CORRELATION AND PATH ANALYSIS IN SESAMUM (*Sesamum indicum* L.) UNDER RAINFED CONDITIONS

BY

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THESIS

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Dedicated to

My Beloved Parents

DECLARATION

I hereby declare that this thesis entitled "Correlation and path analysis in Sesamum (*Sesamum indicum* L.) under rainfed conditions" is a bonafide record of research work done by me and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Correlation and path analysis in Sesamum (*Sesamum indicum* L.) under rainfed conditions" is a record of research work done independently by Sri. Kuriakose Conil under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

INTRODUCTION

Oil seeds occupy an important position in the Indian economy, accounting for about 10 per cent of the value of all agricultural products and about 5 per cent of the Gross National Produce (Vasudevan, 1990). During the past 20 years, the country has been facing problems of shortage and rise in the prices of edible oils. This situation is due to the tardy progress in the production of nine major oil seeds - groundnut, sesamum, mustard, sunflower, safflower, soyabean, nigerseed, linseed and castorseed.

The average yields of most oil seeds in India are extremely low when compared to those prevailing in other countries of the world. To cite an example, the average yield of sesamum in India is 1.6 quintals per hectare, while those in Sudan and China are 10 quintals per hectare and 5.6 quintals per hectare respectively (Gupta and Labana, 1980). One of the reasons for this low productivity is that oil seed crops in India are grown under sub-optimal and poor management conditions, whereas in most other countries they are raised under better management conditions. The cultivation of oil seeds in India is concentrated in high risk regions where returns on investment are uncertain (Ninan, 1989). About 85 per cent of the oil seed crops in India are grown in rainfed regions, particularly regions having low or uncertain rainfall. Consequently, there is a high element of uncertainty in oil seed production associated with weather. Owing to these constraints, an average of about 10 lakh tons of edible oils, valued at Rs.600 to Rs.800 crores, [redacted] is being imported by the country annually (Vasudevan, 1990).

India, accounting for 32.5 per cent of the world sesamum acerage (2174 thousand hectares), contributes only 21.3 per cent to the world production (475 thousand tons) (FAO, 1987). It has been estimated that, of the total area under sesamum in India, only 5 per cent is irrigated and the remaining 95 per cent is purely rainfed. Therefore, any crop improvement programme undertaken in sesamum should be based on studies conducted under rainfed conditions.

Sesamum is the most important oil seed of Kerala, accounting for 59.5 per cent of the total oil seeds area in the State. The State has 13,985 hectares of sesamum producing 3520 tons of seeds annually (Ninan, 1989). The traditional areas of sesamum cultivation in the State are the rice fallows during the summer season and the uplands during the rabi season. This study was undertaken to evaluate sesamum genotypes in order to identify superior ones possessing high oil content and seed yield under rainfed conditions in rabi uplands and to assess the relationship between yield and other characters through correlation and path analysis.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A brief review of the variability studies, genetic parameters, correlation and path analysis undertaken in sesamum (*Sesamum indicum* L.) is attempted below. Since the literature available on works done in sesamum under rainfed conditions is scanty, the research works carried out in other crops under similar conditions are also reviewed.

2.1. Variability

Quantitative characters are known to be governed by the co-ordinated action of genes at many loci. Gaul (1967) reported that the individual substitution of these jointly acting genes provides small effects at the phenotypic level and on the environmental influences. Information on the type of variability available in the genetic stock and the part played by the environment on the expression of characters is a pre-requisite for any crop improvement programme. Sesamum is a crop showing much variability for the different morphological characters.

A wide range of variability was observed for number of days to flowering by Shrivas and Kaushal (1972). Trehan *et al*. (1974) found that variability for number of days to flowering was highly significant. Yadava *et al*.

(1980) after studying 22 genotypes of sesamum found that the genotypic variability was high for days to first flowering.

High variability for plant height at maturity was reported by Kashiram (1930), Hiltebrandt (1932) and Muhammed et al. (1970). It was reported by Shrivas and Kaushal (1972) that morphological variation for plant height was wide among kharif types and that the character depends on the regions from which they were collected. Murugesan et al. (1979) reported that 30 varieties of sesamum significantly differed in their mean values for plant height during the two seasons of kharif and rabi. Rai et al. (1981) noticed high estimates for the genotypic coefficient of variation in 24 sesamum varieties.

A low coefficient of variation for number of primary branches was reported by Shukla and Verma (1976). Gupta and Gupta (1977) observed a wide range of phenotypic variance for number of primary branches and its genotypic component was more than the environmental component. A high genotypic variance was reported by Yadava et al. (1980) for number of primary branches in 22 genotypes of sesamum.

A wide range of variability was reported for number of capsules per plant by Muhammad et al. (1970), Dabral and

Holker (1971) and Sawant (1971). In a study of 45 varieties, high genotypic coefficient of variation was observed by Gupta (1975). Gupta and Gupta (1977) reported a wide range of phenotypic variability for number of capsules per plant and the genotypic component of variance was greater than environmental component. In both kharif and rabi seasons, Murugesan et al. (1979) noticed high genotypic and phenotypic coefficient of variation for number of capsules per plant. High genotypic and phenotypic variances for number of capsules per plant was observed in 25 varieties by Solanki and Paliwal (1981) and high genotypic coefficient of variation was recorded by Rai et al. (1981).

The capsules in Sesamum vary much in their size (Muhammad, 1970; Sawant, 1971). Trehan et al. (1974) reported high variability for length of the capsule but Murugesan et al. (1979) reported very low genotypic and phenotypic coefficient of variation for this character.

The range of variability observed for number of seeds per capsule by Kashiram (1930), Muhammad (1970) and Dabral and Holker (1971), was very wide. Sawant (1971) reported very high phenotypic and genotypic coefficients of variation for this character. Similar results were reported by Trehan et al. (1974), Murugesan et al. (1979) and Solanki and Paliwal (1981).

Reports by Muhammad (1970) and Dabral and Holker (1971) indicate a wide range of variability for seed yield. Sawant (1971) found that the yield of seeds had very high phenotypic and genotypic coefficients of variability. In a study of 45 varieties of Sesamum, high genotypic coefficients of variation was observed for seed yield by Gupta (1975). Murugesan _et al_. (1979) reported similar to Sawant (1971) while Rai _et al_. (1981) reported similar to Gupta (1975).

Mazzani (1959) reported that seed oil content of Sesamum was more influenced by environmental effects than genotypic differences. On the other hand, Brar and Yermanos (1973) reported that oil content varied according to genotypes. Gangrade _et al_. (1973) reported a variation in seed oil content ranging from 52 to 57 per cent in capsules borne at different axils of the same plant. Low phenotypic and genotypic coefficients of variability were obtained for oil content by Osman and Khidir (1974). El-Jinay _et al_. (1976) identified a range of 42 to 52 per cent for seed oil content. Brar (1982) reported that seed oil content varied from 46 to 58 per cent.

2.2. Heritability

Heritability is an index of the transmissibility of characters from generation to generation. It provides a measure of the value of selection for different characters in various genotypes. The total variance of a character consists of a heritable portion, an environmental portion and a portion due to genotype x environment interaction. The heritable portion in turn includes the additive genetic effects which is fixable and the dominance and epistatic effect which are non-fixable.

The term heritability was introduced and defined by Fisher (1918) as the ratio of fixable (additive) genetic variance to the total genetic variance. Robinson et al. (1949) defined heritability as the additive genetic variance in percentage of the total variance. Lush (1940) introduced heritability in broad sense and heritability in narrow sense. The former estimates the percentage of the genotypic variance over the phenotypic variance, whereas the latter is the ratio of the additive genetic variance to the total variance. The estimate of heritability is useful to the plant breeder for selection based on the genotypic worth of a character. Heritability of different morphological characters has been estimated in sesamum by various workers, as detailed below:

Mohanty and Sinha (1965) reported low heritability for duration upto flowering. In a study with 15 sesamum varieties, Chaudhary et al. (1970) observed high heritability for number of days to initial flowering and to 50 per cent flowering. High estimate of heritability was also observed by Sawant (1971) for days to flowering. Heritability of days to flowering and maturity exceeded eighty per cent in one season or the other in a study conducted by Osman and Khidir (1974).

High heritability value for height of the plant was observed by Dabral (1967), Chaudhary et al. (1970) and Sawant (1971). More than 80 per cent heritability was observed for this character by Osman and Khidir (1974). Salazar and Onoro (1975) reported that height of the plant had the highest heritability among the characters studied. In a study of 34 sesamum varieties, Gupta and Gupta (1977) observed that heritability estimates of plant height was as high as 92.36 per cent. High heritability for this character was also obtained by Murugesan et al. (1979), Rai et al. (1981) and Zhan (1983).

Bhargava and Saxena (1964), Dabral (1967) and Nephandae and Kolte (1975) obtained high estimates of heritability for number of branches. Studies by Sanjeeviah and Joshi (1974) in thirty one varieties of sesamum revealed very high values of heritability for number of branches per plant. Estimates of heritability and co-heritability were observed to be high in twenty eight genotypes of sesamum, by Shukla and Verma (1976), for this character. High heritability for number of branches per plant was also reported by Murugesan *et al*. (1979), Paramasivam and Prasad (1981) and Rai *et al*. (1981).

The number of primary branches showed high estimates of heritability according to Osman and Khidir (1974) and Chavan *et al*. (1982). Paramasivam and Prasad (1981) obtained high heritability value for number of secondary branches.

It was seen in the studies of Dabral and Holker (1971) and Osman and Khidir (1974) that number of capsules per plant was highly heritable. At the same time, the number of capsules on main branch showed very high heritability estimates, as reported by Sanjeeviah and Joshi (1974). High heritability and co-heritability values for number of capsules per plant were observed by Shukla and Verma (1976), Gupta and Gupta (1977), Paramasivam and Prasad (1981), Chavan *et al*. (1982) and Zhan (1983) among others. Medium heritability and low heritability were observed for this character by Solanki and Paliwal (1981) and Murugesan *et al*. (1979) respectively.

High estimates of heritability for length and breadth of the capsule were observed by Dabral and Holke (1971) and Solanki and Paliwal (1981). High heritability for length of the capsule was reported by Osman and Khidir (1974).

Dabral and Holker (1971), Sawant (1971), Osman and Khidir (1974) and Solanki and Paliwal (1981) are some of the workers who obtained a high estimate of heritability for the number of seeds per capsule.

Seed yield per plant was seen to be highly heritable according to Chaudhary et al. (1970), Dabral and Holker (1971), Sawant (1971), Sanjeeviah and Joshi (1974), Gupta and Gupta (1977), Paramasivam and Prasad (1981) and Zhan (1983). On the other hand, a medium estimate of heritability was observed by Solanki and Paliwal (1981) and a low estimate of heritability by Murugesan et al. (1979).

Osman and Khidir (1974) reported that the oil content in sesamum gave heritability estimates exceeding eighty percentage in one season or the other.

2.3. Genetic Advance

Johnson et al. (1955) pointed out that the estimates of heritability indicates only the effectiveness with which selection of a genotype can be made based on the phenotypic performance, but fails to indicate its genetic progress that can be achieved. Swarup and Chaugale (1962) had cautioned that high heritability per se was not an index of high genetic gain, but should be accompanied by high genetic advance. Studies undertaken in this line in sesamum are mentioned below:

High genetic advance associated with high heritability for number of days to flowering and height of the plant was reported by Sawant (1971). According to Osman and Khidir (1974) days to flowering exhibited a very high magnitude of genetic advance. Solanki and Paliwal (1981) observed high genetic advance with heritability for number of days to maturity and number of seeds per capsule.

Osman and Khidir (1974) and Murugesan et al. (1979) observed a high genetic advance with respect to height upto the first capsule. Studies by Rai et al. (1981) revealed that plant height exhibited high heritability in conjunction with low genetic advance.

Number of branches showed high genetic advance in the studies of Bhargava and Saxena (1964) and Rai et al. (1981). A high estimate of genetic advance along with high heritability for number of branches, has been reported by Nephande and Kolte (1975) and Osman and Khidir (1974). High genetic advance in respect of primary and secondary branches was observed by Murugesan et al. (1979) and Paramasivam and Prasad (1981), while Chavan et al. (1982) observed that high heritability estimate accompanied by high expected genetic advance existed in the case of number of primary branches.

Osman and Khidir (1974), Gupta and Gupta (1977) and Solanki and Paliwal (1981) found high genetic advance coupled with high heritability for number of capsules per plant. This was later confirmed by Chavan et al. (1982).

High genetic advance for number of capsules per plant and seed yield per plant was reported by Paramasivam and Prasad (1981). John (1985) observed that in the rabi uplands, yield per plant had the highest genetic advance followed by number of capsules on main stem. In the same season, high heritability for number of capsules on main stem, number of branches and yield per plant were associated with high genetic advance. In the summer rice fallows, maximum genetic advance was observed for number of capsules on branches and lowest for seed yield per plant.

Osman and Khidir (1974) reported that the seed oil content, protein content and moisture content gave very low values of genetic advance.

2.4. Correlation studies in sesamum

Gene correlation gives an idea about the extent to which two characters are under the control of the same set of genes or have the same physiological basis for their expressions. Correlation between characters may arise from linkage or from developmental genetic interactions, with or without a purely phenotypic component (Simmonds, 1979). Genotypic correlations can be separated from phenotypic correlations by analysis of covariance and by methods analogous to those used for the partitioning of variance.

If the correlation is high then probably pleiotropy is more important; if the correlation is low then the two traits may be inherited independently or they are under the control of different sets of genes (Jain, 1982).

2.4.1. Correlation of plant characters with seed yield

Yield is a complex polygenic quantitative character greatly affected by the environment. Hence selection of superior genotypes based on yield as such is not effective. Selection has to be made for the components of yield. This association of plant characters with yield thus assumes special importance in formulating a basis of selection of desired strains. Estimates of genotypic association and phenotypic association would give a clear picture of the extent of inherent correlation and also indicate how much of the phenotypic expression is influenced by the environment.

To make effective selection for higher yields, a thorough understanding of yield contributing characters and the interrelationships among themselves as well as with seed and oil yield is necessary.

2.4.1.1. Days to first flowering

Positive and significant correlation of number of days to flowering and maturity with yield of seeds was observed by Khidir (1970) in ninety Sudanese cultivars of sesamum. Osman and Khidir (1974) reported that days to flowering and maturity gave positive and highly significant correlation coefficient with seed yield.

Significant and positive correlation of days to 50 per cent flowering with seed yield was reported by Chavan and Chopde (1981).

Muhammad _et al_. (1970) and Kaushal _et al_. (1974) observed no significant correlation of number of days to flowering with yield of seeds. On the other hand, a negative correlation between seed yield and number of days to first flowering was reported by Chandramony (1984). According to John (1985), during both rabi and summer seasons, the yield of seeds was negatively and significantly correlated, at the genotypic level, with number of days to flowering.

2.4.1.2. Height of the plant at maturity

Positive and significant association of height of the plant with yield of seeds was observed by Dabral (1967), Chaudhary _et al_. (1970) and Khidir (1970). Plant height gave a positive and highly significant correlation coefficient with seed yield, as reported by Osman and Khidir (1974).

El-Nadi and Lazim (1974) observed that seed yield per plot was positively and significantly correlated with height of the main stem. Palaniswamy _et al_. (1978) reported that correlation between yield and plant height was positive and highly significant. Similar results were communicated by Paramasivam and Prasad (1980) in a study of F_2 and F_3 population of three crosses of Sesamum.

In an experiment with varying fertility levels, Ghosh and Sen (1980) observed that seed yield was positively correlated with plant height at maturity. Positive, significant association of this character with seed yield was reported by Chavan and Chopde (1981) and Zhan (1983). Thangavelu and Rajasekaran (1983) observed that plant height had significant positive correlation with seed yield at both genotypic and phenotypic levels. Chandramony (1984) could obtain a positive and significant correlation between seed yield and plant height.

Height of the plant had positive genotypic correlation with yield during rabi, but had negative and significant correlation with seed yield during summer season (John, 1985). Uzo et al. (1985) observed that seed yield was positively and significantly correlated with plant height. In a 20 x 5 line x tester analysis, Krishnadoss and Kadambavanasundaram (1986) found that height of the plant was positively correlated with seed yield. Positive and significant association of yield per plant and plant height at genotypic and phenotypic levels, was observed by Bhele et al. (1987).

A study with 100 Sesamum types revealed that height of the plant was one of the characters to be given prime importance in selection during rabi season (KAU, 1987).

Conversely, Muhammad et al. (1970) and Kaushal et al. (1974) reported no significant correlation of plant height with yield of seeds in Sesamum.

2.4.1.3. Number of primary branches

Positive association of number of branches with yield of seeds was reported by Dabral (1967), Khidir (1970), Ramachandran et al. (1972), Nephande and Kolte (1975) and Gupta (1976). The number of branches showed significant positive correlation with seed yield at both genotypic and phenotypic levels, according to Thangavelu and Rajasekaran (1983) and John (1985) during the summer season. At the same time, Gupta and Chopra (1984) could observe a positive and significant correlation of this character with seed yield only at the phenotypic level. Positive significant association of the number of branches per plant has also been reported by Krishnadoss and Kadambavanasundaram (1986) and Godawat and Gupta (1986).

Palaniswamy et al. (1978), Paramasivam and Prasad (1980), Yadava et al. (1980) and Chavan and Chopde (1981) had reported that the number of primary branches had a significant positive correlation with seed yield in Sesamum. The number of primary productive branches was positively and significantly associated with seed yield (Chandramony, 1984).

2.4.1.4. Number of capsules per plant

Asthana and Rai (1970) reported that yield of seeds is significantly and positively correlated with number of capsules on main stem. Positive and significant association of number of capsules per plant with seed yield was observed by Khidir (1970), Osman and Khidir (1974), El-Nadi and Lazim (1974), Dixit (1975), Salazar and Onoro (1975), Shukla and Verma (1976), Gupta (1976), Gupta and Gupta (1977), Palaniswamy et al. (1978), Murugesan et al. (1979), Paramasivam and Prasad (1980), Ghosh and Sen (1980), Yadava et al. (1980) and Chavan and Chopde (1981).

According to Rai et al. (1981), seed yield had a significant and positive correlation with number of capsules on the main stem, number of capsules on the branches and total number of capsules, most so with the last one. Thangavelu and Rajasekaran (1983) observed that the number of capsules and capsules on main stem showed significant positive correlation with seed yield at both genotypic and phenotypic levels. Gupta and Chopra (1984) reported that at the phenotypic level, seed yield was positively and significantly correlated with number of capsules on branches and at the same time, negatively correlated with capsules on the main shoot. Chandramony (1984) observed that capsules on the main axis and total number of capsules per plant were positively and significantly correlated with seed yield.

It was reported by John (1985) that number of capsules on branches and number of capsules per plant were positively and significantly correlated at genotypic and phenotypic levels, during the two seasons of rabi and summer. Number of capsules on the main stem was positively and significantly correlated with seed yield during the rabi season only. Uzo et al. (1985), Krishnadoss and

Kadambavanasundaram (1986) and Godawat and Gupta (1986) reported that seed yield per plant showed significant positive correlation with number of capsules per plant.

In a study on 100 Sesamum types with 16 characters, it was observed that number of capsules had to be given prime importance in selection during the rabi season (KAU, 1987). At the genotypic and phenotypic levels, yield per plant was significantly and positively associated with number of capsules per plant, according to Bhele et al. (1987).

Muhammad et al. (1970) and Kaushal et al. (1974), on the other hand, found no significant correlation between number of capsules per plant and yield of seeds.

2.4.1.5. Size of the capsule

Positive and significant correlation of length of the capsule with yield of seeds, was observed by Khidir (1970). Ramachandran et al. (1972) observed that seed yield was positively and significantly correlated with size of the capsule. It was reported by Dixit (1975), Gupta and Gupta (1977) and Chavan and Chopde (1981) that length of the capsule had a positive significant correlation with seed yield.

John (1985) observed that during rabi season, length and circumference of the capsule were positively and significantly correlated with seed yield at both genotypic and phenotypic levels. On the other hand, during the summer season, length of the capsule had a negative significant association with yield of seeds. Godawat and Gupta (1986) reported significant positive correlation with capsule length and seed yield at three different locations.

2.4.1.6. Number of seeds per capsule

Positive correlation of number of seeds per capsule with seed yield was reported by Khidir (1970) and Muhammad et al. (1970). Osman and Khidir (1974) observed that the total number of seeds per plant gave a positive and highly significant correlation coefficient with yield. Studies by El-Nadi and Lazim (1974), Gupta and Gupta (1977) and Zhan (1983) have indicated that seed yield was positively and significantly correlated with number of seeds per capsule.

