0.12	63.46
$X_1X_3X_4X_7$	$0.0120\ X_1 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0307\ X_7$	0.09	47.71
$X_1X_3X_4X_8$	$0.0120\ X_1 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0047X_8$	0.06	31.32
$X_1X_3X_5X_6$	$0.0120\ X_1 + 0.0014\ X_3 + 0.0247X_5 + 0.0198\ X_6$	0.16	88.18
$X_1X_3X_5X_7$	$0.0120\ X_1 + 0.0014\ X_3 + 0.0247X_5 + 0.0307\ X_7$	0.03	16.19
$X_1X_3X_5X_8$	$0.0120\ X_1 + 0.0014\ X_3 + 0.0247X_5 + 0.0047\ X_8$	0.10	56.48
$X_1X_3X_6X_7$	$0.0120\ X_1 + 0.0014\ X_3 + 0.0198X_6 + 0.0307\ X_7$	0.14	77.54
$X_1X_3X_6X_8$	$0.0120\ X_1 + 0.0014\ X_3 + 0.0198X_6 + 0.0047\ X_8$	0.16	87.53
$X_1X_4X_5X_6$	$0.0120\ X_1 + 0.2594X_4 + 0.0247X_5 + 0.0198\ X_6$	0.12	67.70
$X_1X_4X_5X_7$	$0.0120\ X_1 + 0.2594X_4 + 0.0247X_5 + 0.0307X_7$	0.04	21.32
$X_1X_4X_5X_8$	$0.0120\ X_1 + 0.2594X_4 + 0.0247X_5 + 0.0047\ X_8$	0.07	35.96
$X_1X_4X_6X_7$	$0.0120\ X_1 + 0.2594X_4 + 0.0198X_6 + 0.0307\ X_7$	0.13	70.29
$X_1X_4X_6X_8$	$0.0120\ X_1 + 0.2594X_4 + 0.0198X_6 + 0.0047X_8$	0.13	70.58
$X_1X_4X_7X_8$	$0.0120\ X_1 + 0.2594X_4 + 0.0307X_7 + 0.0047\ X_8$	0.11	58.62
$X_1X_5X_6X_7$	$0.0120\ X_1 + 0.0247X_5 + 0.0198X_6 + 0.0307\ X_7$	0.15	83.64
$X_1X_5X_6X_8$	$0.0120\ X_1 + 0.0247X_5 + 0.0198X_6 + 0.0047\ X_8$	0.19	101.88

Selection index	**Discriminant function**	**Genetic advance**	**Relative efficiency**
$X_2X_3X_4X_5$	$0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5$	0.06	31.42
$X_2X_3X_4X_6$	$0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0198\ X_6$	0.14	74.58
$X_2X_3X_4X_7$	$0.0120\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0307\ X_7$	0.07	40.16
$X_2X_3X_4X_8$	$0.0120\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0047\ X_8$	0.05	27.26

$X_2X_3X_5X_6$	0.0120 X_2 + 0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6	0.17	91.99
$X_2X_3X_5X_7$	0.0120 X_2 + 0.0014 X_3 + 0.0247 X_5 + 0.0307 X_7	0.03	17..35
$X_2X_3X_5X_8$	0.0120 X_2 + 0.0014 X_3 + 0.0247 X_5 + 0.0047 X_8	0.07	38.49
$X_2X_3X_6X_7$	0.0120 X_2 + 0.0014 X_3 + 0.0198 X_6 + 0.0307 X_7	0.15	82.87
$X_2X_3X_6X_8$	0.0120 X_2 + 0.0014 X_3 + 0.0198 X_6 + 0.0047 X_8	0.16	88.17
$X_2X_4X_5X_6$	0.0120 X_2 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6	0.13	73.86
$X_2X_4X_5X_7$	0.0120 X_2 + 0. 2594 X_4 + 0.0247 X_5 + 0.0307 X_7	0.05	29.12
$X_2X_4X_5X_8$	0.0120 X_2 + 0. 2594X_4 + 0.0247 X_5 + 0.0047 X_8	0.04	23.32
$X_2X_4X_6X_7$	0.0120 X_2 + 0. 2594X_4 + 0.0198 X_6 + 0.0307 X_7	0.13	68.97
$X_2X_4X_6X_8$	0.0120 X_2 + 0. 2594X_4 + 0.0198 X_6 + 0.0047 X_8	0.13	71.18
$X_2X_5X_6X_7$	0.0120 X_2 + 0. 0247 X_5 + 0.0198 X_6 + 0.0307 X_7	0.16	87.98
$X_2X_5X_6X_8$	0.0120 X_2 + 0. 0247 X_5 + 0.0198 X_6 + 0.0047 X_8	0.17	94.38
$X_3X_4X_5X_6$	0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6	0.12	65.58
$X_3X_4X_5X_7$	0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0307 X_7	0.06	32.14
$X_3X_4X_5X_8$	0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0047 X_8	0.05	30.20
$X_3X_4X_6X_7$	0.0014 X_3 + 0.2594 X_4 + 0.0198X_6 + 0.0307 X_7	0.12	63.96
$X_3X_4X_6X_8$	0.0014 X_3 + 0.2594 X_4 + 0.0198 X_6 + 0.0047 X_8	0.12	65.89
$X_3X_5X_6X_7$	0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7	0.15	82.74
$X_3X_5X_6X_8$	0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8	0.17	93.69
$X_4X_5X_6X_7$	0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7	0.12	66.97
$X_4X_5X_6X_8$	0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8	0.14	75.50
$X_1X_2X_3X_4X_5$	0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5	0.06	30.53
$X_1X_2X_3X_4X_6$	0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0198 X_6	0.16	85.89
$X_1X_2X_3X_4X_7$	0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0307 X_7	0.11	59.52
$X_1X_2X_3X_4X_8$	0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0047 X_8	0.07	40.22