In an experiment with varying fertility levels, seed yield was positively correlated with number of seeds per capsule (Chavan and Chopde, 1981).

Thangavelu and Rajasekaran (1983) reported that the association of seed number with seed yield was negative but non-significant at both genotypic and phenotypic levels. Chandramony (1984) also observed a negative correlation between seed yield and number of seeds per capsule. According to John (1985) the number of seeds per capsule had significant positive correlation with seed yield at the genotypic level only during rabi season. But during the summer season, this character exerted negative significant genotypic correlation with seed yield. Bhele et al. (1987) observed that number of seeds per capsule was positively and significantly associated with seed yield per plant at the genotypic level only.

2.4.2. Correlation of plant characters with seed oil

Hiltebrandt (1932) and Poehlman and Borthakur (1969) reported positive correlation between the colour of seed and oil content in Sesamum - the lighter the colour of the seed, the higher was the oil content. This was confirmed by El-Shamma and Al-Hassen (1973) who found that the white-seeded variety had the highest percentage of oil (59.1-59.9) and the black-seeded variety had the lowest percentage (52.5-56.6). The colours in between, red and grey, had medium oil content (57.1-59.7 and 54.3-57.4 respectively). Bradi (1972), on the other hand, reported that the black-seeded varieties are richer in seed oil content than white-seeded varieties.

Oil analysis report on the world sesame collection of 721 varieties from 38 countries revealed the following conclusions:

(a) Short, early plants had a clear oil while tall plants had light green oil.

(b) Early plants had a higher seed oil content than mid-season and late plants (Anonymous, 1972).

In a study including 40 varieties of Sesamum, Trehan et al. (1975) observed that the seed oil percentage was positively and significantly correlated with seed length, seed thickness and 100-seed weight. Thangavelu and Rajasekaran (1983) reported that seed oil content had a significant positive correlation with seed yield at both genotypic and phenotypic levels. On the contrary, Chandramony (1984) found that oil content was negatively correlated with seed yield. But the correlations of oil content with plant height, number of primary productive branches and number of seeds per capsule were positive.

It was observed by John (1985) that seed oil was positively and significantly correlated with height of the plant and length of the capsule during rabi season. In the summer season, seed oil was positively affected by days to flowering, 1000-seed weight, number of seeds per capsule, circumference of the capsule and number of fruiting axils per unit length. Mosjidis and Yermanos (1985) found that in *Sesamum*, the capsules located at intermediate positions in the plant (nodes 21 to 25) had heavier seeds, but with lesser oil content.

Taylor et al. (1986) reported that in *Sesamum* the mean seed oil contents were correlated with seed yield. Seed oil content was most affected by site and season. According to Bhele et al. (1987) oil content was positively and significantly associated with yield per plant at the genotypic level only.

2.4.3. Inter-correlations among plant characters

Yadava et al. (1980) reported that the character days to first flowering had a positive and significant relationship with days to 50 per cent flowering. Chavan and Chopde (1981) observed that days to 50 per cent flowering had positive and significant correlation with number of capsules per plant and plant height. At the same time, this character had negative significant correlation with number of seeds per capsule and length of the capsule.

Plant height at maturity had a significant positive correlation with size of the capsule, as reported by Ramachandran et al. (1972). Chavan and Chopde (1981) observed that the character plant height was significantly and positively correlated with number of capsules per plant and length of the capsule.

The number of primary branches was seen to be positively and significantly associated with days to 50 per cent flowering, plant height and number of capsules per plant. A negative significant correlation of this character was obtained with number of seeds per capsule (Chavan and Chopde, 1981).

The total number of capsules had a positive and significant association with number of primary branches, according to Yadava et al. (1980). Rai et al. (1981) reported that the total number of capsules was significantly correlated with both plant height and number of branches. Gupta and Chopra (1984) observed that while the number of capsules on branches had a significant positive correlation with number of branches per plant, the number of capsules on main shoot had a significant negative correlation with the number of branches per plant.

According to Chavan and Chopde (1981), the length of the capsule had a non-significant negative correlation with capsules per plant. The number of seeds per capsule had a positive significant correlation with length of the capsule and with plant height.

2.5. Path analysis studies in Sesamum

Correlation coefficients could be helpful in measuring the association between two characters, but they do not provide the causal basis of such an association. Wright (1921) developed 'Path Analysis', which facilitates the separation of the correlation coefficient into components of direct and indirect effects. Dewey and Lu (1959) defined path analysis as a simple standardised partial regression coefficient which measures the direct influence of one variable upon another and permits the separation of the correlation coefficient into components of direct and indirect effects.

The study of path analysis throws light on the cause and effect relationship in crops, so that complex quantitative characters like yield could be understood in a simpler and better way. The two characters whose relationship is measured, may not exist by themselves, but an intricate system of pathway can be involved, in which various other attributes also contribute. So it will be desirable to separate the direct contribution of each yield component and the indirect contribution it makes through its relationship with other attributes. When the causal factors are uncorrelated, the path coefficient is simply, the correlation between the two variables concerned.

Based on path analysis studies, Krishnamoorthy et al. (1964) had reported that the number of primary branches per plant had a positive direct impact on yield of seeds in Sesamum. It was reported by Kaushal et al. (1974) that height of the plant and number of capsules per plant had positive direct effect on yield of seeds in Sesamum. According to Osman and Khidir (1974), the number of capsules per plant and plant height are the important yield - contributing characters in sesamum. Direct but negative effects of days to flowering and height of the plant on seed yield, was reported by Nephande and Kolte (1975). At the same time, they could observe indirect effects of number of capsules and number of branches on seed yield of sesamum. Partly similar results were communicated by Dixit (1975), who observed that days to flowering and height of the plant had indeed a negative direct effect on seed yield. But he obtained a positive direct effect of number of branches with seed yield and the maximum direct effect on yield of seeds was shown by number of capsules on main stem. This was confirmed by Gupta (1976) and Gupta and Gupta (1977). In the work cited last, it was also observed that the length of the capsule had a negative direct effect and the number of seeds per capsule had positive direct effect on yield of seeds.

It was reported by Palaniswamy *et al*. (1978) that the number of primaries had a positive direct effect on yield, while all the other direct effects were negligible. Murugesan *et al*. (1979) found that the greatest direct effect on seed yield varied with season. During the monsoon season, it was height upto the first capsule and during the summer season, it was number of primary branches per plant. Path coefficient analysis by Ghosh and Sen (1980) revealed that the number of capsules per plant exerted the greatest direct effect on seed yield, followed by plant height and number of seeds per capsule. Similarly, Yadava *et al*. (1980) found that number of capsules had the maximum direct effect, followed by days to 50 per cent flowering and number of primary branches. The number of days to first flowering had a direct negative effect on seed yield. Chavan and Chopde (1981) observed that the length of capsule and number of capsules per plant had greater direct effects on seed yield, than any other character. The direct effects of days to 50 per cent flowering, number of primary branches and plant height were positive, while that of number of seeds per capsule was negative. The number of seeds per capsule had a positive indirect effect through length of the capsule. Also, the effects of length of the capsule, number of capsules per plant, number of primary branches and days to 50 per cent flowering, on seed yield, were mainly direct.

According to Shukla (1983) the number of capsules and primary branches per plant had positive effects on seed yield. At the same time, plant height and days to 50 per cent flowering had negative effects. Both these characters had positive effects on yield of seeds via number of primary branches. The number of primary branches showed negative effect on seed yield via days to 50 per cent flowering and plant height. Thus, early flowering, reduced plant height and more number of primary branches seem to contribute to seed yield. Investigations by Thangavelu and Rajasekaran (1983) showed that the maximum direct effect on seed yield was through number of capsules. The indirect effects of this character were also considerable. This was followed by number of seeds and oil content, both of which exhibited positive direct effects on seed yield.

Plant height and number of capsules per plant had a positive direct effect and number of branches per plant, a negative effect on seed yield in parents and F_1 hybrids of sesamum, as observed by Reddy et al. (1984). Seed yield was a major component of oil yield. Gupta and Chopra (1984) reported that the number of capsules on branches had the highest positive direct effect on seed yield per plant. The work of Chandramony (1984) revealed that the number of capsules per plant had the highest direct effect on seed yield, followed by plant height, number of primary productive branches and number of productive nodes on main axis. John (1985) observed the maximum direct effect on yield of seeds was exerted by number of capsules per plant during both rabi and summer seasons. But its indirect effects were negligible. This character was followed by height of the plant which had its major effect indirectly via number of capsules per plant. It is suggested that number of capsules and height of the plant are to be given importance during rabi season, and number of capsules and number of branches in the summer season.

Path coefficient analysis by Pathak and Dixit (1986) indicated that days to flowering, plant height, length of the capsule and number of seeds per capsule, in that order, had the highest direct effects on seed yield. It was observed by Bhele et al. (1987) that maximum positive direct effect on yield was through 1000-seed weight. Indirect effects of other characters via this character were considerable. The number of capsules per plant and plant height directly or indirectly influenced all the correlations of yield with its components.

Path analysis of seed oil content of sesamum has been reported by a few workers. Trehan *et al.* (1975) found that the seed oil content in sesamum was the result of two characters, viz. seed length and seed thickness. Seed thickness had the highest positive direct effect on oil content, while 100-seed weight had negative, but low effect on oil content. Its indirect effect through seed length was positive but low and the indirect effect via seed thickness was positive and medium. Taylor *et al.* (1986) reported that the seed oil content of sesamum was most affected by site and season.

2.6. Yield components and physiological characters under moisture stress

Water is the most abundant compound on earth. Even so, the most important single factor crippling crop production the world over is inadequacy of water for growth and development of crop plants. Thus the crop is subjected to moisture stress, to which it responds in various ways. Turner (1979) is of opinion that moisture stress due to lack of rain is called 'drought'. In other words, drought is simply a natural water stress as opposed to an artificially induced water stress.

Crop plants respond to drought in a variety of ways and adapt to it or resist its adverse effects through different mechanisms. Moisture stress does not affect all aspects of plant growth and development equally. Some processes are highly susceptible to increasing moisture stress while others are far less affected. The final yield of the crop will be the integral result of these effects.

The general effect of moisture stress is reduction in growth and yield of the plant. The results of studies by various workers bear ample testimony to this fact. Some of them are cited below:

Deshmukh (1980) reported that moisture stress in sunflower, at any stage of growth reduces the seed yield and oil content, although the degree of damage depends on the stage of the plant growth exposed to stress. In chickpea (*Cicer arietinum*) a higher initial soil profile moisture or additional irrigation significantly influenced the growth and yield contributing characters as observed by Singh and Sharma (1980). Wan and Pan (1984) found that in groundnut, plant growth was seriously inhibited by soil moisture lesser than sixty percentage of field moisture capacity and the inhibition varied with different soil textures - the stickier the texture, the higher the inhibitive effect. Sadasivum *et al.* (1988) found that greengram was highly sensitive to moisture stress during vegetative phase.

On the contrary, Dudde *et al*. (1980) reported that in groundnut, soil moisture had no effect on seed yield. Likewise, in mungbean, Bagga *et al*. (1985) found that the vegetative growth was unaffected by soil moisture levels.

2.6.1. Correlation and path analysis under moisture stress conditions

Srivastava *et al*. (1981) found that in linseed, some of the characters associated with yield under irrigated conditions, are not associated with yield under moisture stress. This points to the need for collecting information on the morphological characters associated with seed yield and oil content under moisture stress conditions. Correlation and path analysis studies carried out under moisture stress conditions are summed up below:

Ali and Naidu (1982) analysed the association of different plant characters with drought-tolerance capacity of genotypes in inbred lines, open pollinated varieties, synthetics, composites and hybrids of maize. There was significant positive correlations between yield under stress and plant height, number of leaves, leaf area, number of ears, length and girth of ears and 1000-kernel weight. Studies by Sen and Misra (1982) in gamma-irradiated wheat grown under rainfed conditions, revealed that grain yield was positively correlated with number of leaves, number of tillers and dry weight of shoot per plant. Amrithadevarathinam (1983) found that moisture stress had a pronounced effect on duration of upland rice. Grain yield was positively and significantly associated with total number of tillers and productive tillers, but it was negatively associated with plant height and duration. Days to first flowering, duration, plant height, total tillers etc. were directly correlated with grains per panicle. Path analysis revealed that total tillers, days to first flowering and grains per panicle had positive direct influence on grain yield, while duration, plant height and grain weight had ■ negative influence.

In huskless barley grown under rainfed condition, ear length, number of ears per plant, days to 75 per cent maturity, number of spikelets per spike and number of grains per spike exerted a direct effect on grain yield at genotypic level, while number of ears per plant and number of grains per spike exerted the same influence at phenotypic level (Singh, 1987). In upland rice, investigations by Gomathinayagam et al. (1988) revealed that grain yield was significantly correlated with duration and plant height. Significant negative correlation existed between grain yield and total tillers. Duration was positively correlated with plant height. A similar relationship existed between plant height and total tillers, length of panicle and grains per panicle. Path analysis showed that plant height contributed the maximum to yield. The other important factors were duration and grains per panicle.

Correlation and path coefficients between nine quantitative characters were worked out by Jatasra and Dahiya (1988) on forage cowpea under rainfed condition. The results indicated that forage yield was significantly and positively correlated with leaf weight, stem weight, plant height and number of primary branches. Leaf weight and stem weight were positively correlated among themselves and also with plant height, leaf length and leaf width. In the same crop grown under similar conditions, Jindal (1989) observed that green fodder yield was positively and highly significantly associated with number of branches, plant height, and number of leaves at both phenotypic and genotypic levels. These were positively and significantly associated among themselves. Based on path analysis it was seen that branches per plant was the major component of fodder yield and leafiness.

2.6.2. Vegetative characters under moisture stress

Vegetative characters are affected by growth under sub-optimal moisture. The general effect of drought on vegetative performance is a reduction in size of the plant or plant part that is developing when the plant is subjected to stress.

2.6.2.1. Days to flowering and maturity

Muchow (1985) in a study on the phenology and seed yield of grain legumes like soybean, greengram, blackgram, cowpea, lablab bean and pigeonpea in a semi-arid tropical environment, observed that water deficits had little effect on the date of flowering. But the time taken to maturity was markedly shortened. In general, early-maturing cultivars yielded better than late maturing ones, under stress.

2.6.2.2. Plant height

It was revealed by Henckel (1964) that drought causes dwarfing effect on plants, mainly due to early cell maturation. Day and Intalap (1970) reported that soil moisture stress at the critical period of growth resulted in shorter plants. In tomato, Kapuya (1972) found a reduction in plant height under sub-optimal moisture. A significant reduction in plant height during stress was reported by Ali and Alam (1973) in greengram. Momem et al. (1979) reported that limited soil moisture influences field crop performance by reducing plant height in soybean.

Gupta *et al*. (1985) found that in safflower, plant height was unaffected till -3 bar soil moisture stress and then declined rapidly. In lowland rice, water stress during early tillering stage for a continuous period of both 10 days and 15 days had no significant effect on plant height, according to Rajaram (1988).

2.6.2.3. Number of branches

Hayashi and Hanada (1985) reported that in safflower, water deficit inhibited elongation of internodes on main stem and strongly inhibited growth of lateral buds at the lower nodes. The decrease in seed yield per plant observed was caused by lesser number of heads per plant, resulting from the decrease in the number of branches. Ram *et al*. (1988) found that water stress imposed at the tillering and booting stages of rice caused a reduction in the number of panicles per plant. In sesamum, Ayyaswamy and Kulandaivelu (1988) observed that the number of primary and secondary branches were increased by lower levels of moisture in the alternate furrows and broad bed systems of irrigation, once in twenty days.

2.6.2.4. Number of leaves per plant

A reduction in the number of leaves per plant was observed by Ali and Alam (1973) in greengram under conditions of water stress. Sivakumar and Shaw (1978) found that soybean plants grown in irrigated plots were superior to those in non-irrigated plots in the average size and number of leaflets per plant. Studies by Turk and Hall (1980) revealed that in cowpea increasing levels of drought resulted in a reduction in the number of leaflets. It was observed by Vidal (1981) that drought resistant varieties of soybean tended to loose more leaves than susceptible varieties when grown under water stress, but showed a small decrease in leaf size. On the contrary, in safflower, Hayashi and Hanada (1985) observed that the number of leaves, bracts and leaves + bracts in the main stem remained unaffected under soil water deficit. But the mean area of leaves was significantly reduced. Turner _et al_. (1986) suggested that the drop in final yield of cotton under water deficit was due to reduced leaf development.

2.6.2.5. Number of capsules per plant

Yield reductions of soybean cultivars susceptible to moisture stress resulted from a significant reduction in the number of pods per plant, according to Sammons _et al_. (1981). In mungbean, Bagga _et al_. (1985) found that the number of pods was adversely affected when the soil moisture was 5 to 7 percentage. Results of studies by Muchow (1985) indicated that in grain legumes including soybean, the reduction in yield under moisture stress came from a decrease in the number of pods. The number of pods per plant was one of the yield components most affected by water stress in soybean, as reported by Neyshabouri and Hatfield (1986). In chickpea, Singh et al. (1987) observed that water stress primarily affected the number of pods per plant. Sadasivum et al. (1988) reported that the effect of stress treatment was significant for the number of pods in greengram. In sesamum, Ayyaswamy and Kulandaivelu (1988) found that the number of capsules present on main stem was increased by lower levels of moisture in the alternate furrows and broad bed systems of irrigation, once in 20 days. It was also seen that the length of the capsule was significantly increased by higher moisture levels.

2.6.2.6. Number of seeds per capsule

In soybean cultivars susceptible to moisture stress, yield reduction occurred due to a significant reduction in the number of seeds produced per plant (Sammons et al., 1981). According to Hochman (1982), water stress in wheat during the periods from tillering to anthesis and booting to grain-filling reduced the number of grains produced. Studies by Hayashi and Hanada (1985) in safflower indicated that the number of seeds and seed dry weight yield per plant were considerably decreased by soil water deficits. Muchow (1985) pointed out that in grain legumes including soybean, reduction in yield under moisture stress was contributed to a little by number of seeds per pod. In soybean, Neyshabouri and Hatfield (1986) found that number of seeds per pod was one of the yield components most affected by water stress. On the other hand, Singh et al. (1987) observed that in chickpea, water stress had little effect on the number of grains per pod.

2.6.3. Seed yield and yield components under moisture stress

Keim and Kronstad (1979) maintained that an ideal cultivar must be one having both high yield under the most severe moisture stress and a strong yield response under more favourable environment.

In soybean plants subjected to moisture stress at flowering stage, considerable reduction in the number of pods was noticed by Singh and Tripathi (1972). Studies by Subramanian et al. (1974) showed that in groundnut moisture stress during pod formation and maturity stage will be at the expense of pod yield. Similarly, in cowpea, pod number and pod and seed weight were lowest with deficient moisture level at the podding stage (Kamara, 1976). Sionit and Kramer (1977) pointed out that stress during early pod formation in soybean caused the greatest reduction in number of pods and seeds at harvest. But yield as measured by weight of seeds was reduced most by stress during early pod formation and pod filling.

In *Brassica napus*, Richards and Thurling (1978b) found that moisture stress caused a significant reduction in yield components like pods per plant, pods per main branch and seeds per pod. In rainfed soybean, a reduction in number of seeds per pod and seed size, as compared to irrigated plants, was noticed by Constable and Hearn (1978). Momem *et al*. (1979) communicated that soybean cultivars were highly flexible with regard to yield components under moisture stress.

It was suggested by Sammons *et al*. (1980) that a breeder interested in developing a high yielding soybean cultivar tolerant to moisture stress, should select for vigorous growth potential and yielding ability under a moisture stress environment.

Vidal (1981) found that resistant varieties of soybean had fewer pods, while maintaining the number of seeds per pod and 1000-seed weight. Hochman (1982) observed that in wheat, the reduction of grain yield varied with the growth phase exposed to moisture stress. Stress from tillering to anthesis reduced the grain yield by 28 per cent, stress from booting to grain filling by 36 per cent and stress during grain filling by 16 per cent below normal.

Kavitha (1982) reported that in blackgram, the yield components number of fruiting branches per plant, number of pods per plant and 100-seed weight were adversely affected by moisture stress condition. It was observed by Neyshàbouri (1983) that in soybean, pod drop and reduced seed weight were responsible for a reduced yield under moisture stress. In sunflower, a reduced seed yield was seen under moisture stress, by Fereres et al. (1986). Planchon et al. (1986) observed that in soybean, water stress during late growth phase caused poor seed filling and reduced seed weight, whereas early stress reduced yield due to increased seed abortion. Studies by Rao et al. (1986) in groundnut revealed that moisture stress at flowering decreased the total number of pods per square metre. It was reported by Singh et al. (1987) that when irrigation was withheld in chickpea during the flowering stage, grain yield was reduced by 33 per cent due to a decrease in the number of pods set. Eck et al. (1987)

found that stress initiated during early flowering or full bloom stage and extending to the beginning of pod development in soybean reduced seed yields by 9 to 13 per cent. Similarly, a significant reduction in pod yield per plant of greengram was observed under moisture stress by Sadasivum *et al*. (1988). Similar results were obtained by Ram *et al*. (1988) in rice also.

2.6.4. Physiological attributes under moisture stress

Blum (1982) pointed out that when selection takes place under moisture stress, the heritability for yield, already low, falls further and thus selection for yield alone under these conditions becomes inefficient. It was also indicated by Blum (1983) that unidentified drought adaptive alleles existed in relatively high frequency in common breeding populations. The author proposes a judicious incorporation of some physiological work within the framework of a normal breeding programme for crop improvement under moisture stress. If so, the potential exists for simultaneous, but indirect selection for these drought adaptive mechanisms within already productive and well adapted materials.

Moisture stress influences physiological traits like leaf area index, drymatter production, root-shoot ratio and proline accumulation in crop plants. Some of the works carried out in these lines are presented below:

2.6.4.1. Leaf Area Index

Kramer (1959) suggested that a small leaf area was characteristic of reduced drought injury in crop plants. Lower leaf water potential considerably inhibited leaf enlargement in corn, soybean and sunflower, according to Boyer (1970). Eckardt *et al*. (1971) observed that sunflower reacted to moisture stress by restricting leaf area development. When Singh and Tripathi (1972) subjected soybean plants to moisture stress at flowering stage, considerable reduction in leaf area was noticed. In sunflower, the photosynthetic area was reduced when subjected to moisture stress at six different stages of plant ontogeny, as reported by Lovett and Campbell (1973).

According to Hsiao (1973), sensitivity of drymatter yield to moisture stress should be greater in a growing crop with a low leaf area index, than in a crop with high leaf area index. In upland cotton, Bhardwaj *et al*. (1975) found that high seed cotton yield was found related to medium leaf area. Studies by Sivakumar and Shaw (1978) indicated that the rate of leaf area expansion per plant over a period of time had a close correspondence with soil water potential, in soybean. It was reported by Momem *et al*. (1979) that limited soil moisture influences field crop performance of soybean by reducing the size of assimilating leaf area.

Ali (1980) proposed that a cowpea genotype suited to rainfed conditions should show a lesser reduction in leaf area index and thus be able to produce high drymatter. In soybean, leaf area index was affected most rapidly by water stress according to Vidal *et al*. (1981). Hochman (1982) observed that in wheat, moisture stress from tillering to anthesis reduced leaf area index. In cowpea, soybean, groundnut and mungbean, Pandey *et al*. (1984) found that increasing soil moisture stress caused progressively lesser leaf area and shoot drymatter and found that these crops differed in their ability to maintain leaf area index under higher levels of water stress.

It was seen by Gupta *et al*. (1985) that green leaf area remained almost unaffected upto -3 bars soil moisture stress and then declined rapidly. Bamber and Jager (1986) are of opinion that cultivars of sugarcane which could adjust their leaf area more rapidly under water stress appeared to be better adapted to it. Hoogenboom *et al*. (1987) suggested reduction in functional leaf area as an adaptation mechanism to drought tolerance in soybean. In Sappo spring wheat, Talukder (1987) reported that drought in the early stages decreased the green leaf area index. Late drought also resulted in the reduction of this character during grain formation period.

2.6.4.2. Drymatter production

In upland cotton, high seed cotton yield was found related to a medium amount of drymatter by Bhardwaj et al. (1975). In pearl millet, Ibrahim et al. (1985) found that the dry weights were significantly reduced by water stress. The total drymatter seemed to decrease when early stages of Sappo spring wheat were exposed to drought, as reported by Talukder (1987). In greengram, Sadasivum et al. (1988) found that moisture stress treatment significantly affected leaf and stem drymatter and total drymatter production per plant.

2.6.4.3. Root-shoot ratio

A high root to shoot ratio was an effective means of adaptation of plants to moisture stress conditions and under such conditions, the growth rate of the roots considerably exceeded that of the shoot (Killian and Lemee, 1956). When sunflower plants were subjected to moisture stress at six different stages of plant ontogeny, the root-shoot ratio was reduced, as observed by Lovett and Campbell (1973). In a study of the response of two species of rape seed to water stress, Richards and Thurling (1978a) observed a smaller root weight relative to the above ground plant weight and a greater tap root weight relative to lateral root weight associated with higher yield in both the species.

Pandey et al. (1984) observed reduction in shoot weights to the tune of 78 per cent in mungbean, 52 per cent in soybean, 60 per cent in cowpea and 37 per cent in groundnut under drought conditions. Chang and Wang (1985) observed that significant differences existed between varieties of soybean under drought stress in root dry weight, shoot dry weight and root-shoot ratio. It was reported by Gupta et al. (1985) that increase in soil moisture stress caused more depression of safflower root growth than shoot growth, as indicated by a linear increase in shoot-root ratio. The relative dry weights of shoots and roots decreased rapidly with increasing moisture stress.

Murty (1987) proposed that a well ramified deep root system with greater root-shoot ratio to tap moisture from the deeper zones is important for drought tolerance. Sheoran and Khan (1987), in a study of drought tolerance in Indian mustard found that under moisture stress, a better radicle growth would help in the early establishment of seedling by absorbing moisture from the deeper layers of soil and a better hypocotyl length would result in early emergence of seedling from the soil, thus providing a better scope for germination and seedling survival. Arjunan et al. (1988) attributed the drought tolerance characters of groundnut cultivars VG-77, JL-24 and CO-2 to their higher root-shoot ratios, which in turn contributed to higher pod yields under moisture stress conditions. Venkataramana and Naidu (1989) observed a low shoot-root ratio in water stressed sugarcane plants which suggested a higher root growth than shoot growth. It was also seen that shoot-root ratio had a positive association with growth and yield.

Chaudhary et al. (1989) reported that seed yield was not significantly associated with any of the physiological characters studied or with indices of moisture stress in chickpea.

2.6.4.4. Proline accumulation

A major effect of water stress on plant metabolism involves an inhibition of protein synthesis and the modification of amino acid metabolism leading to a rapid and extensive accumulation of proline (Barnett and Naylor, 1966). Parker (1968) pointed out that in water stressed plants, proline accumulation may not be related to a protective mechanism, but may result from some protein breakdown or it may simply be a storage compound for nitrogen. Singh et al. (1972) stated that the potential for proline accumulation appeared to vary directly with the ability of the genotype to yield under drought conditions. It was also suggested by Singh et al. (1973) that proline content may be linked in an indirect manner to tissue survival during and after stress. According to Palfi et al. (1974), a species can be regarded as 'proline accumulating' if the amount of free proline in the leaves at the time of strong water deficit reached at least 1 per cent of the dry weight. Aspinall and Paleg (1981) found that substantial quantities of the amino acid proline accumulated in many plants in response to water deficiency.

Proline content increased in water stressed plants. Therefore proline accumulation potential was suggested to be an index of drought tolerance in plants by Singh et al. (1972), Waldren et al. (1974) and Hurd (1976) among others. On the other hand, Hanson et al. (1977) contradicted the above suggestion by observing that proline accumulation potential cannot be an index of drought tolerance in plants.

Kaufmann (1972) recorded an increase in proline in oranges associated with low water potential. Waldren *et al*. (1974) found that in soybean, accumulation of free proline was not significant until the plants were suffering severe moisture stress and were wilting visibly. Blum and Ebercon (1976) recorded a high proline accumulation in water stressed sorghums, which was reduced on re-watering. They suggested that proline may act as a source of respiratory energy in the recovering plant. Stewart (1977) is of opinion that increased concentration of free proline in water stressed tissues occurred due to lower rates of proline oxidation under conditions of water deficit. It was reported by Fukutoku and Yamada (1981) that in soybean, proline accumulated only under severe water stress and attained 0.86 per cent of the dry weight. In castor, Khvostova (1981) found that moisture deficit increased the proline content. Bhale *et al*. (1982) observed that proline accumulated due to stress at both panicle initiation and panicle emergence stages of sorghum. Also, the magnitude of heterosis for proline accumulation decreased after water stress. Free proline contents increased with increasing water stress in all the three genotypes of rice studied by Goyal *et al*. (1985). But the increase was more marked in drought tolerant genotype N-22 as compared to susceptible Jaya. In N-22, more than eight-fold increase was seen whereas in Jaya, the increase was only three-fold. On re-watering there was a conspicuous fall in free proline. Similar results were communicated by Ram et al. (1988) in the same crop.

Mekhri et al. (1977) saw a positive correlation between the magnitude of free proline accumulation and drought tolerance in groundnut. Deshmukh and Srivastava (1982) reported that correlation coefficient between proline content and percentage reduction in seed weight of sunflower was found to be positive. Therefore the genotype which accumulated more proline content had higher reduction in yield under moisture stress. Chandra and Chauhan (1983) observed that in pearl millet hybrids excluding synthetic lines a significant negative correlation existed between free proline accumulation and yield level at a given salinity level. Free proline in leaf was not related to salinity resistance. Studies on proline accumulation in leaves of potato by Bansal and Nagarajan (1986) revealed that proline accumulation in leaves showed a significant negative correlation with tuber weight and tuber number in water stressed plants.

2.7. Influence of weather parameters on yield and yield components

Kunju and Salam (1980) reported that sesamum seeds registered no germination at zero and ten percentage soil moisture levels. Maximum germination of 97.5 per cent was recorded at 30 per cent moisture level, followed by 20 per cent at which germination was 95.0 per cent. When soil moisture was increased from 30 to 40 per cent the germination percentage dropped to 32.5. Singh *et al.* (1981) observed that in winter sown maize irrigation at 70 per cent available soil moisture measured at 0 to 30 cm soil profile in the vegetative phase and 70 or 50 per cent available soil moisture in reproductive phase resulted in the maximum yield. It was revealed by Singh and Yusuf (1981) that the oil content of safflower (*Carthamus tinctorius* Linn.) had a quadratic relationship with moisture supply. Patel and Mistry (1981) found that the relationship between the percentage moisture available days during the growth period and the reported yield, in groundnut, was fairly linear. Yield of pods was highly dependent on the number of moisture available days at all the locations tried. Inadequate soil moisture caused an average reduction in yield to the tune of 58.09 per cent for the bunch types and 60.48 per cent for the spreading types. Studies by Daulay and Singh (1982) revealed that in rainfed sesamum, plant density had no effect on seed yield under high rainfall. But when rainfall was low, seed yield increased significantly as plant densities reduced.

The decline in seed yield of sunflower was associated with a reduced mean temperature regime during the vegetative stages of growth (Anderson et al., 1978). Shastry and Kumar (1981) found that the weather prevailing during the growth phases of Indian mustard had a considerable influence on seed yield. The maximum temperature during the vegetative growth phase had positive correlation with seed yield and with the percentage of oil. At the same time, the maximum temperature prevalent during the vegetative phase had negative correlation with the duration of vegetative phase. Studies by Shipler and Blum (1986) indicated that hot day temperature affected yield components of wheat like number of grains per spikelet the most and number of spikes per plant the least. High temperature reduced grain weight via reduced grain growth duration. Variation for number of spikes per plant had the greatest effect on yield variation among the cultivars in winter. In summer, variation for number of grains per spikelet and spikelets per spike were the most important.

In rainfed sorghum, Subramanian et al. (1988) observed that grain yield, grain number and harvest index had positive correlations with rainfall, relative humidity and cumulative total of daily mean air temperature. Association of grain yield was stronger with temperature than rainfall. Rainfall, cumulative total of daily mean temperature and average relative humidity could predict grain yield and its components with very high coefficient of determination. Total rainfall had a positive association with number of grains, but a negative association with 1000-grain weight. Cumulative total of daily mean temperature had positive association with grain yield and its components.

MATERIALS AND METHODS

MATERIALS AND METHODS

The study was undertaken at the College of Agriculture, Vellayani, during the rabi season of 1989. The crop was raised as a purely rainfed crop, with irrigation given only once, just after sowing.

3.1. Materials

Twenty five Sesamum varieties showing a wide range of variability in morphological characters, were used in this study. The varieties used were CO-1, ACV-2, RT-73, NPG-3, No. 42, VT-43, Kayamkulam-1, IS-614, Vayalellu, BS-5-18-6-G, S-16, TSS-6, C-6, IS-164, TNAU-12, RAUSS-17-4, VS-80, C-7, TNAU-11, ACV-1, Vinayak, Kayamkulam-2, B-14, TNAU-10 and TMV-3. Four of the above varieties namely, Kayamkulam-1, Kayamkulam-2, ACV-1 and ACV-2 were collected from the Department of Plant Breeding, College of Agriculture, Vellayani. The remaining twenty one varieties were obtained from the Sesamum germplasm maintained at Rice Research Station, Kayamkulam.

3.2. Methods

The present study was initiated with the objective of evaluation of the Sesamum genotypes to identify superior ones possessing high oil yield and to assess the relationship between yield and other characters through correlation and path analysis under rainfed conditions in rabi uplands.

The twenty five varieties of Sesamum were allotted treatment numbers randomly using lots and laid out following a randomised block design with three replications. Each variety was grown in plots of size 3 x 2 m with a spacing of 25 x 10 cm. The cultural and manurial practices were followed as per the Package of Practices Recommendations (1986) of KAU.

Observations were recorded on 13 plant characters and meteorological parameters. For recording the observations, twenty five plants were selected at random from each plot.

1. Days to first flowering

The number of days taken for the first flower to appear was recorded as the days to first flowering.

2. Height of the plant

The height of the main shoot from the ground level to the tip was measured, at maturity, before harvest and recorded in centimetres.

3. Number of primary branches

The number of branches on the main stem was counted and recorded as the number of primary branches.

4. Number of capsules per plant

The total number of capsules present on the main stem and branches after discarding the malformed and under developed ones, was counted and recorded.

5. Size of the capsule

The length of the capsule and the breadth of the capsule at the broadest part were measured using a thread and scale and recorded in centimetres.

6. Number of seeds per capsule

The number of seeds present inside a well-formed capsule was counted and recorded as the number of seeds per capsule.

7. Number of leaves per plant

The total number of leaves borne on the main stem and branches was counted after discarding the malformed ones. This was recorded as the number of leaves per plant.

8. Leaf Area Index

The total area occupied by all the leaves of a plant was measured, in square centimetres, using LI.3100

Leaf Area Meter. From this, the leaf area index was calculated using the relationship,

$$\text{Leaf Area Index} = \frac{\text{Leaf area}}{\text{Spacing of the crop}}$$

9. Seed yield

The total quantity of seed obtained from the plants in a plot was weighed and recorded as the seed yield in grams.

10. Oil content of seeds

The seed oil content of the twenty five varieties from the three replications, was estimated by the cold percolation method following Kartha and Sethi (1957) and recorded as percentage.

11. Drymatter production

Whole plants were oven dried at 60°C for 24 hours and weighed. The observations were recorded as the dry weight of the plants and expressed in grams.

12. Root-shoot ratio

The above-ground portion and the below-ground portion of the oven dried plants were separated and weighed. The observations were recorded separately as shoot weight and root weight. The root-shoot ratio was computed from this, in the following manner:

$$\text{Root shoot ratio} = \frac{\text{Dry weight of root}}{\text{Dry weight of shoot}}$$

13. Proline content

The proline content of finely powdered dried leaves was estimated in the 25 varieties in this study, as per the procedure outlined by Bates et al. (1973).

Acid ninhydrin was prepared by warming 1.25 g of ninhydrin in 30 ml glacial acetic acid and 20 ml 6 M phosphoric acid, with agitation until fully dissolved. The resulting acid ninhydrin was stored at 4°C for a maximum period of 24 hours.

Approximately 0.5 g of the leaf material was homogenized in 10 ml of 3 per cent aqueous sulfosalicylic acid and the homogenate filtered through Whatman No. 2 filter paper. 2 ml of the filtrate was reacted with 2 ml acid ninhydrin and 2 ml glacial acetic acid in a test tube for 1 hour at 100°C and the reaction was terminated in an ice-bath. The reaction mixture was extracted with 4 ml toluene and mixed vigorously with a test tube stirrer for 15 to 20 seconds. The chromophore containing toluene was aspirated from the aqueous phase, warmed to room temperature and the absorbance was read at 520 nm, using toluene for a blank.

The proline concentration was estimated from a standard curve and calculated as follows:

$\left[(\mu g \text{ proline/ml x ml toluene})/115.5 \mu g/\mu \text{ mole}\right] / \left[(\text{g sample})/5\right] = \mu$ moles of proline/g of material.

Each sample was subjected to analysis for a minimum of 3 times until agreement of consecutive values was obtained.

14. Soil moisture percentage

The moisture content of soil from each plot was analysed at weekly intervals starting from 7 days after sowing and expressed as percentage. The soil moisture content was estimated following Hesse (1971), as follows:

Approximately 5 g of soil were taken in a soil moisture tin and accurately weighed. It was then dried in an electric oven at a temperature of 105 to 110°C for 8 hours. After cooling in a dessicator, the loss in weight was determined. The soil moisture percentage was computed using the relationship.

$$\text{Soil moisture percentage} = \frac{(X_1 - X_2)}{X_1} \times 100$$

where X_1 = Weight of soil and tin before drying

X_2 = Weight of soil and tin after drying

15. Weather parameters

The weather condition prevalent during the cropping period was recorded from the Meteorological Observatory, College of Agriculture, Vellayani. The weather parameters recorded were maximum and minimum atmospheric temperature expressed in degree celsius, rainfall received expressed in millimetres, relative humidity of the atmosphere expressed as percentage and duration of sunshine from 6 AM to 6 PM expressed in hours.

3.2.1. Statistical Techniques

3.2.1.1. Analysis of variance and covariance

The analysis of variance and covariance were done with the following objectives:

1. to test whether there is any significant difference between the varieties with respect to the various traits,
2. to estimate the components of variance and
3. to estimate the correlation coefficients (Singh and Choudhary, 1979).

The extent of phenotypic variation for any character is the sum of the genotypic and environmental variations and can be determined by the methods proposed by Kempthorne (1957).

$$V(P) = V(G) + V(E) + 2\,COV(G, E)$$

where $V(P) = \sigma p^2(x)$ = variance due to phenotype

$V(G) = \sigma g^2(x)$ = variance due to genotype

$V(E) = \sigma e^2(x)$ = variance due to environment

$COV(G,E)$ = Covariance between genotype and environment

If the genotype and environment are independent, COV (G, E) is equal to zero, so that

$$V(P) = V(G) + V(E)$$

$$\sigma p^2(x) = \sigma g^2(x) + \sigma e^2(x)$$

If there are observations on two characters x and y on each individual, the extent of covariance between x and y due to the genotype and environment can be estimated as suggested by Kempthorne (1957) in the following way:

$$COV(x, y) = COV(G(x, y)) + COV(E(x, y))$$

or $\sigma p(x, y) = \sigma g(x, y) + \sigma e(x, y)$

where $\sigma p(x, y)$ = phenotypic covariance between x and y

$\sigma g(x, y)$ = genotypic covariance between x and y

$\sigma e(x, y)$ = environmental covariance between x and y

If the experiment is designed in a randomised complete block design with 'v' treatments and 'r' replications, the estimates of $\sigma p^2(x)$, $\sigma p^2(y)$, $\sigma g^2(x)$, $\sigma g^2(y)$, $\sigma e^2(x)$, $\sigma e^2(y)$, $\sigma p(x, y)$, $\sigma g(x, y)$

and σe (x, y) are obtained from the analysis of variance and covariance.

Variation in crop stand was noticed in a few plots due to erratic germination. Hence the population count in each plot was taken and the total yield from each plot was statistically adjusted by analysis of covariance, with plant population as the co-variate.

3.2.1.2. Heritability

Heritability in the broad sense is the fraction of the total variance which is heritable and was estimated as a percentage following Jain (1982) as

$$H^2 = \frac{\sigma g^2}{\sigma p^2} \times 100$$

where H^2 = Heritability in the broad sense

σg^2 = Genotypic variance

σp^2 = Phenotypic variance

Heritability provides a measure of the genetic variance, ie. the variance upon which all the possibilities of changing the genetic composition of the population through selection depends.

3.2.1.3. Genetic advance under selection

Genetic advance is a measure of the change in the mean phenotypic level of the population produced by the selection and depends upon heritability of the character and selection differential.

$$g.a = \frac{K\ H^2\ \sigma p}{\bar{x}}$$

where g.a is the genetic advance, H^2 is the heritability, $\bar{x}$ is the mean of the character x and k is the selection differential, which is 2.06 at 5 per cent intensity of selection in large samples (Allard, 1960).