Selection index	**Discriminant function**	**Genetic advance**	**Relative efficiency**
$X_1X_2X_3X_5X_6$	0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6	0.18	96.75
$X_1X_2X_3X_5X_7$	0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.0247 X_4 + 0.0307 X_7	0.02	12.68
$X_1X_2X_3X_5X_8$	0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.0247 X_4 + 0.0047 X_8	0.08	46.25
$X_1X_2X_3X_6X_7$	0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.0198 X_6 + 0.0307 X_7	0.16	88.46

$X_1X_2X_3X_6X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.0198 X_6 + 0.0047 X_8$	0.17	92.60
$X_1X_2X_4X_5X_6$	$0.0120 X_1 + 0.0100 X_2 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6$	0.15	80.02
$X_1X_2X_4X_5X_7$	$0.0120 X_1 + 0.0100 X_2 + 0.2594 X_4 + 0.0247 X_5 + 0.0307 X_7$	0.06	30.35
$X_1X_2X_4X_5X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.2594 X_4 + 0.0247 X_5 + 0.0047 X_8$	0.05	26.42
$X_1X_2X_4X_6X_7$	$0.0120 X_1 + 0.0100 X_2 + 0.2594 X_4 + 0. 0198 X_6 + 0.0307 X_7$	0.16	86.16
$X_1X_2X_4X_6X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.2594 X_4 + 0. 0198 X_6 + 0.0047 X_8$	0.15	81.21
$X_1X_2X_5X_6X_7$	$0.0120 X_1 + 0.0100 X_2 + 0.0247 X_5 + 0. 0198 X_6 + 0.0307 X_7$	0.17	92.65
$X_1X_2X_5X_6X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.0247 X_5 + 0. 0198 X_6 + 0.0047 X_8$	0.18	101.66
$X_1X_3X_4X_5X_6$	$0.0120 X_1 + 0.0014 X_3 + 0.2594 X_4 + 0. 0247 X_5 + 0.0198 X_6$	0.13	72.57
$X_1X_3X_4X_5X_7$	$0.0120 X_1 + 0.0014 X_3 + 0.2594 X_4 + 0. 0247 X_5 + 0.0307 X_7$	0.06	32.52
$X_1X_3X_4X_5X_8$	$0.0120 X_1 + 0.0014 X_3 + 0.2594 X_4 + 0. 0247 X_5 + 0.0047 X_8$	0.07	35.96
$X_1X_3X_4X_6X_7$	$0.0120 X_1 + 0.0014 X_3 + 0.2594 X_4 + 0. 0198 X_6 + 0.0307 X_7$	0.14	77.94
$X_1X_3X_4X_6X_8$	$0.0120 X_1 + 0.0014 X_3 + 0.2594 X_4 + 0. 0198 X_6 + 0.0047X_8$	0.14	75.14
$X_1X_3X_5X_6X_7$	$0.0120 X_1 + 0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7$	0.16	87.73
$X_1X_3X_5X_6X_8$	$0.0120 X_1 + 0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8$	0.19	103.32
$X_1X_4X_5X_6X_7$	$0.0120 X_1 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7$	0.13	73.91
$X_1X_4X_5X_6X_8$	$0.0120 X_1 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8$	0.15	82.62