3.2.1.4. Correlation coefficients

The phenotypic correlation coefficient between x and y was estimated as:

$$r_p\ (x, y) = \frac{\sigma p\ (x, y)}{\sigma p\ (x)\ \ \sigma p\ (y)}$$

where σp (x, y) = phenotypic covariance between x and y

σp (x) = standard deviation of the character x

σp (y) = standard deviation of the character y

The genotypic correlation coefficient between x and y was estimated as

$$r_g(x, y) = \frac{\sigma g(x, y)}{\sigma g(x) \; \sigma g(y)}$$

where $\sigma g(x, y)$ = genotypic covariance between x and y

$\sigma g(x)$ = standard deviation of the character x

$\sigma g(y)$ = standard deviation of the character y

The environmental correlation coefficient between x and y was estimated as

$$r_e(x, y) = \frac{\sigma e(x, y)}{\sigma e(x) \; \sigma e(y)}$$

where $\sigma e(x, y)$ = environmental covariance between x and y

$\sigma e(x)$ = standard deviation of the character x

$\sigma e(y)$ = standard deviation of the character y

Critical values of 'r' corresponding to 73 degrees of freedom at both 5 per cent and 1 per cent levels of significance were used for the test of significance for phenotypic as well as environmental correlation coefficients (Fisher and Yates, 1957).

Since techniques are not available for testing the significance of the genotypic correlation coefficients, the standard error for each correlation coefficient was estimated, following Narain et al. (1979).

Standard error of genotypic correlation coefficient r_g is

$$SE(r_g) = \sqrt{V(r_g)}$$

where $V(r_g)$ is the variance of genotypic correlation coefficient r_g, which was estimated as:

$$V(r_g) = \frac{1}{(f+1)} \left[\frac{1}{2}(1-r_g^2)^2 - \frac{1}{2}(1-r_g^2) \left\{ \frac{1}{D} - \frac{r_p\, r_g}{C} \right\} + 4 \left\{ \frac{r_g}{D} - \frac{r_p}{C} \right\}^2 + \frac{2(1-r_g^2)^2 (1-r_p^2)}{C^2} \right]$$

where f+1 = error degrees of freedom

r_g = genotypic correlation coefficient

r_p = phenotypic correlation coefficient

$$\frac{1}{D} = \frac{1}{2}\left[\frac{1}{h_x^2} + \frac{1}{h_y^2}\right] \text{ and}$$

$$C = \sqrt{h_x^2\, h_y^2}$$

where h_x^2 = heritability of the character 'x'

h_y^2 = heritability of the character 'y)

3.2.1.5. Path analysis

The method of path analysis developed by Wright (1921) to study the cause and effect relationship among a system of variables helps to measure the direct influence along each separate path in such a system and to find the degree to which the variation of a given effect is determined by each particular cause.

Path analysis at the genotypic level was carried out using the characters plant height at maturity, number of capsules per plant, length of the capsule, breadth of the capsule, root-shoot ratio, number of seeds per capsule, days to first flowering and oil content of seeds as causes with seed yield as the effect and plant height at maturity, number of primary branches, number of leaves per plant, number of capsules per plant, number of seeds per capsule and seed yield as causes with oil content of seeds as the effect.

The genotypic correlation coefficients of the above component characters with seed yield or oil content of seeds respectively were partitioned into direct and indirect effects as per the methodology of Dewey and Lu (1959).

The simultaneous equations which give solutions for path coefficients are:

$$r_{iy} = r_{i1}\, p_{1y} + r_{i2}\, p_{2y} + \cdots\cdots + p_{iy} + \cdots\cdots + r_{ik}\, p_{ky}$$

where $i = 1.2, \ldots\ldots k$

r_{iy} is the genotypic correlation of the ith independent variable (x_i) with dependent variable (y). P_{iy} is the direct effect of x_i on y and $r_{ik}\, p_{ky}$ is the indirect effect of x_i via x_k on y.

3.2.1.6. Selection Indices

Fisher (1936) proposed a discriminant function in order to discriminate the individuals belonging to two different populations showing some degree of overlapping. The discriminant function Z is defined as:

$$Z = b_1x_1 + b_2x_2 + ---- + b_nx_n.$$

where $x_1, x_2,$ ----- x_n are the variables measured and $b_1, b_2,$ ----- b_n are the weighing coefficients. The b_i values are estimated such that based on Z values, the ratio of variance between populations to that of within the populations would be maximized. The maximization of this ratio leads to a set of simultaneous equations which after solution provides the desired b_i values.

Application of discriminant function as a basis for making selection on several characters simultaneously is aimed at discriminating the desirable genotypes from the undesirable ones on the basis of their phenotypic performance. Smith (1936) defined the genetic worth (H) of an individual as:

$$H = a_1G_1 + a_2G_2 + ---- + a_nG_n$$

where $G_1, G_2,$ ---- G_n are the genotypic values of individual characters and $a_1, a_2,$ ---- a_n signify their relative economic importance. Another function (I) based on the phenotypic performance of various characters is defined as:

$$I = b_1 p_1 + b_2 p_2 + ---- + b_n p_n$$

where b_1, b_2, ---- b_n are to be estimated such that the correlation between H and I, ie. r (H, I) becomes maximum. Once such function is obtained, discrimination of good genotypes from the undesirable ones will be possible on the basis of phenotypic performance, ie, 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 estimate of b_i values.

The mathematical description of the function (I) is known as selection index:

$$I = b1 p_1 + b_2 p_2 + ---- + b_n p_n$$

Using this function, the selection criterion or the index value for each individual may be determined.

Finally on the basis of these selection criteria, the individuals are arranged in the order of merit and then the best 5 per cent or 10 per cent may be selected for further breeding programmes.

3.2.1.7. Expected genetic gain

The expected genetic gain through selection may be predicted by the following formula:

$$\Delta G = (Z/v) \sum \sum a_i b_j \, G_{ij} / (\sum \sum b_i \, b_j P_{ij})^{1/2}$$

where Z/v is the standardised selection differential (s), indicating the intensity of selection (i).

a_i = economic weightage

b_j = regression coefficients

G_{ij} = genotypic variance - covariance matrix

P_{ij} = phenotypic variance - covariance matrix

(Singh and Chaudhary, 1976)

RESULTS

RESULTS

4.1. Varietal effect on biometric characters

The mean varietal response to different biometric characters is presented in Table 4.1. Significant differences existed among varieties with respect to the six characters studied, viz. plant height, number of primary branches, number of leaves, number of capsules per plant, number of seeds per capsule and oil content of seeds. The mean performance of varieties was considered in all the cases.

The variety TNAU-12 had the maximum plant height (155.21 cm), followed by B-14 (150.61 cm). TNAU-12 was on par with B-14, TNAU-10, RAUSS-17-4, ACV-1 and Kayamkulam-2. The plant height at maturity was minimum for Vayalellu (102.92 cm), which was on par with VS-80, Vinayak, No. 42, RT-73, Co-1, BS-5-18-6-G and VT-43.

The number of primary branches varied from 3.87 for the variety TNAU-11 to 2.08 for the variety RT-73. The varieties TSS-6, B-14, VS-80, Vinayak, Kayamkulam-2 and RAUSS-17-4 were on par with TNAU-11 while the varieties S-16, VT-43, IS-614, Vayalellu, Co-1 and ACV-2 were on par with RT-73.

Table 4.1. Varietal response on various biometric characters

Variety	Plant height (cms)	No. of primary branches	No.of leaves	No. of Capsules	Capsule length (cms)	Capsule breadth (cms)	Leaf area index	Root-Shoot Ratio	No. of seeds per capsule	Days to flowering	Seed Yield (gm)	Oil Content (%)
Co - 1	117.55	2.56	42.84	45.95	3.00	2.22	2.16	4.397	62.00	30.67	129.75	32.87
ACV-2	127.52	2.37	31.53	30.48	3.05	2.38	2.47	0.171	93.33	31.33	216.82	47.51
RT-73	119.75	2.08	38.52	45.04	2.93	2.41	2.43	0.115	66.67	32.00	136.60	49.46
NPG-3	128.48	2.99	38.48	40.47	2.88	2.33	2.50	0.148	73.67	33.00	102.03	48.12
No.42	122.68	3.00	40.28	56.93	2.87	2.35	2.36	0.118	52.67	28.33	91.15	41.95
VT-43	115.45	2.64	51.09	56.49	3.02	2.22	2.19	0.109	58.00	27.67	33.32	51.88
Kayamkulam-1	125.20	3.12	43.20	45.32	2.79	2.23	2.11	0.158	69.67	28.00	95.40	45.29
IS-614	130.76	2.63	45.17	55.55	2.75	2.27	2.42	0.139	50.67	29.67	98.18	42.08
Vayalellu	102.92	2.59	32.87	30.13	2.70	2.33	2.49	0.126	64.67	32.33	83.69	51.79
BS-5-18-6-G	116.55	2.81	44.93	52.95	2.47	2.25	2.33	0.145	52.33	29.00	139.99	47.17
S-16	133.81	2.72	38.92	47.31	2.87	2.40	2.40	9.707	60.00	30.67	81.35	38.86
TSS-6	134.75	3.73	39.47	48.32	2.97	2.26	2.26	0.116	61.67	29.67	193.45	56.25
C-6	127.88	2.87	36.63	48.48	2.86	2.51	2.34	0.153	61.33	30.33	110.31	56.96
IS-164	126.67	2.88	43.17	52.19	2.79	2.32	2.32	0.131	62.00	28.33	130.16	51.76
TNAU-12	155.21	3.03	46.35	53.67	2.81	2.05	2.21	0.132	69.33	32.00	122.78	54.88
RAUSS-17-4	137.17	3.23	43.05	50.45	2.78	2.47	2.46	0.125	58.00	29.67	168.47	35.71
VS-80	122.85	3.55	46.88	54.92	2.75	2.46	2.44	0.149	56.67	33.33	89.15	41.58
C-7	125.79	2.76	42.72	51.85	2.75	2.40	2.32	0.126	54.67	29.67	181.53	43.34
TNAU-11	125.37	3.87	45.35	54.16	3.02	2.89	2.37	0.136	64.33	27.67	184.65	51.49
ACV-1	135.24	3.04	45.40	52.49	2.84	2.42	2.54	0.143	58.00	32.67	201.70	51.93
Vinayak	122.79	3.36	47.92	55.15	2.80	2.39	2.56	0.115	72.00	32.00	152.33	48.43
Kayamkulam-2	134.85	3.36	44.44	53.40	2.93	2.50	2.25	0.132	64.33	30.67	104.88	53.90
B-14	150.61	3.67	48.81	56.17	2.78	2.55	2.31	0.146	63.33	30.00	77.97	41.11
TNAU-10	148.32	2.95	54.96	62.52	2.68	2.41	2.38	0.126	72.66	33.33	149.67	53.47
TMV-3	125.65	3.13	47.93	55.72	2.73	2.35	2.36	0.146	65.33	32.00	143.57	53.97
F	2.54**	3.58**	4.93**	5.18**	1.13	1.38	<1	1.01	9.35**	1.24	1.03	48.23**
CD	20.39	0.65	6.86	9.56					8.24			2.67

** *Significant at 1% level*

TNAU-10 had the maximum number of leaves (54.96) and was on par with VT-43 and B-14. The number of leaves was least in the case of ACV-2 (31.52) which was on par with C-6 and Vayalellu.

For the character, the number of capsules per plant, a maximum value of 62.52 was exhibited by TNAU-10. This was on par with No. 42, VT-43, B-14, TMV-3, IS-614, Vinayak, VS-80, TNAU-11, TNAU-12 and Kayamkulam-2. At the same time, the minimum value was shown by Vayalellu (30.13), which was on par with ACV-2.

The number of seeds per capsule was highest for ACV-2 (93.33), followed by NPG-3, while IS-614 had the lowest value (50.07). ACV-2 differed significantly from NPG-3 with respect to this character. NPG-3 was on par with TNAU-10, Vinayak, Kayamkulam-1, TNAU-12 and RT-73 and IS-614 with ACV-1, RAUSS-17-4, VT-43, VS-80, C-7, No. 42 and BS-5-18-6-G.

The variety C-6 had the maximum seed oil percentage of 56.96 per cent among the 25 varieties included in this study, followed by TSS-6 with 56.25 per cent. C-6 was on par with TSS-6 and TNAU-12. The variety Co-1 had the minimum seed oil percentage of 32.87 per cent.

4.2. Variability

The magnitude of phenotypic, genotypic and environmental components of variation observed on various biometric characters of *Sesamum* are presented in Table 4.2.

The characters length of the capsule, root-shoot ratio, days to first flowering and seed yield were seen to be more influenced by the environment rather than the genotype. The variations in number of leaves, number of capsules per plant, number of seeds per capsule and oil content of seeds were influenced by genotypic differences, among which oil content of seeds was most influenced by genotype.

4.3. Heritability

The heritability of the different characters, brought under the purview of this study, and their estimates are presented in Table 4.2.

Oil content of seeds was found to be the most heritable character with an estimate of 94 per cent. High heritability was also exhibited by the number of seeds per capsule (74 per cent). Moderate heritability was noticed in the case of characters like number of capsules per plant (58 per cent), number of leaves per plant (57 per cent), number of primary branches (46 per cent) and

Table 4.2 Estimates of Genetic Parameters

Sl No.	Character	σp^2	σg^2	σe^2	H^2	g.a. (5%)
1.	Plant Height	233.420	79.040	154.380	0.339	10.657
2.	No. of Primary Branches	0.290	0.134	0.156	0.462	0.512
3.	No. of Leaves	40.390	22.900	17.490	0.567	7.423
4.	No. of Capsules	81.180	47.240	33.940	0.582	10.801
5.	Capsule Length	0.046	0.002	0.044	0.112	0.041
6.	Capsule Breadth	0.031	0.004	0.028	0.112	0.041
7.	Root-Shoot Ratio	2.163	0.009	2.154	0.004	0.013
8.	Seeds/Capsule	95.340	70.140	25.200	0.736	14.797
9.	Days to flowering	8.382	0.624	7.758	0.075	0.444
10.	Seed Yield	5998.650	50.980	5947.670	0.009	1.356
11.	Oil Content	44.300	41.650	2.650	0.940	12.891

plant height at maturity (34 per cent). The characters length of the capsule, breadth of the capsule, root-shoot ratio, days to first flowering and seed yield were found to be less heritable, indicating that these characters are more controlled by the environment. The heritability percentage for nine characters studied are presented in Fig. 1.

4.4. Genetic Advance

The genetic advance of different characters under selection was estimated and presented in Table 4.2.

When 5 per cent selection of individuals are made, the predicted genetic advance was 14.80 for number of seeds per capsule, 12.89 for oil percentage of seeds, 10.80 for number of capsules per plant, 10.66 for plant height at maturity and 7.42 for number of leaves per plant. For these characters, heritability was either high or moderate. In the case of characters length of the capsule, breadth of the capsule, root-shoot ratio, days to first flowering and seed yield, which were having low heritabilities, the genetic advance was very low or negligible.

4.5. Correlation Coefficients

The phenotypic, genotypic and environmental correlations were estimated for all the characters and are presented in Tables 4.3, 4.4 and 4.5 respectively.

Fig. 1. Heritability for nine characters in *Sesamum*

X_1 - Plant height at maturity

X_2 - Number of primary branches

X_3 - Number of leaves per plant

X_4 - Number of capsules per plant

X_5 - Length of the capsule

X_6 - Breadth of the capsule

X_7 - Number of seeds per capsule

X_8 - Days to first flowering

X_9 - Oil content of seeds

Fig 1. Heritability for nine characters in Sesamum

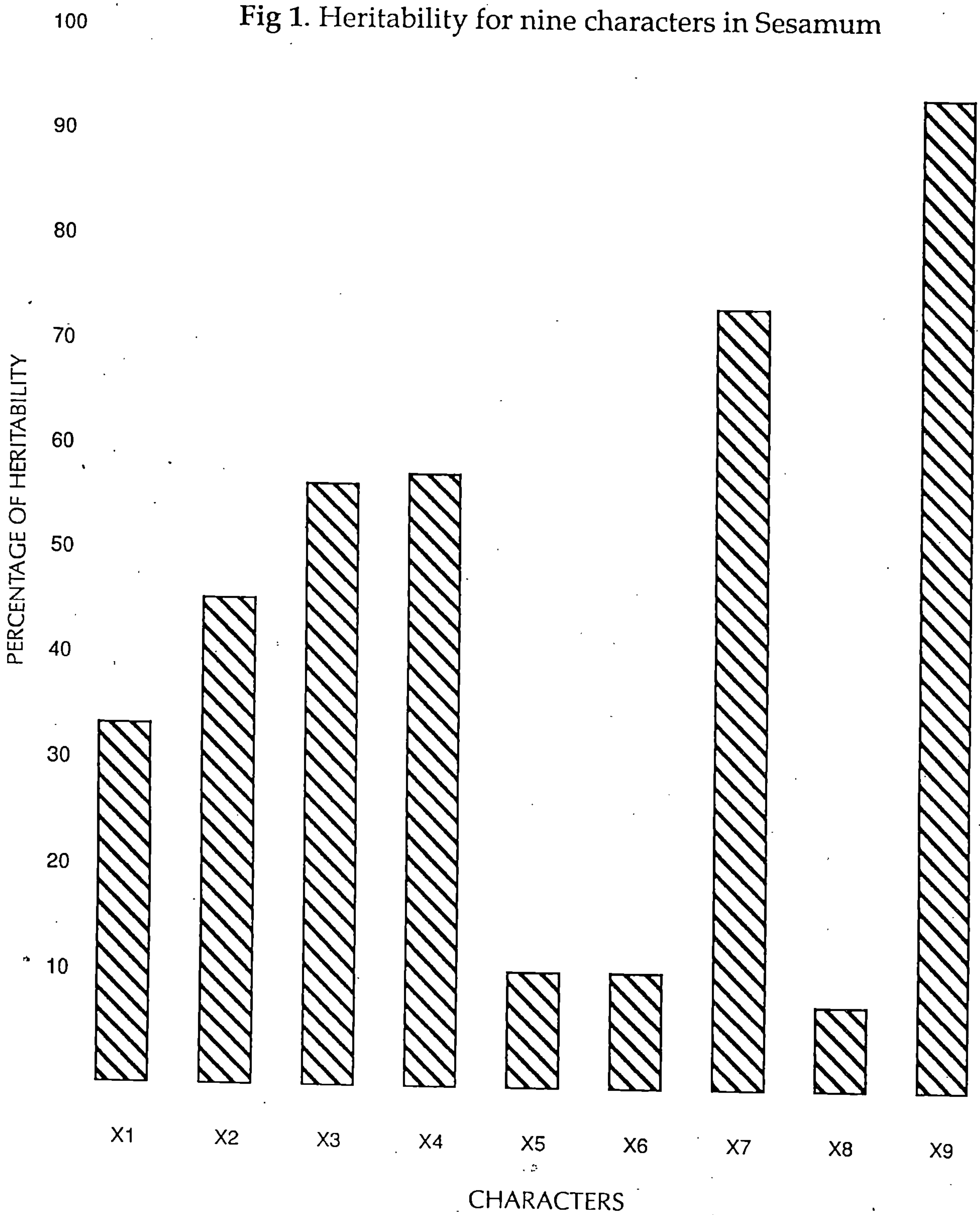


Table 4.3 Phenotypic correlation matrix

	No.of Primary branches	No.of leaves	No.of capsules	Capsule length	Capsule breadth	Leaf Area Index	Root-shoot ratio	No.of seeds/ capsule	Days to flowering	Seed yield	Oil content (%)
Plant height	0.3425**	0.3271**	0.4172**	-0.0405	-0.0220	-0.1163	-0.2139	0.0472	0.1131	0.1259	0.0684
No. of primary branches		0.4067**	0.4728**	-0.0321	0.0325	-0.1031	-0.2099	-0.0585	-0.0507	0.1730	0.0818
No. of leaves			0.8484**	-0.1555	-0.0569	-0.1475	0.0479	-0.2244	-0.0181	0.0739	0.0213
No. of capsules				-0.2345*	-0.0164	-0.1580	-0.1548	-0.4007**	-0.1167	0.1033	0.0145
Capsule length					0.1254	0.1340	0.1134	0.1473	-0.1142	0.0505	0.0061
Capsule breadth						0.3243**	-0.0166	-0.0512	-0.0299	0.0535	-0.0745
Leaf area index							-0.0684	0.1788	0.0788	0.0720	-0.0068
Root-shoot ratio								0.0056	0.0962	-0.0392	-0.2828*
No.of seeds/capsule									0.2440*	0.1651	0.2339*
Days to flowering										-0.0219	0.1084
Seed yield											0.0815

* *Significant at 5 % level*

** *Significant at 1 % level*

Table 4.4 Genotypic correlation matrix

	No.of primary branches	No.of leaves	No.of capsules	Capsule length	Capsule breadth	Root-shoot ratio	No.of seeds/ capsule	Days to flowering	Seed yield	Oil content (%)
Plant height	0.4222 *0.5060*	0.4678 *0.4680*	0.4385 *0.4261*	0.0496 *1.0625*	0.4348 *1.1583*	-0.6012 *6.4010*	0.2742 *0.4320*	0.4154 *1.3904*	0.8588 *4.9136*	0.1065 *0.3718*
No. of primary branches		0.3729 *0.3551*	0.3974 *0.3298*	-0.0134 *0.9108*	0.7530 *1.1377*	-0.9266 *6.5243*	-0.1757 *0.3624*	-0.3563 *1.1775*	-0.1450 *3.1409*	0.1497 *0.3183*
No. of leaves			0.8915 *0.3187*	-0.9077 *1.1013*	-0.0108 *0.8212*	-0.7632 *5.4460*	-0.2912 *0.3104*	-0.0399 *1.0054*	-2.1367 *6.8357*	0.0477 *0.2880*
No. of capsules				0.5058 *0.8865*	0.2926 *0.8470*	-0.2585 *4.3255*	-0.5774 *0.2905*	-0.3978 *1.0551*	-2.0534 *6.5514*	0.0482 *0.2843*
Capsule length					-0.9736 *2.5731*	6.2636 *62.5668*	1.2439 *1.1493*	-0.6823 *2.7128*	1.6721 *12.6753*	0.1859 *0.6531*
Capsule breadth						-5.9167 *58.4977*	0.0791 *0.7250*	1.4020 *3.8786*	1.0116 *9.2437*	-0.1701 *0.6473*
Root-shoot ratio							-0.4416 *4.1572*	-2.2511 *29.5153*	3.9907 *141.6357*	-4.1134 *15.1869*
No.of seeds/capsule								0.8134 *1.1170*	2.1015 *6.0013*	0.2848 *0.2333*
Days to flowering									3.2893 *27.3076*	0.2668 *0.8006*
Seed yield										1.0208 *3.2080*

The values in italics indicate the standard error.

Table 4.5 Environmental correlation matrix

	No.of primary branches	No.of leaves	No.of capsules	Capsule length	Capsule breadth	Leaf area index	Root-shoot ratio	No.of seeds/ capsule	Days to flowering	Seed yield	Oil content (%)
Plant height	0.2942*	0.2282*	0.4232**	-0.0582	-0.1392	-0.1313	-0.2354*	-0.2144	0.0603	0.0986	0.0420
No. of primary branches		0.4472**	0.5624**	-0.0421	-0.2008	-0.1471	-0.2306*	0.1165	0.0218	0.2493*	0.0943
No. of leaves			0.7905**	-0.0276	-0.0874	-0.1034	0.1301	-0.1074	-0.0157	0.3392**	-0.0840
No. of capsules				-0.2474*	-0.1495	-0.1538*	-0.2199	-0.0690	-0.0544	0.3847**	-0.1341
Capsule length					-0.2070	0.2704*	0.0317	-0.1345	-0.0813	0.0200	-0.1262
Capsule breadth						0.2620*	0.1198	-0.1525	-0.1742	0.0238	-0.0840
Leaf area index							0.0525	0.3111**	-0.1365	-0.0260	0.0054
Root-shoot ratio								0.0591	0.1420	-0.0636	-0.0919
No.of seeds/capsule									0.1084	-0.0022	-0.0234
Days to flowering										-0.1093	0.1609
Seed yield											-0.0402

* *Significant at 5 % level*

** *Significant at 1 % level*

At the phenotypic level, plant height at maturity was positively and significantly correlated with the number of primary branches, number of leaves per plant and number of capsules per plant. The number of primary branches had a similar relationship with plant height, number of leaves per plant and number of capsules per plant. The number of leaves per plant exhibited a significant positive phenotypic correlation with plant height at maturity, number of primary branches and number of capsules per plant. The character, number of capsules per plant had significant positive relationships with plant height at maturity, number of primary branches and number of leaves per plant and significant negative relationships with length of the capsule and number of seeds per capsule. The length of the capsule had a negative correlation with number of capsules alone. Positive significant correlation was observed between breadth of the capsule and leaf area index. Root-shoot ratio was significantly and negatively correlated with oil content of seeds and the number of seeds per capsule was positively associated with days to first flowering and oil content of seeds. Intercorrelations among other pairs of characters were not significant.

Moderately good values of genotypic correlations were observed for plant height at maturity with number of primary branches, number of leaves, number of capsules, breadth of the capsule, days to first flowering and seed yield, which were positive and a negative genotypic correlation with root-shoot ratio. The number of primary branches was positively correlated with plant height at maturity, number of leaves, number of capsules per plant and breadth of the capsule and negatively with root-shoot ratio and days to first flowering. A positive correlation was seen between number of leaves and plant height at maturity, number of primary branches and number of capsules per plant. The same character had negative correlations with length of the capsule, root-shoot ratio and seed yield, which were high and with number of seeds per capsule, which was low. The number of capsules per plant had positive correlations with plant height at maturity, number of primary branches and number of leaves and negative correlations with length of the capsule, number of seeds per capsule, days to first flowering and seed yield. The correlations of length of the capsule with root-shoot ratio, number of seeds per capsule and seed yield were positive and those with number of leaves, number of capsules per plant, breadth of the capsule and days to first flowering were negative. Breadth of the capsule was positively related to plant height at maturity, number of primary branches, number of capsules per plant, days to first flowering and seed yield. It was negatively related to length of the capsule and root-shoot ratio. The correlations of leaf area index were not estimable because its genotypic variance was not estimable. Positive correlations of root-shoot ratio with the length of the capsule and seed yield were noticed while negative correlations for this character was noticed with plant height at maturity, number of primary branches, number of leaves per plant, number of capsules per plant, breadth of the capsule, number of seeds per capsule, days to first flowering and oil content of seeds. The correlation of number of seeds per capsule with plant height at maturity, length of the capsule, days to first flowering, seed yield and oil content of seeds were positive and the correlation of this character with number of leaves per plant, number of capsules per plant and root-shoot ratio were negative. There existed positive correlations between days to first flowering and plant height at maturity, breadth of the capsule, number of seeds per capsule, seed yield and oil content of seeds and negative correlations with number of primary branches, number of capsules per plant, length of the capsule and root-shoot ratio. No correlation was observed between seed yield and/or oil content of seeds with dry matter production and proline content.

Seed yield had positive genotypic correlations with plant height at maturity, length of the capsule, breadth of the capsule, root-shoot ratio, number of seeds per capsule, days to first flowering and oil content of seeds and negative genotypic correlations with number of leaves per plant and number of capsules per plant. Fig. 2 shows the genotypic correlations of seed yield with 10 other characters studied.

The oil content of seeds was positively correlated at the genotypic level with number of seeds per capsule, days to first flowering and seed yield. This trait had a high negative correlation with root-shoot ratio. The genotypic correlations between seed oil content and 10 other characters included in this study are presented in Fig. 3.

In the case of environmental correlations plant height at maturity was positively correlated with number of primary branches, number of leaves per plant and number of capsules per plant and negatively correlated with root-shoot ratio. The number of primary branches too had a negative relationship with the character root-shoot ratio, while positive relationships existed between this character and plant height at maturity, number of leaves per plant, number of capsules per plant and seed yield.

Fig. 2. Genotypic correlation between seed yield and ten characters in Sesamum

X_1 - Plant height at maturity

X_2 - Number of primary branches

X_3 - Number of leaves per plant

X_4 - Number of capsules per plant

X_5 - Length of the capsule

X_6 - Breadth of the capsule

X_7 - Root-shoot ratio

X_8 - Number of seeds per capsule

X_9 - Days to first flowering

X_{10} - Oil content of seeds

Fig 2. Genotypic Correlation between seed yield and ten characters in Sesamum

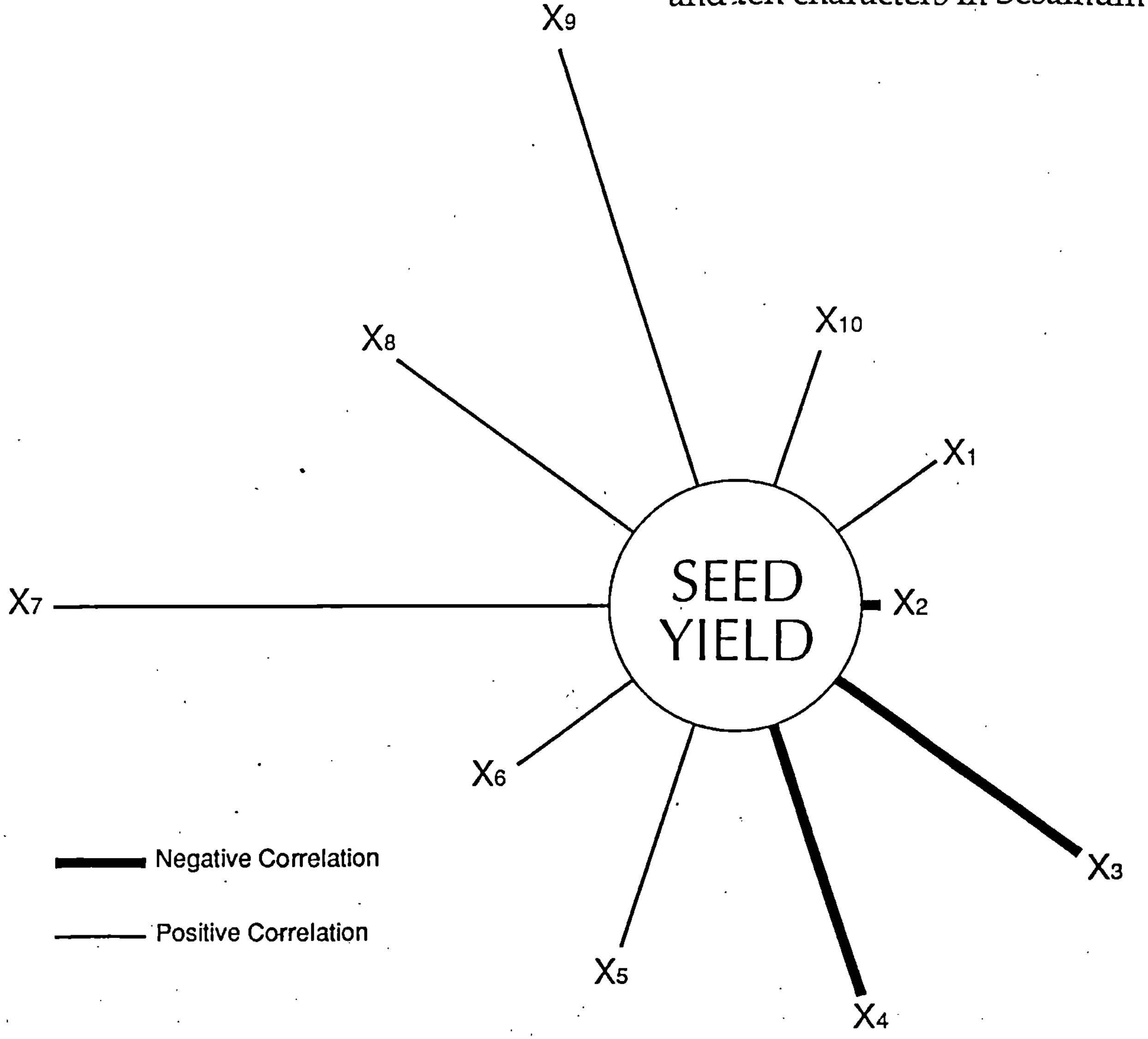


Fig. 3. Genotypic correlation between seed oil content and ten characters in *Sesamum*

X_1 - Plant height at maturity

X_2 - Number of primary branches

X_3 - Number of leaves per plant

X_4 - Number of capsules per plant

X_5 - Length of the capsule

X_6 - Breadth of the capsule

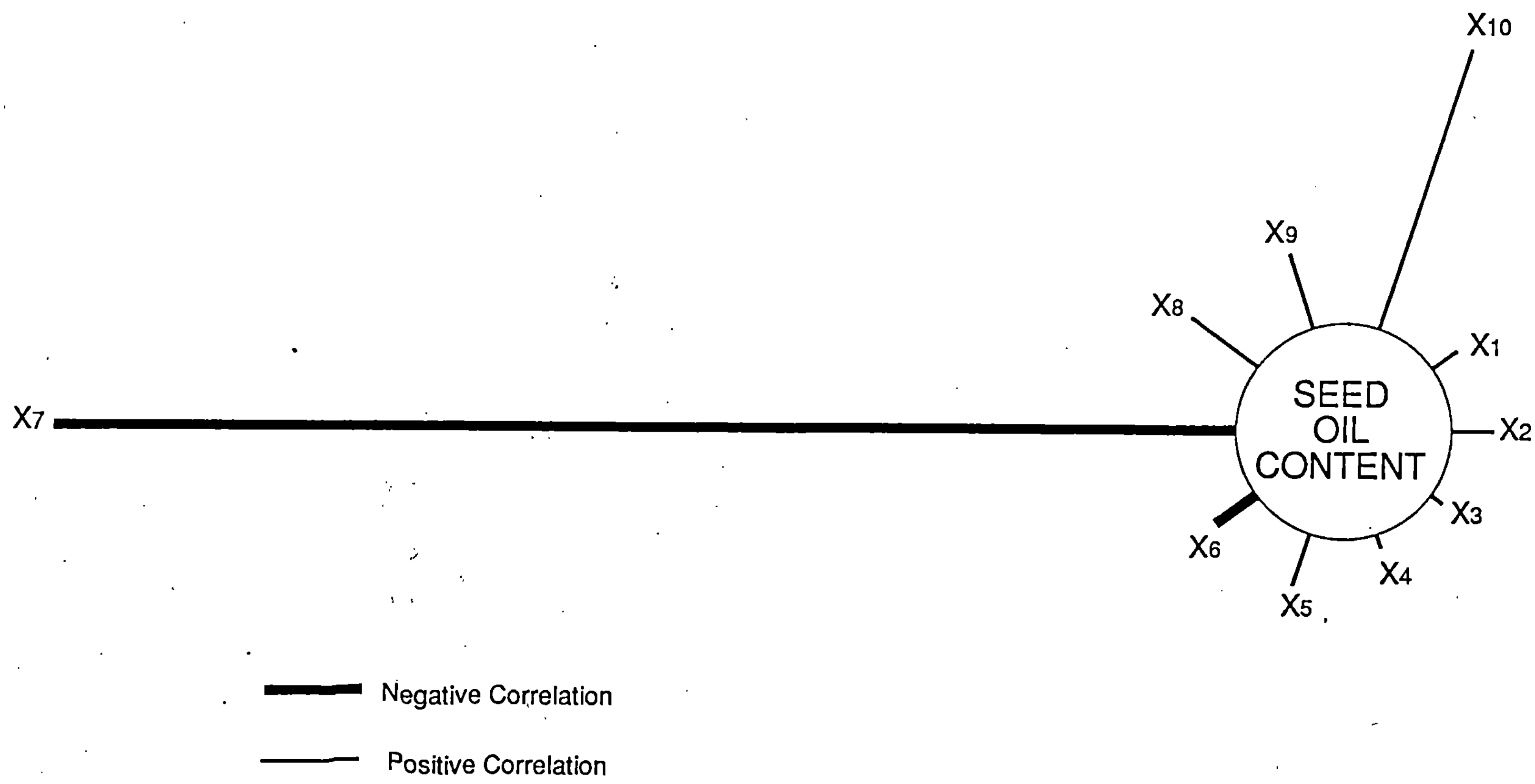
X_7 - Root-shoot ratio

X_8 - Number of seeds per capsule

X_9 - Days to first flowering

X_{10} - Seed yield

Fig 3. Genotypic Correlation between seed oil content and ten characters in Sesamum



The characters plant height at maturity, number of primary branches, number of capsules per plant and seed yield were positively correlated with the number of leaves per plant. Positive correlations were seen for number of capsules per plant with plant height, number of primary branches, number of leaves per plant and seed yield and negative correlation with length of the capsule. The length of the capsule was positively associated with leaf area index and negatively associated with the number of capsules per plant while the breadth of the capsule had positive correlation with leaf area index alone. Leaf area index, on the other hand, had positive correlations with length of the capsule, breadth of the capsule and number of seeds per capsule. Root-shoot ratio was negatively associated with plant height at maturity and number of primary branches. The number of seeds per capsule was positively correlated with leaf area index. Positive correlations for the characters number of primary branches, number of leaves per plant and number of capsules per plant with seed yield were also seen.

4.6. Path Analysis

The direct and indirect effects of different biometric characters on seed yield and oil content of seeds were estimated by path analysis technique and the results are presented in Tables 4.6 and 4.7 respectively.

The high residual values show that the characters selected for path analysis are not sufficient to explain the correlations in the present study.

4.7. Selection Indices and Genetic gain

The discriminant function analysis was done to identify the superior genotypes. The characters plant height at maturity, number of primary branches, number of capsules per plant, number of seeds per capsule, seed yield and oil content of seeds were considered to work out the selection indices.

Table 4.8 gives the selection indices and the rank orders of the varieties. The varieties ACV-2, TNAU-12, TNAU-10, NPG-3 and TSS-6 were identified as the superior genotypes at 20 per cent selection.

The expected genetic gain at 20 per cent intensity of selection was estimated as 37.25.

4.8. Drymatter production

The quantities of drymatter produced per plant are presented in Table 4.9. Drymatter production was the highest for ACV-1 followed by TNAU-12 and the lowest for Vayalellu. Fig. 4 shows the drymatter production in the 25 varieties of Sesamum.