Selection index	**Discriminant function**	**Genetic advance**	**Relative efficiency**
$X_2X_3X_4X_5X_6$	$0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6$	0.15	80.65
$X_2X_3X_4X_5X_7$	$0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0307 X_7$	0.06	32.41
$X_2X_3X_4X_5X_8$	$0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0047 X_8$	0.05	28.26
$X_2X_3X_4X_6X_7$	$0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0198 X_6 + 0.0307 X_7$	0.14	74.37
$X_2X_3X_4X_6X_8$	$0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0198 X_6 + 0.0047 X_8$	0.14	77.26
$X_2X_3X_5X_6X_7$	$0.0100 X_2 + 0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7$	0.17	91.67
$X_2X_3X_5X_6X_8$	$0.0100 X_2 + 0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8$	0.18	99.64
$X_2X_4X_5X_6X_7$	$0.0100 X_2 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7$	0.14	75.79
$X_2X_4X_5X_6X_8$	$0.0100 X_2 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8$	0.15	80.78
$X_3X_4X_5X_6X_7$	$0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7$	0.13	71.51
$X_3X_4X_5X_6X_8$	$0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8$	0.14	78.68
$X_1X_2X_3X_4X_5X_6$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6$	0.16	88.16
$X_1X_2X_3X_4X_5X_7$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0307 X_7$	0.07	39.08w
$X_1X_2X_3X_4X_5X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 + 0.0047 X_8$	0.06	32.72
$X_1X_2X_3X_4X_6X_7$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0198 X_6 + 0.0307 X_7$	0.17	94.95
$X_1X_2X_3X_4X_6X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.2594 X_4 + 0.0198 X_6 + 0.0047 X_8$	0.16	88.85
$X_1X_2X_3X_5X_6X_7$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7$	0.18	96.61
$X_1X_2X_3X_5X_6X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.0014 X_3 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8$	0.19	106.28
$X_1X_2X_4X_5X_6X_7$	$0.0120 X_1 + 0.0100 X_2 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0307 X_7$	0.16	87.00
$X_1X_2X_4X_5X_6X_8$	$0.0120 X_1 + 0.0100 X_2 + 0.2594 X_4 + 0.0247 X_5 + 0.0198 X_6 + 0.0047 X_8$	0.16	88.29
Selection index	**Discriminant function**	**Genetic advance**	**Relative efficiency**
$X_1X_3X_4X_5X_6X_7$	$0.0120 X_1 + 0.0014 X_3 + 0.2594 X_4 + 0.0247 X_5 +$	0.15	81.49

	$0.0198\ X_6 + 0.0307\ X_7$		
$X_1X_3X_4X_5X_6X_8$	$0.0120\ X_1 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0047\ X_8$	0.16	86.46
$X_2X_3X_4X_5X_6X_7$	$0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0307\ X_7$	0.15	80.23
$X_2X_3X_4X_5X_6X_8$	$0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0047\ X_8$	0.16	86.46
$X_1X_2X_3X_4X_5X_6X_7$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0307\ X_7$	0.17	94.75
$X_1X_2X_3X_4X_5X_6X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0047\ X_8$	0.17	95.07
$X_1X_2X_3X_4X_5X_7X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0307\ X_7 + 0.0047\ X_8$	0.10	52.91
$X_1X_2X_3X_4X_6X_7X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0198\ X_6 + 0.0307\ X_7 + 0.0047\ X_8$	0.18	101.22
$X_1X_2X_3X_5X_6X_7X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0307\ X_7 + 0.0047\ X_8$	0.20	109.48
$X_1X_2X_4X_5X_6X_7X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0307\ X_7 + 0.0047\ X_8$	0.18	98.63
$X_1X_3X_4X_5X_6X_7X_8$	$0.0120\ X_1 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0307\ X_7 + 0.0047\ X_8$	0.18	99.49
$X_2X_3X_4X_5X_6X_7X_8$	$0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0307\ X_7 + 0.0047\ X_8$	0.16	90.26
$X_1X_2X_3X_4X_5X_6X_7X_8$	$0.0120\ X_1 + 0.0100\ X_2 + 0.0014\ X_3 + 0.2594\ X_4 + 0.0247\ X_5 + 0.0198\ X_6 + 0.0307\ X_7 + 0.0047\ X_8$	0.19	104.39