Table 4.6 Direct and indirect effects of characters on seed yield

Character	Plant height at maturity	No.of capsules per plant	Length of the capsule	Breadth of the capsule	Root-shoot ratio	No. of seeds per capsule	Days to first flowering	Oil content (%) of seeds
Plant height at maturity	***3.4304***	-0.4522	-1.6307	-0.0121	0.1725	0.6283	0.6186	-1.8959
No. of capsules per plant	1.6047	***-0.9666***	-3.3153	0.2220	-0.0043	0.7976	-0.6569	0.1821
Length of the capsule	1.5042	-0.8616	***-3.7188***	0.1237	0.1161	0.2701	-1.3025	1.8155
Breadth of the capsule	0.1702	0.8774	1.8810	***-0.2446***	-0.3862	-6.5458	2.8061	3.1140
Root-shoot ratio	1.4915	0.0104	-1.0881	0.2382	***0.3966***	6.1832	0.1784	-6.3987
No.of seeds per capsule	-2.0623	0.7377	0.9613	-1.5319	-2.3468	***-1.0451***	-0.9962	10.2737
Days to first flowering	0.9406	0.2815	2.1472	-0.3042	0.0314	0.4615	***2.2559***	-3.7123
Oil content (%) of seeds	1.4250	0.0386	1.4793	0.1669	0.5561	2.3525	1.8349	***-4.5640***

RESIDUE=1.67

The figures in bold italics indicate the direct effects

Table 4.7 Direct and indirect effects of characters on oil content of seeds

Character	Plant height at maturity	No. of primary branches	No. of leaves per plant	No. of capsules per plant	No. of seeds per capsule	Seed yield
Plant height at maturity	***-0.2081***	0.2514	0.0715	-0.1208	0.0612	0.0513
No. of primary branches	-0.0879	***0.2611***	0.0284	-0.2301	0.1641	0.0141
No. of leaves per plant	-0.2081	0.2367	***-0.0126***	0.0752	-0.0948	0.0513
No. of capsules per plant	-0.0974	0.5308	-0.0208	***-0.2217***	-0.0240	-0.1189
No. of seeds per capsule	-0.0776	0.5954	-0.0413	0.0374	***-0.3370***	0.1079
Seed yield	-0.2018	0.1633	0.0715	0.5980	0.3449	***0.0514***

RESIDUE=0.92

The figures in bold italics indicate the direct effects

Table 4.8 Selection Indices

Variety	Selection Criterion	Rank Order
Co - 1	727.7815	25
ACV - 2	987.8809	1
RT - 73	849.0386	15
NPG - 3	916.2469	4
No. 42	759.7998	24
VT - 43	816.4105	17
Kayamkulam - 1	868.2418	12
IS - 614	761.1025	22
Vayalellu	838.6353	16
BS - 5 - 18 - 6 - G	759.8171	23
S - 16	808.1144	18
TSS - 6	915.1851	5
C - 6	903.9184	7
IS - 164	862.0115	13
TNAU - 12	986.3549	2
RAUSS - 17 - 4	776.7895	20
VS - 80	778.4656	19
C - 7	767.7563	21
TNAU - 11	870.0270	11
AÇV - 1	855.0576	14
Vinayak	875.9891	10
Kayamkulam - 2	914.8563	6
B - 14	878.4394	9
TNAU - 10	957.3229	3
TMV - 3	882.4449	8

Table 4.9 Dry matter production in 25 varieties of Sesamum

Sl No.	Variety	Quantity of Dry matter produced per plant (grams)
1.	Co - 1	23.86
2.	ACV - 2	13.61
3.	RT - 73	20.89
4.	NPG - 3	19.01
5.	No. 42	24.35
6.	VT - 43	21.35
7.	Kayamkulam - 1	14.95
8.	IS - 614	18.90
9.	Vayalellu	9.80
10.	BS - 5 - 18 - 6 - G	14.08
11.	S - 16	15.96
12.	TSS - 6	24.01
13.	C - 6	24.54
14.	IS - 164	22.06
15.	TNAU - 12	25.03
16.	RAUSS - 17 - 4	23.52
17.	VS - 80	16.75
18.	C - 7	23.03
19.	TNAU - 11	22.80
20.	ACV - 1	26.67
21.	Vinayak	23.41
22.	Kayamkulam - 2	20.28
23.	B - 14	22.56
24.	TNAU - 10	20.01
25.	TMV - 3	21.65

Fig. 4. Drymatter production in 25 varieties of *Sesamum*

V_1 - Co-1
V_2 - ACV-2
V_3 - RT-73
V_4 - NPG-3
V_5 - No. 42
V_6 - VT-43
V_7 - Kayamkulam -1
V_8 - IS-614
V_9 - Vayalellu
V_{10} - BS-5-18-6-G
V_{11} - S-16
V_{12} - TSS-6
V_{13} - C-6
V_{14} - IS-164
V_{15} - TNAU-12
V_{16} - RAUSS-17-4
V_{17} - VS-80
V_{18} - C-7
V_{19} - TNAU-11
V_{20} - ACV-1
V_{21} - Vinayak
V_{22} - Kayamkulam-2
V_{23} - B-14
V_{24} - TNAU-10
V_{25} - TMV-3

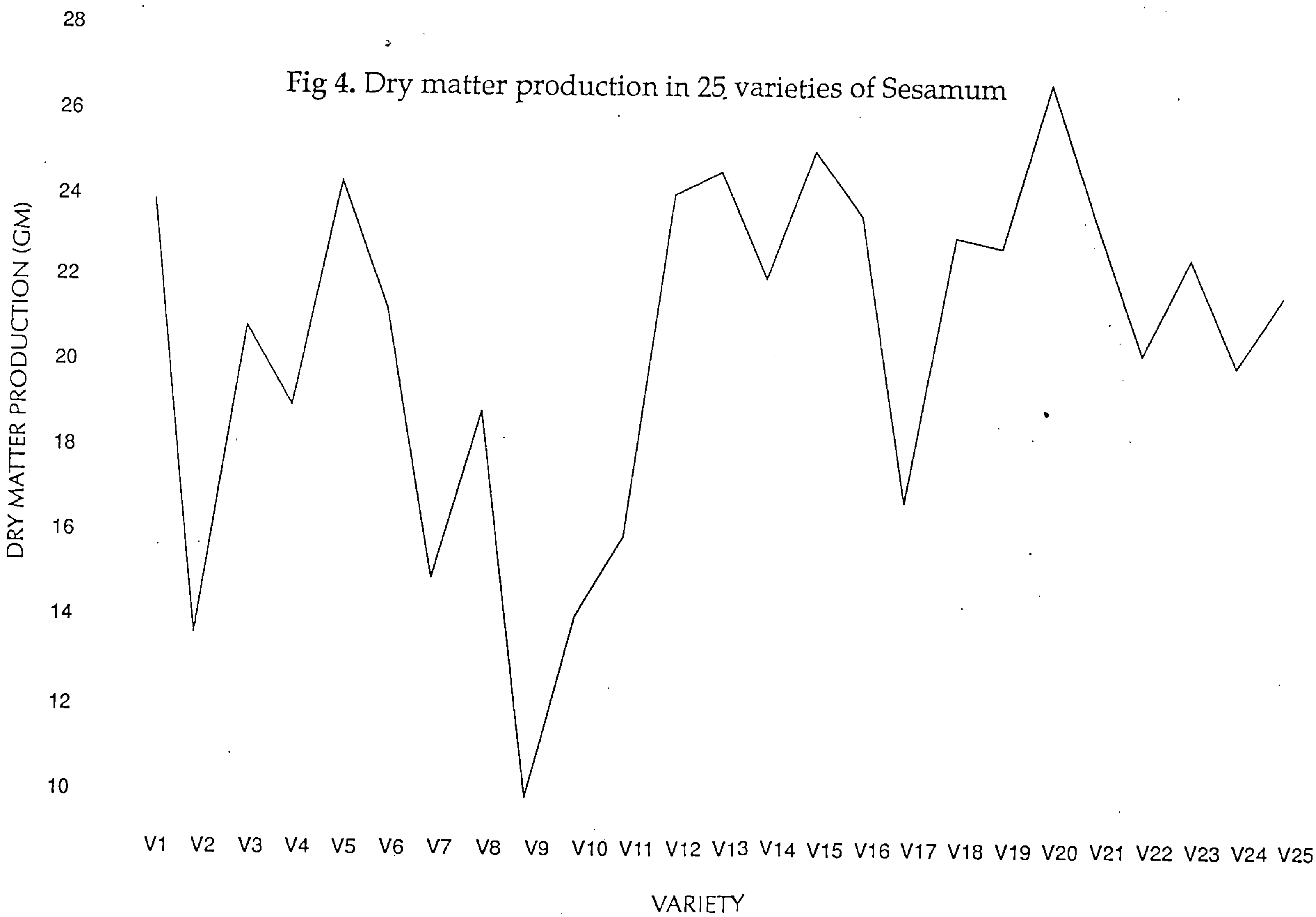


Fig 4. Dry matter production in 25 varieties of Sesamum

4.9. Proline accumulation

Under moisture stress, the amino acid proline was found to accumulate in plants, as reported by many research workers. The amount of proline accumulation has been cited as an index for measuring the drought-tolerance of crops.

In the present study the amount of proline present in the leaves was estimated and presented in Table 4.10. The maximum amount of proline per gram of dry weight was seen in NPG-3, followed by Kayamkulam-1. The least amount of proline was seen in the variety BS-5-18-6-G.

The extent of proline accumulation in the 25 varieties of Sesamum included in this study, was estimated as percentage of dry weight and presented in Table 4.11 and Fig. 5. In the variety NPG-3, proline content accounted for 0.60 per cent of the dry weight, which was the maximum, followed by Kayamkulam-1 which contained 0.55 per cent of the amino acid. The variety which had accumulated the least amount of proline was BS-5-18-6-G (0.01 per cent).

4.10. Soil moisture percentage

The soil moisture percentage available for the 25 varieties of Sesamum in 3 replications, were estimated at weekly intervals. The mean values of soil moisture percentage during the cropping period are presented in

Table 4.10 Proline content in 25 varieties of Sesamum

Sl No.	Variety	Proline Content (μ moles/g of dry weight)
1.	Co - 1	79.1031
2.	ACV - 2	438.9448
3.	RT - 73	105.4708
4.	NPG - 3	520.3745
5.	No. 42	361.3927
6.	VT - 43	338.9026
7.	Kayamkulam - 1	473.8432
8.	IS - 614	188.0807
9.	Vayalellu	114.7771
10.	BS - 5 - 18 - 6 - G	8.5307
11.	S - 16	70.5724
12.	TSS - 6	369.1479
13.	C - 6	40.3271
14.	IS - 164	108.5729
15.	TNAU - 12	49.6333
16.	RAUSS - 17 - 4	73.6745
17.	VS - 80	14.7349
18.	C - 7	69.0214
19.	TNAU - 11	210.1661
20.	ACV - 1	37.2250
21.	Vinayak	22.4901
22.	Kayamkulam - 2	56.6130
23.	B - 14	438.1693
24.	TNAU - 10	125.6344
25.	TMV - 3	25.1464

Table 4.11. Extent of Proline accumulation in 25 varities of Sesamum

Sl. No.	Variety	Dry weight per plant (g)	Proline content per gram of dry weight (g)	Proline content as percentage of dry weight
1	Co - 1	23.86	0.0217	0.09
2	ACV - 2	13.61	0.0688	0.51
3	RT-73	20.89	0.0254	0.12
4	NPG - 3	19.01	0.1139	0.60
5	No. 42	24.35	0.1013	0.42
6	VT - 43	21.35	0.0833	0.39
7	Kayamkulam-1	14.95	0.0816	0.55
8	IS - 614	18.90	0.0409	0.22
9	Vayalellu	9.80	0.0129	0.13
10	BS -5-18 -6 -G	14.08	0.0014	0.01
11	S - 16	15.96	0.0130	0.08
12	TSS - 6	24.01	0.1020	0.42
13	C - 6	24.54	0.0114	0.05
14	IS - 164	22.06	0.0276	0.13
15	TNAU - 12	25.03	0.0143	0.06
16	RAUSS - 17 - 4	23.52	0.0200	0.09
17	VS - 80	16.75	0.0028	0.02
18	C - 7	23.03	0.0183	0.08
19	TNAU - 11	22.80	0.0534	0.23
20	ACV - 1	26.67	0.0114	0.04
21	Vinayak	23.41	0.0061	0.03
22	Kayamkulam - 2	20.28	0.0132	0.07
23	B - 14	22.56	0.1138	0.50
24	TNAU - 10	20.01	0.0289	0.15
25	TMV - 3	21.65	0.0636	0.29

Fig. 5. Proline content as percentage of dry weight

V_1 - Co-1
V_2 - ACV-2
V_3 - RT-73
V_4 - NPG-3
V_5 - No. 42
V_6 - VT-43
V_7 - Kayamkulam -1
V_8 - IS-614
V_9 - Vayalellu
V_{10} - BS-5-18-6-G
V_{11} - S-16
V_{12} - TSS-6
V_{13} - C-6
V_{14} - IS-164
V_{15} - TNAU-12
V_{16} - RAUSS-17-4
V_{17} - VS-80
V_{18} - C-7
V_{19} - TNAU-11
V_{20} - ACV-1
V_{21} - Vinayak
V_{22} - Kayamkulam-2
V_{23} - B-14
V_{24} - TNAU-10
V_{25} - TMV-3

Fig 5. Proline content as percentage of dry weight

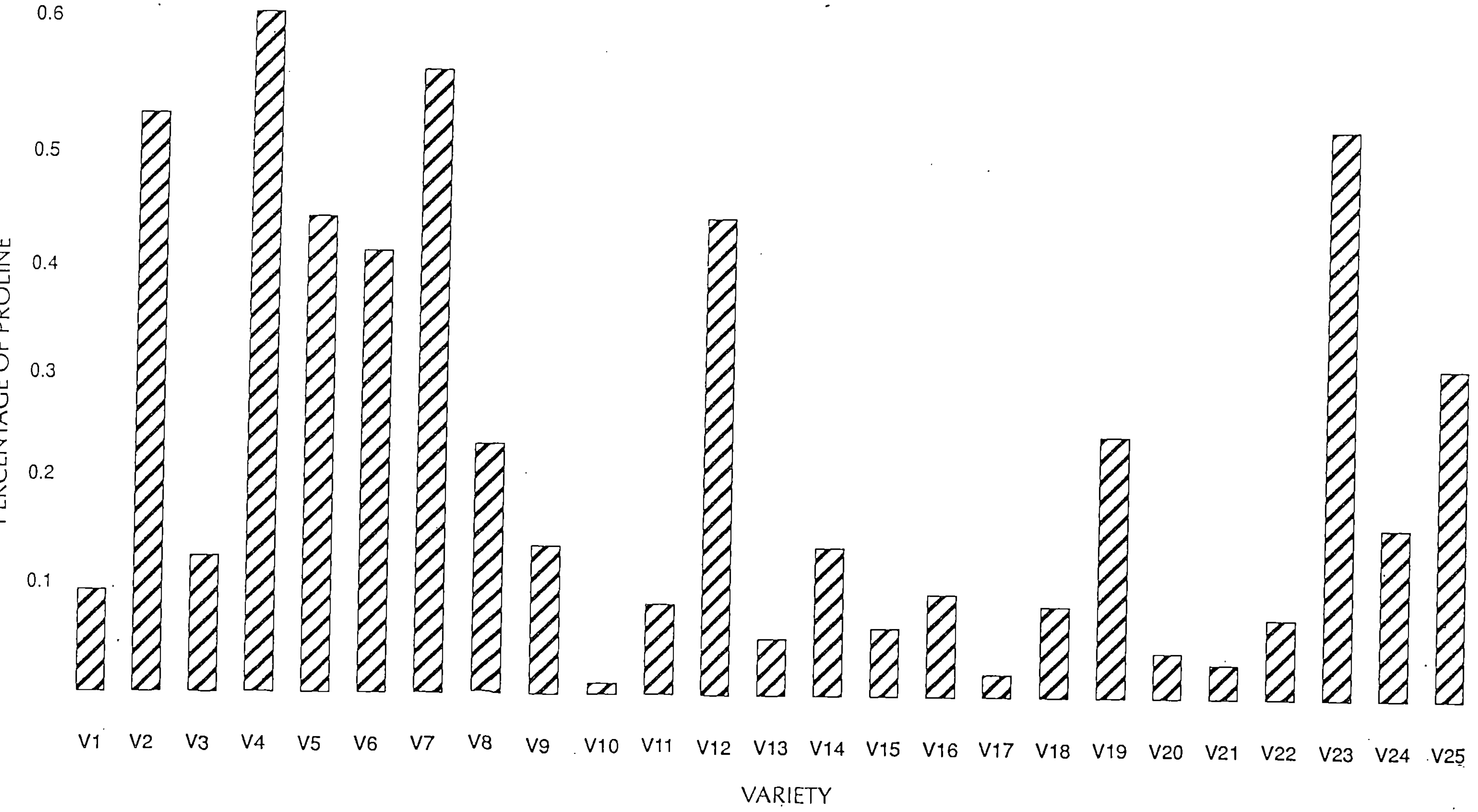


Table 4.12. The variation in the mean soil moisture percentage during the cropping period is depicted in Fig. 6. Soil moisture percentage was the highest (8.05 per cent) at 56 days after sowing and was the lowest (6.08 per cent) at 21 days after sowing.

4.11. Weather parameters

The weather condition prevalent during the cropping period was observed and recorded. The daily weather condition during the cropping period is presented in Appendix I. The mean values of maximum temperature and minimum temperature expressed in degree celsius, rainfall expressed in millimetres, relative humidity expressed in percentage and the amount of sunshine received from 6 AM to 6 PM expressed in hours for each standard meteorological week, during the cropping period, were worked out and presented in Table 4.13. The mean values of temperature, rainfall, relative humidity and duration of sunshine during the cropping period are depicted in Fig. 7, Fig. 8, Fig. 9 and Fig. 10 respectively.

The maximum and minimum atmospheric temperature were the highest during the 52nd standard meteorological week. The maximum temperature dropped to the least value during the 41st standard meteorological week and the

Table 4.12. Mean Soil Moisture Percentage at weekly intervals

Variety	7 DAS *	14 DAS *	21 DAS *	28 DAS *	35 DAS *	42 DAS *	49 DAS *	56 DAS *	63 DAS *	70 DAS *	77 DAS *	84 DAS *
Co - 1	6.83	7.36	5.49	5.20	7.20	7.06	6.88	8.63	6.91	6.79	6.23	7.68
ACV-2	6.80	8.43	6.68	5.72	7.39	6.95	7.01	9.23	6.76	6.22	5.77	6.93
RT-73	6.97	7.65	5.13	6.65	6.65	6.34	6.54	8.10	7.41	6.87	5.93	5.98
NPG-3	7.54	6.53	5.33	5.49	6.46	7.38	6.81	8.86	6.78	6.38	6.37	6.23
No.42	6.85	8.41	6.02	5.83	7.67	6.34	6.79	8.94	6.98	6.07	6.40	6.25
VT-43	7.83	8.73	6.41	5.98	6.62	6.65	7.74	9.79	6.57	6.75	6.21	6.20
Kayamkulam-1	6.64	6.02	6.38	5.75	6.62	6.48	6.83	9.61	6.43	7.15	5.80	6.86
IS-614	6.48	6.23	5.97	5.23	6.70	7.17	6.40	8.05	7.99	7.00	6.35	6.37
Vayalellu	6.68	8.87	6.68	5.78	7.47	6.40	6.78	9.03	6.74	6.22	6.10	6.12
BS-5-18-6-G	7.43	7.49	6.33	6.07	6.54	6.98	8.13	9.11	7.38	6.84	5.93	6.75
S-16	6.55	6.83	7.25	5.90	6.92	7.04	6.63	8.75	6.93	6.95	6.03	6.87
TSS-6	6.47	7.95	5.69	6.40	6.90	7.58	7.71	9.38	7.12	7.00	6.41	6.98
C-6	7.73	7.92	6.95	5.33	7.23	7.33	8.06	8.34	7.06	5.76	6.00	6.37
IS-164	6.69	8.39	6.06	6.31	7.02	6.35	6.48	9.73	7.91	6.22	6.45	6.36
TNAU-12	7.58	7.70	5.39	5.11	7.08	7.56	6.55	9.12	7.38	6.62	6.38	6.35
RAUSS-17-4	6.04	8.24	5.16	6.73	6.96	7.18	7.94	10.89	7.37	6.34	6.89	6.63
VS-80	7.73	8.55	7.98	6.56	6.52	6.47	6.96	9.93	6.63	6.41	6.16	6.13
C-7	6.16	8.98	5.51	6.19	6.80	7.41	8.06	8.96	7.57	6.25	6.02	8.10
TNAU-11	6.11	7.97	5.34	6.94	6.30	7.01	6.66	7.97	6.79	6.72	5.74	6.51
ACV-1	7.34	7.58	6.21	6.59	7.10	6.34	6.50	9.80	7.12	6.50	6.44	6.21
Vinayak	7.26	6.99	5.66	7.88	5.86	7.02	7.07	8.05	7.07	6.21	6.15	6.46
Kayamkulam-2	6.71	7.02	6.11	6.72	6.58	6.66	7.48	8.09	6.29	7.28	6.49	6.41
B-14	7.04	8.75	5.54	5.29	6.70	7.32	9.48	8.71	7.92	6.98	6.34	6.47
TNAU-10	6.82	6.19	7.80	7.92	6.76	6.94	7.16	7.37	6.21	6.53	5.96	6.31
TMV-3	6.89	8.04	5.01	6.10	6.69	6.64	7.48	8.68	7.10	6.80	7.00	6.67
Mean	6.93	7.71	6.08	6.15	6.83	6.90	7.21	8.05	7.06	6.59	6.22	6.57

* *DAS - Days after sowing*

Fig. 6. Mean soil moisture during the cropping period

D.A.S. - Days after sowing

Fig 6. Mean soil moisture during the cropping period

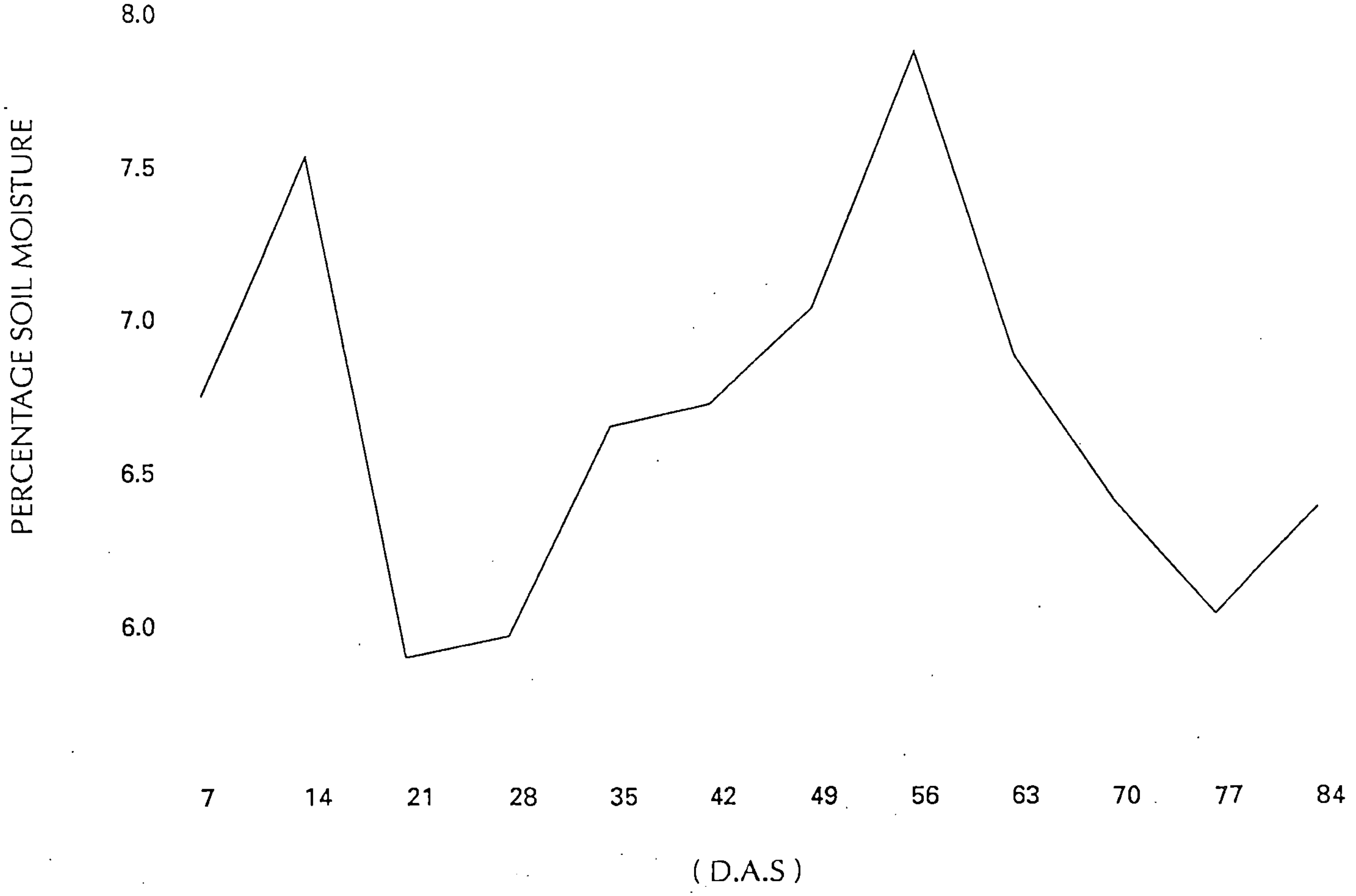


Table 4.13 Weather condition prevalent during the cropping period (5-10-1989 to 9-1-1990)

Standard Week	Period		Temperature (°c)		Rainfall (mm)	Relative humidity (%)	Sunshine (hours)
	From	To	Maximum	Minimum			
40	01-10-89	07-10-89	30.4	23.7	22.6	82	6.7
41	08-10-89	14-10-89	29.5	23.7	10.8	87	6.0
42	15-10-89	21-10-89	29.8	23.9	25.5	86	5.1
43	22-10-89	28-10-89	30.1	23.6	12.2	80	7.7
44	29-10-89	04-11-89	30.0	23.4	5.8	86	2.9
45	05-11-89	11-11-89	31.1	24.3	11.9	83	6.0
46	12-11-89	18-11-89	31.0	23.7	5.5	82	4.2
47	19-11-89	25-11-89	30.7	22.7	1.4	74	7.3
48	26-11-89	02-12-89	31.1	22.8	2.7	71	8.4
49	03-12-89	09-12-89	31.0	22.9	13.1	68	7.9
50	10-12-89	16-12-89	31.1	21.2	1.0	65	8.9
51	17-12-89	23-12-89	30.9	27.9	4.3	67	7.7
52	24-12-89	30-12-89	31.4	28.4	5.1	70	7.4
53	31-12-89	06-01-90	31.1	22.5	6.4	66	5.6
54	07-01-90	13-01-90	30.7	22.4	8.4	79	6.4

Source : Meteorological Observatory, College of Agriculture, Vellayani.

Fig. 7. Mean temperature prevalent during the cropping period (5-10-1989 to 9-1-1990)

Fig 7. Mean temperature prevalent during the cropping period (05-10-1989 to 09-01-1990)

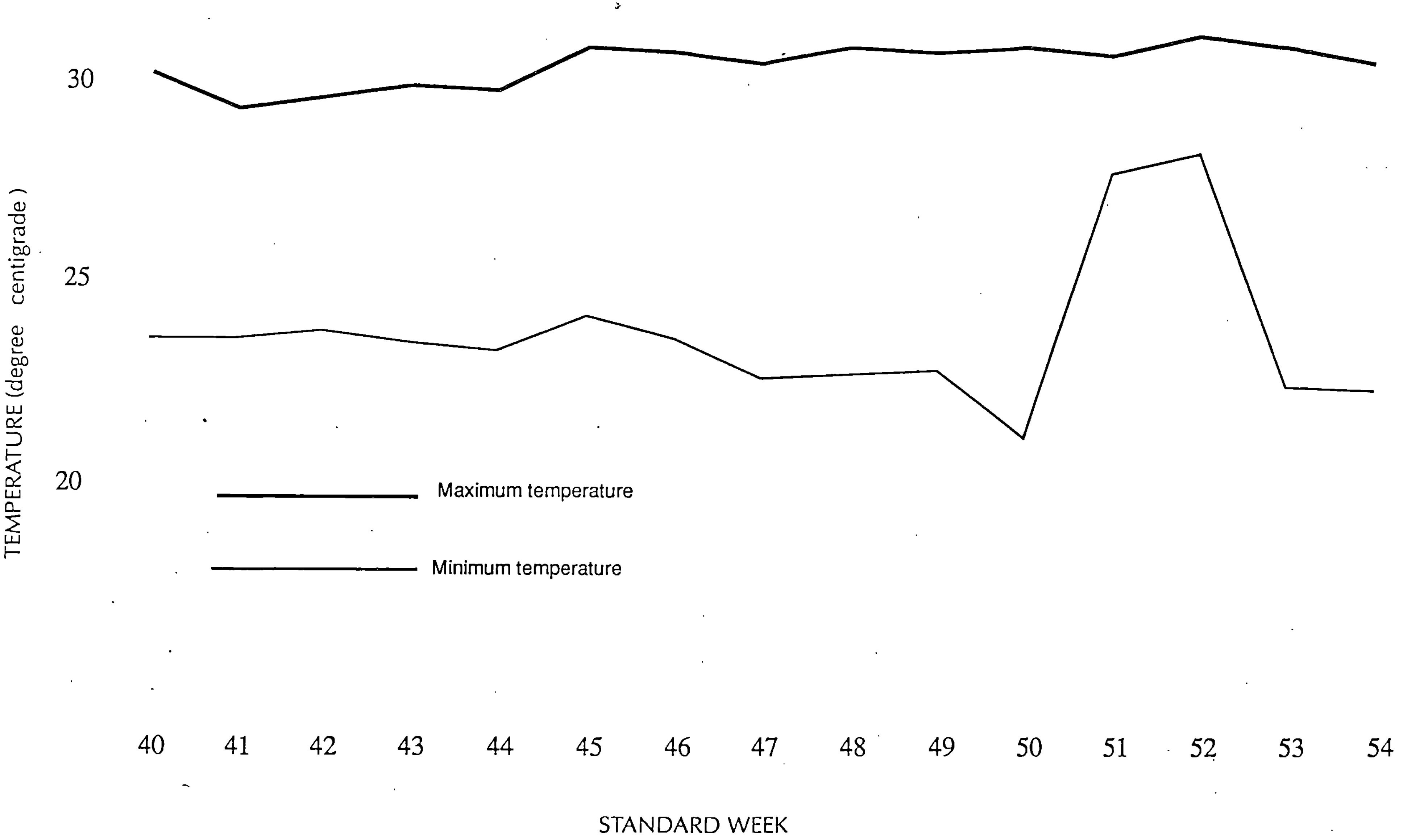


Fig. 8. Mean rainfall during the cropping period
(5-10-1989 to 9-1-1990)

Fig 8. Mean rainfall during the cropping period
(05-10-1989 to 09-01-1990)

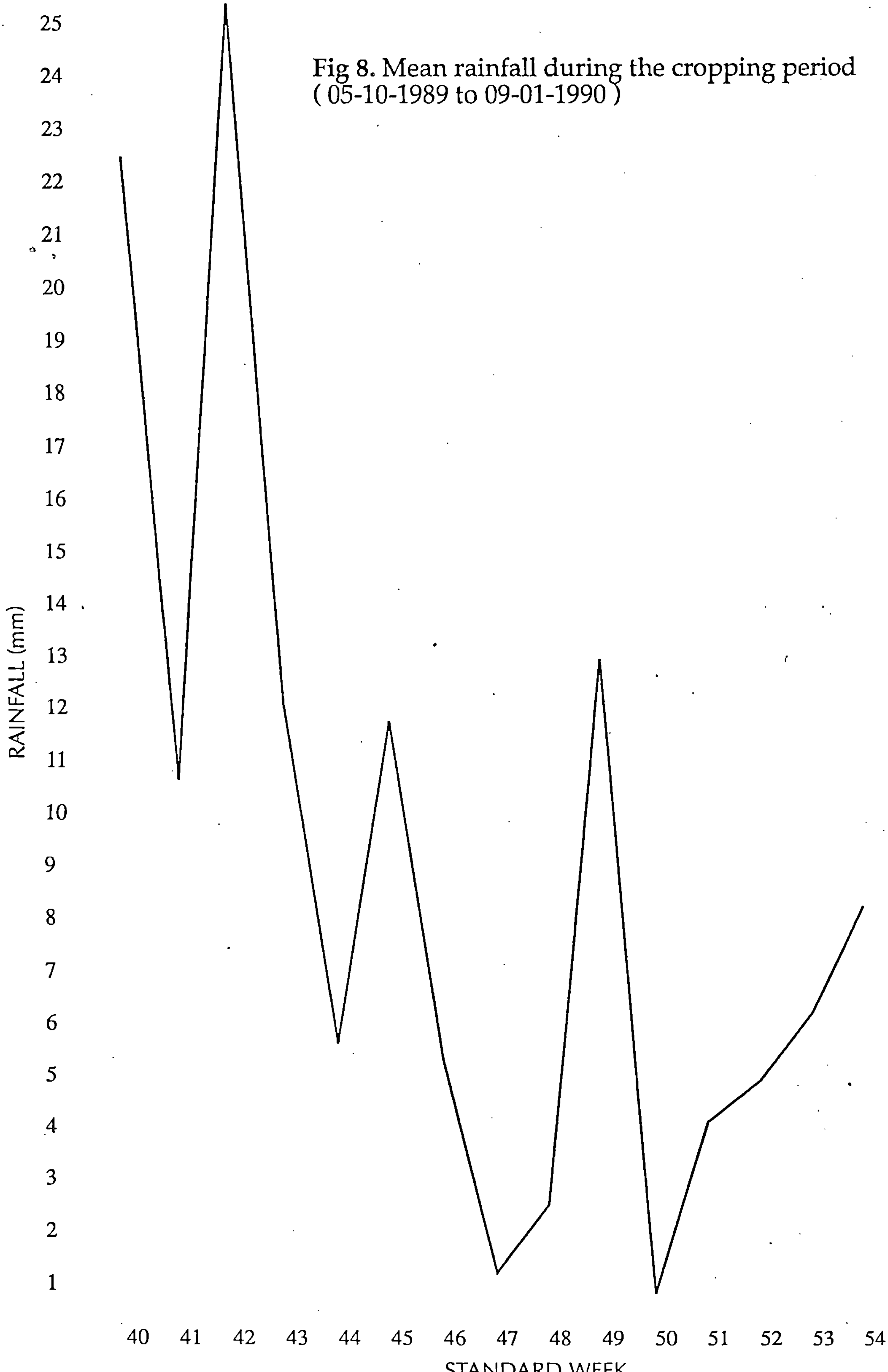


Fig. 9. Mean relative humidity during the cropping period (5-10-1989 to 9-1-1990)

Fig 9. Mean relative humidity during the cropping period
(05-10-1989 to 09-01-1990)

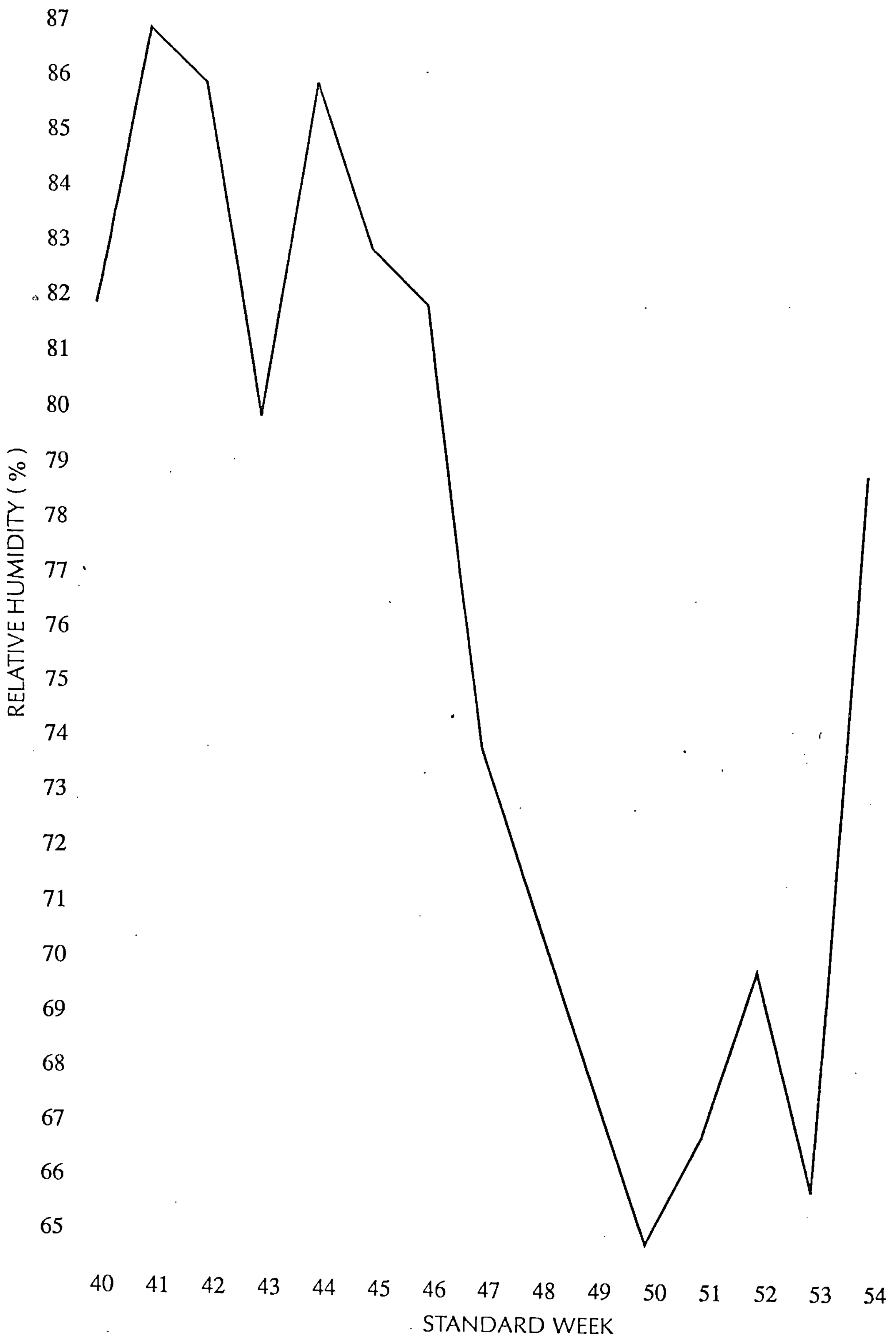
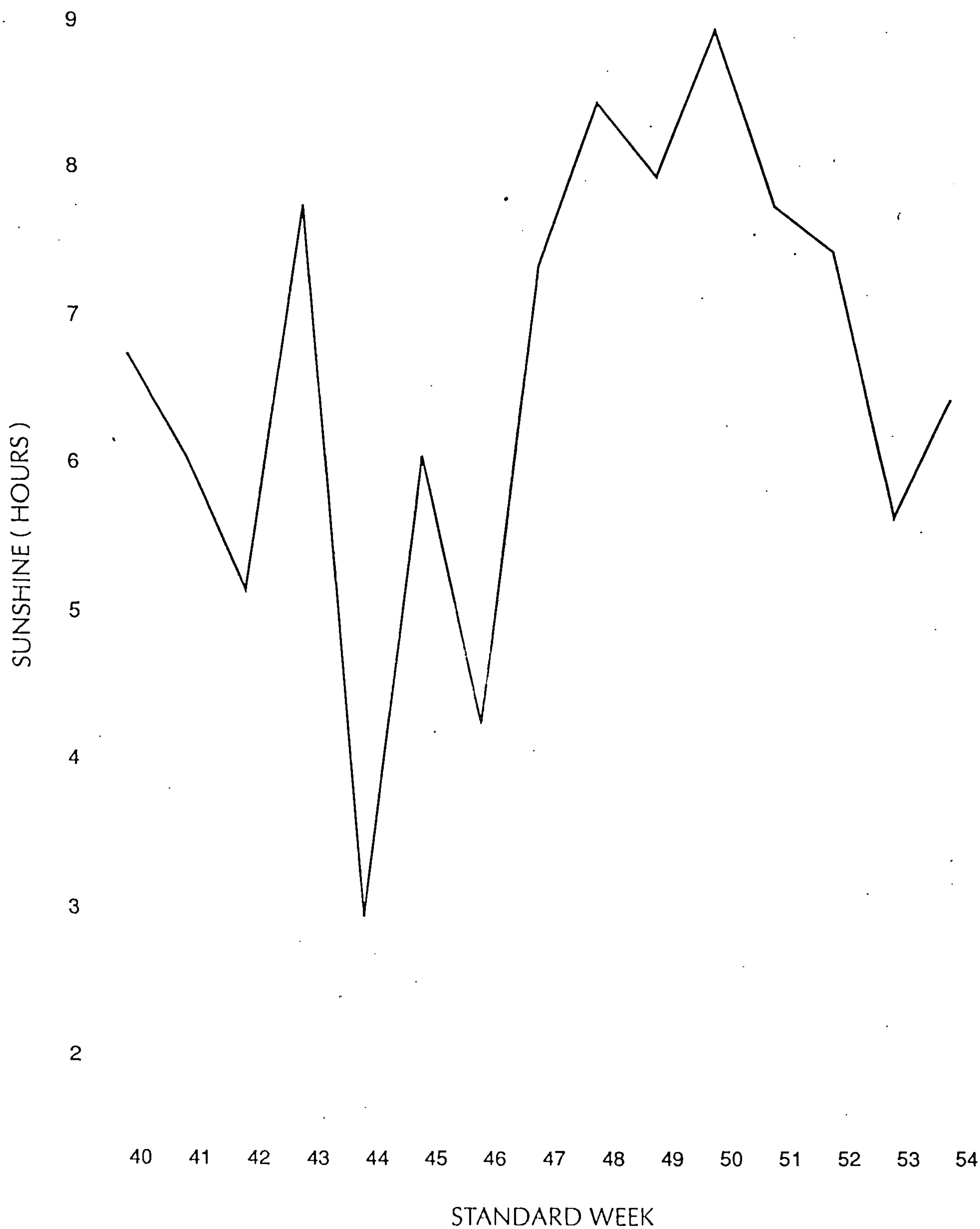


Fig. 10. Mean duration of sunshine during the cropping period (5-10-1989 to 9-1-1990)

Fig 10. Mean duration of sunshine during the cropping period (05-10-1989 to 09-01-1990)



minimum temperature showed the lowest value during the 50th standard meteorological week. During the cropping period, the Sesamum crop received the highest amount of rainfall (25.5 mm) during the 42nd standard meteorological week and the lowest amount of rainfall (1 mm) during the 50th standard meteorological week. The relative humidity showed a maximum value of 87 per cent during the 41st standard meteorological week and a minimum value of 65 per cent during the 50th standard meteorological week. The duration of sunshine, from 6 AM to 6 PM, was the maximum during the 50th standard meteorological week (8.9 hours) and was the minimum during the 44th standard meteorological week (2.9 hours).

DISCUSSION

DISCUSSION

The development of Plant Breeding strategy hinges mainly on the support provided by genetic information on the pattern of inheritance and behaviour of major quantitative characters associated with yield and quality. The choice of the most suitable breeding method for the improvement of yield and its components in any crop largely depends on the available genetic variability, heritability, genetic advance under selection and association between characters. Selection based on yield alone is not very efficient, but based on its components as well, could be more efficient (Evans, 1978).

It was observed by Srivastava *et al*. (1981) that in linseed, some of the characters associated with yield under irrigated conditions, were not associated with yield under moisture stress conditions. Blum (1982) had pointed out that when selection takes place under stress, the heritability for yield, already low, falls further and thus selection for yield alone under such conditions becomes inefficient. This means that alternative physiological characters associated with yield must be employed, to augment selection for yield. This points to the need for collecting information on the morphological and physiological characters associated with seed yield and oil content under moisture stress conditions. In Sesamum, information regarding the genetic parameters and association of characters under rainfed conditions is scanty. The present study was therefore taken up to identify superior sesamum genotypes possessing high seed yield and oil content under rainfed conditions and to assess the relationship between yield and other characters.

The results obtained in this study are discussed below:

5.1. Variability

Selection is the fundamental process in the development of superior varieties and it depends on the variability available in the crop. Information on the type of variability available in the genetic stock and the part played by the environment on the expression of characters is a pre-requisite for any crop improvement programme. Sesamum is a crop showing much variability for the different morphological characters.

Among the twelve biometric characters included in this study, significant differences existed between varieties with respect to six characters, viz. plant height at maturity, number of primary branches, number of leaves per plant, number of capsules per plant, number of seeds per capsule and seed oil content. The mean performance of varieties was considered in all cases. The plant height at maturity ranged from 155.21 cm in the case of TNAU-12 to 102.92 cm in the case of Vayalellu. This is in confirmation with the findings of Murugesan et al. (1979) who reported that 30 varieties of Sesamum significantly differed in their mean values for plant height at maturity during kharif and rabi seasons. For this character, the genotypic component of variation was lesser than the environmental component indicating that this trait was more influenced by the environment rather than genotypic differences. This is contradictory to the observation of Rai et al. (1981).

The number of primary branches per plant varied from 3.87 in the case of TNAU-11 to 2.08 in the case of RT-73. Shukla and Verma (1976) also observed a low coefficient of variation for the number of primary branches in Sesamum. In the present study, the genotypic component of variation for number of primary branches was slightly lesser than the environmental component of variation, indicative of dominance of environment over genotype in determining this trait. This is contrary to the results obtained by Gupta and Gupta (1977) and Yadava et al. (1980), in sesamum, who found that the genotypic component was more than the environmental component.

A high variation was noticed for the number of leaves per plant, in this study. TNAU-10 had the maximum number of leaves (54.96) and the variety ACV-2 had the least number of leaves (31.53). The genotypic component of variation for number of leaves per plant was higher than the environmental component of variation. Hence this character is more determined by the genotype than the environment.

The number of capsules per plant showed a wide range of variability from 62.52 for the variety TNAU-10 to 30.13 for the variety Vayalellu. The results reported by Muhammad (1970), Dabral and Holker (1971) and Sawant (1971) in sesamum were on similar lines. In the present study, the genotypic component of variation was seen to be larger than the environmental component of variation for the number of capsules per plant, which indicates that the genotype plays a larger role in determining this trait. This finding confirms those by Gupta (1975), Gupta and Gupta (1977) and Rai et al. (1981) in sesamum.

The length of the capsule varied from 2.47 centimetres to 3.05 cm, the minimum length being observed in the case of BS-5-18-6-G and the maximum in the case of ACV-2. The genotypic component of variation was very less when compared to the environmental component of variation for this character. The breadth of the capsule varied from 2.05 centimetres, in the variety TNAU-12, to 2.55 centimetres, in the variety B-14. As in the case of length of the capsule, the genotypic component of variation had a much lesser value than the environmental component of variation. This is in consonance with the findings of Murugesan et al. (1979) in sesamum, which implies that the size of the capsule in sesamum is controlled more by the environment than the genotype.

Leaf area index is the ratio between the total area occupied by the leaves of a plant to the ground area occupied by the plant. Moisture stress has been found to reduce the leaf area index in many crops like soybean (Vidal et al., 1981), wheat (Hochman, 1982) and Sappo spring wheat (Talukder, 1987). Under higher levels of water stress, Pandey et al. (1984) found that crops like cowpea, soybean, groundnut and mungbean differed in their ability to maintain leaf area index. In the present study, the leaf area indices were generally low and showed only little variability. The highest leaf area index of 2.56 was seen in the variety Vinayak and the lowest leaf area index of 2.11 was seen in Kayamkulam-1. It has been pointed out by Kramer (1959) that a reduced leaf area, and hence leaf area index, was indicative of lesser injury in crop plants during drought.

The variability observed for the character root-shoot ratio, which is the ratio of dry weight of roots to the dry weight of shoots, was very wide in this study. The highest ratio of 9.707 was observed in the case of S-16 and the lowest ratio of 0.109 was observed in the case of VT-43. Killian and Lemee (1956) observed that under conditions of moisture stress the growth rate of roots considerably exceeded that of the shoots and that a high root to shoot ratio was an effective means of adoptation to tide over the stress condition. It was proposed by Murty (1987) that a well-ramified deep root system with greater root-shoot ratio to tap moisture from the deeper zones of soil is important for drought tolerance. Arjunan <u>et</u> <u>al</u>. (1988) attributed the drought tolerance characters of groundnut cultivars to their higher root-shoot ratios, which in turn contributed to higher pod yields under moisture stress conditions. The higher root-shoot ratios observed in the two sesamum varieties S-16 and CO-1 in this study, may be indicative of the better capability of these varieties to adapt themselves to conditions of moisture stress.

The number of seeds per capsule ranged from 93.33 in the variety ACV-2, to 50.67 in the variety IS-614. The wide range of variability of this trait is in line with the findings of Muhammad (1970) and Dabral and Holker (1971) in sesamum. In the present study, it was observed that the predominant component of variation for this trait was the genotypic variation. This showed a high value and was much greater than the environmental component of variation. This confirms the observations of Trehan et al. (1974), Murugesan et al. (1979) and Solanki and Paliwal (1981) in sesamum.

In the present study, two varieties, VT-43 and TNAU-11, were the earliest to putforth the first flower, each flowering within a span of 27.67 days after sowing. On the other hand, the two varieties VS-80 and TNAU-10 took the longest period of 33.33 days each to register the first flowering. Since a high value was obtained for the environmental component of variation, in comparison with the genotypic component of variation, it may be concluded that this trait is more influenced by the environment than the genotype.

The seed yield, in this study, has shown a very wide range of variation. The variety yielding the maximum quantity of seeds was ACV-2 (216.82 grams) and that yielding the minimum quantity VT-43 (33.32 grams). Muhammad (1970) and Dabral and Holker (1971) had also reported a wide range of variability for seed yield in sesamum. In the current study, seed yield was observed to be a trait highly influenced by the environment rather than the genotype, due to the predominance of environmental component of variation over genotypic component of variation. This is contrary to the reports of Gupta (1975) and Rai *et al*. (1981), who observed high genotypic coefficients of variation for seed yield.

The oil content of Sesamum seeds, in the present study, showed a rather wide range of variation. This trait ranged from 32.87 per cent in the case of the variety Co-1 to 56.96 per cent in the case of the variety C-6. The range of variability observed for oil content of seeds, in the current study, was wider than those identified by El-Jinay *et al*. (1976) and Brar (1982) in sesamum. In the present study, of all the characters studied, oil content of seeds was seen to be the trait most influenced by the genotype. The environmental component of variation was very less compared to the genotypic component of variation. This result is in agreement with the findings of Brar and Yermanos (1973), but is contrary to the findings of Mazzani (1959) who had reported that the seed oil content of Sesamum was more influenced by environmental effects than genotypic differences.

5.2. Heritability

Heritability is an index of the transmissibility of characters from generation to generation and it provides a measure of the value of selection for different characters in various genotypes. The estimate of heritability is useful to the plant breeder for selection based on the genotypic worth of a character.

In this study, the oil content of seeds was seen to be the most heritable character, with a heritability estimate of 94 per cent. This confirms the reports of Osman and Khidir (1974), who observed that the oil content in Sesamum gave heritability estimates exceeding eighty percentage in one season or the other. The high estimates of heritability observed for number of seeds per capsule (74 per cent) in this study, is in consonance with the observations of Dabral and Holker (1971), Sawant (1971), Osman and Khidir (1974) and Solanki and Paliwal (1981) in Sesamum. Moderate estimates of heritability were observed for number of capsules per plant (58 per cent), number of leaves per plant (57 per cent), number of primary branches (46 per cent) and plant height at maturity (34 per cent) in this study. A medium heritability for number of capsules per plant in sesamum was also reported by Solanki and Paliwal (1981). For this character, a low heritability was observed in sesamum by Murugesan et al. (1979) and a high heritability by Paramasivam and Prasad (1981), Chavan et al. (1982) and Zhan (1983) among others. The present study does not confirm to the reports of Osman and Khidir (1974) and Chavan et al. (1982), who observed that the number of primary branches in sesamum showed high estimates of heritability. The estimate of heritability for plant height at maturity, in this study, was only moderate, as against the reports of high estimates by Osman and Khidir (1974), Salazar and Onoro (1975), Gupta and Gupta (1977) and Rai et al. (1981) in sesamum. In the current study, the characters length of the capsule, breadth of the capsule, root-shoot ratio, days to first flowering and seed yield were found to be less heritable. Osman and Khidir (1974) had observed high heritability for length of the capsule and Dabral and Holker (1971) and Solanki and Paliwal (1981) had observed high heritability for length and breadth of the capsule, which is contrary to the present finding. The results of this study confirms the observations of Mohanty and Sinha (1965) who reported a low heritability for duration upto flowering in sesamum. Murugesan et al. (1979) had obtained a low estimate of heritability for seed yield in sesamum, which is in line with the observation in the present study. But for the same trait, a moderate estimate of heritability was observed by Solanki and Paliwal (1981) and high estimates of heritability by Sanjeeviah and Joshi (1974), Paramasivam and Prasad (1981) and Zhan (1983) among others.

5.3. Genetic Advance

The estimates of heritability indicates only the effectiveness with which selection of a genotype can be made based on the phenotypic performance, but fails to indicate its genetic progress that can be achieved (Johnson *et al*., 1955). Swarup and Chaugale (1962) had pointed out that high heritability per se was not an index of high genetic gain, but should be accompanied by high genetic advance.

In the present study, it was observed that under 5 per cent intensity of selection, the predicted genetic advance was high for the characters number of seeds per capsule, percentage oil content of seeds, number of capsules per plant, plant height at maturity and number of leaves per plant, in the descending order. For these characters the estimates of heritability were either high or moderate. Solanki and Paliwal (1981) had also observed high genetic advance coupled with high heritability for number of seeds per capsule. The high estimate of genetic advance obtained for the character oil content of seeds is contrary to the finding of Osman and Khidir (1974) who reported that seed oil content gave a very low value of genetic advance. High estimates of genetic advance and heritability, for the character number of capsules per plant in sesamum, were reported by Osman and Khidir (1974), Gupta and Gupta (1977), Solanki and Paliwal (1981) and Chavan et al. (1982). John (1985) observed high genetic advance for number of capsules on main stem during the rabi season and for number of capsules on branches during the summer season. The finding of Sawant (1971), that high genetic advance associated with high heritability for height of the plant, has been confirmed by this study. But Rai et al. (1981) reported that plant height exhibited high heritability in conjunction with low genetic advance. For the characters length of the capsule, breadth of the capsule, root-shoot ratio, days to first flowering and seed yield, which gave low estimates of heritability, in the present study, the genetic advance observed was either very low or negligible. Sawant (1971) and Osman and Khidir (1974) observed that the magnitude of genetic advance for days to flowering was high in sesamum, which is contradicted in this study. In the case of seed yield, John (1985) reported that genetic advance for the trait was the lowest in the summer rice fallows, which has been confirmed by the present study. On the other hand, during the rabi season, John (1985) observed that seed yield had the highest genetic advance.

5.4. Correlation Coefficients

Gene correlation gives an idea about the extent to which two characters are under the control of the same set of genes or have the same physiological basis for their expressions. Estimates of genotypic association, phenotypic association and environmental association would give a clear picture of the extent of inherent correlation and also indicate how much of the phenotypic expression is influenced by the environment.

5.4.1. Phenotypic correlations

At the phenotypic level, plant height at maturity was positively correlated with seed yield, in the present study. This is in accordance with the results of Ghosh and Sen (1980), Thangavelu and Rajasekaran (1983), Krishnadoss and Kadambavanasundaram (1986) and Bhele *et al.* (1987) in sesamum. The character number of primary branches had a positive association with seed yield, which confirms the reports of Thangavelu and Rajasekaran (1983), Gupta and Chopra (1984), John (1985) during the summer season and Godawat and Gupta (1986). Studies by Jatasra and

Dahiya (1988) on forage cowpea grown under rainfed conditions had revealed that the number of primary branches was positively correlated with forage yield. The number of leaves had a positive association with seed yield, in the present study. This is in consonance with the results obtained by Ali and Naidu (1982) in maize grown under moisture stress, Sen and Misra (1982) in gamma-irradiated wheat grown under rainfed conditions and Jindal (1989) in forage cowpea grown under rainfed conditions. The positive association of number of capsules per plant and seed yield was revealed in the present study also, which is in accordance with the findings of Rai et al. (1981), Chandramony (1984), John (1985), Uzo et al. (1985), Godawat and Gupta (1986) and Bhele et al. (1987). The results of the present study indicate that both length of the capsule and breadth of the capsule had a positive correlation with seed yield. Thus, the results of studies undertaken in sesamum by Gupta and Gupta (1977), Chavan and Chopde (1981) and Godawat and Gupta (1986) in the case of length of the capsule, and Ramachandran et al. (1972) and John (1985), in the case of breadth of the capsule, have been confirmed. A positive correlation was observed between the leaf area index and seed yield, in the present study, as was reported by Ali and Naidu (1982) in inbred lines, open pollinated varieties, synthetics, composites and hybrids of maize grown under moisture stress conditions. The character root-shoot ratio had a negative non-significant association with seed yield in the present study. This is contrary to the finding of Venkataramana and Naidu (1989), who reported that in water-stressed sugarcane, the shoot-root ratio had a positive association with growth and yield. On the other hand, Chaudhary et al. (1989) observed that in chickpea grown under moisture stress, seed yield was not significantly associated with any of the physiological characters studied, like root-shoot ratio, or with indices of moisture stress. It was observed in the present study that the number of seeds per capsule was positively correlated with seed yield, which is in confirmation with the findings of Chavan and Chopde (1981) and Zhan (1983), but contrary to the reports of Thangavelu and Rajasekaran (1983) and Chandramony (1984), who observed a negative correlation of this character with seed yield in sesamum. It has been pointed out by Neyshabouri and Hatfield (1986) that in soybean, the number of seeds per pod was one of the yield components most affected by water stress. The character number of days to first flowering, was negatively, but non-significantly associated with seed yield in the present study. This confirms the finding of Chandramony (1984), who reported a negative correlation and the findings of Muhammad <u>et al</u>. (1970) and Kaushal <u>et al</u>. (1974), who reported a non-significant correlation between days to first flowering and seed yield.

The seed oil content of Sesamum was positively associated with plant height at maturity, in this study, as observed by Chandramony (1984) and John (1985) during the rabi season. It was also observed in the present study that the number of primary branches had a positive correlation with the seed oil percentage of Sesamum. Chandramony (1984) had reported that the correlation between the number of primary productive branches and oil content of seeds was positive, which is confirmed by this result. This study has revealed the positive association of length of the capsule with seed oil content, which confirms the finding of John (1985) during the rabi season. The character breadth of the capsule had a negative non-significant correlation with oil content of seeds. This does not agree with the finding of John (1985) that seed oil was positively affected by circumference of the capsule during the summer season. The correlation of number of seeds per capsule with oil content of seeds was positive and significant in this study. A similar relationship was observed by Chandramony (1984) and John (1985) during the summer season.

The positive correlation of days to first flowering with oil content of seeds, observed in this study, is in consonance with the result of John (1985) in the summer season. In the present study, seed yield and seed oil content exhibited a positive association between themselves, which is confirmatory to the reports of Thangavelu and Rajasekaran (1983) and Taylor et al. (1986), but contrary to the report of Chandramony (1984). A significant negative correlation of root-shoot ratio with seed oil content was observed in this study. The correlation of leaf area index with seed oil content was negative but non-significant. The number of leaves per plant and the number of capsules per plant were positively associated with the seed oil content.

Plant height at maturity was significantly and positively correlated with number of primary branches, number of leaves per plant and number of capsules per plant. The report of Chavan and Chopde (1981) indicating that plant height at maturity was significantly and positively correlated with number of capsules per plant and number of primary branches, stands confirmed by this result. Both the length and breadth of the capsule, in this study, had a non-significant negative association with plant height at maturity, contrary to the findings of Ramachandran et al. (1972) and Chavan and Chopde (1981).

In the present study, plant height at maturity had a non-significant negative association with root-shoot ratio and similar type of positive association with number of seeds per capsule and days to first flowering. The number of primary branches was seen to be positively and significantly correlated with number of primary branches, number of leaves per plant and number of capsules per plant, which is in agreement with the report of Chavan and Chopde (1981). The negative correlation of this character with number of seeds per capsule is also in confirmation with the finding of Chavan and Chopde (1981). The number of primary branches was negatively and non-significantly associated with length of the capsule, leaf area index, root-shoot ratio and days to first flowering and positively associated with breadth of the capsule. Positive and significant correlations were seen between number of leaves and plant height at maturity, number of primary branches and number of capsules per plant. This trait had non-significant negative associations with length of the capsule, breadth of the capsule, leaf area index, number of seeds per capsule and days to first flowering and a positive association with root-shoot ratio. The significant positive correlations of number of capsules per plant with plant height at maturity and number of primary branches, are in accordance with the findings of Yadava et al. (1980), Rai et al. (1981) and Gupta and Chopra (1984). This trait was positively and significantly correlated with number of leaves per plant and negatively and significantly with length of the capsule and number of seeds per capsule. On the other hand, the negative correlations of number of capsules per plant with breadth of the capsule, leaf area index, root-shoot ratio and days to first flowering were not significant. The length of the capsule was negatively and significantly correlated with number of capsules per plant. Chavan and Chopde (1981) had reported a negative, but non-significant correlation of length of the capsule with number of capsules per plant. Length of the capsule showed negative non-significant associations with plant height at maturity, number of primary branches, number of leaves per plant and days to first flowering and similar positive associations with breadth of the capsule, leaf area index, root-shoot ratio and number of seeds per capsule. The breadth of the capsule was positively and significantly correlated with leaf area index and non-significantly correlated with length of the capsule and number of primary branches. The correlations between this character and plant height at maturity, number of leaves per plant, number of capsules per plant, root-shoot ratio, number of seeds per capsule and days to first flowering were negative but not significant. Leaf area index had a significant association with breadth of the capsule only, which was a positive correlation. Its correlations with length of the capsule, number of seeds per capsule and days to first flowering were positive while those with plant height at maturity, number of primary branches, number of leaves, number of capsules and root-shoot ratio were negative. Root-shoot ratio was positively associated with number of leaves per plant, length of the capsule, number of seeds per capsule and days to first flowering, and was negatively associated with plant height at maturity, number of primary branches, number of capsules per plant, breadth of the capsule and leaf area index. The number of seeds per capsule was positively and non-significantly correlated with plant height at maturity and length of the capsule. This is similar to the report of Chavan and Chopde (1981) who observed a positive significant correlation of the number of seeds per capsule, with plant height at maturity and length of the capsule. In the present study, number of seeds per capsule showed a significant positive association with days to first flowering and a significant negative association with number of capsules per plant. Non-significant correlations of this characters were observed with number of primary branches, number of leaves per plant, and breadth of the capsule, which were negative and with leaf area index and root-shoot ratio, which were positive. The character days to first flowering was positively and significantly correlated to number of seeds per capsule, contrary to the finding of Chavan and Chopde (1981) who observed a significant negative association between these characters. Days to first flowering was observed to have non-significant positive correlation with plant height at maturity and a similar negative correlation with length of the capsule, which are in agreement with the report of Chavan and Chopde (1981) and a negative non-significant correlation with number of capsules per plant, which is contrary to the report of Chavan and Chopde (1981). Non-significant correlations of days to first flowering with number of primary branches, number of leaves per plant and breadth of the capsule were negative, while non-significant correlations with leaf area index and root-shoot ratio were positive.

5.4.2. Genotypic correlations

At the genotypic level, plant height at maturity was positively correlated with seed yield, which confirm the reports of Thangavelu and Rajasekaran (1983), John (1985) during the rabi season and Bhele <u>et al</u>. (1987), who observed a positive correlation of this trait with seed yield at the genotypic level. A negative association was observed between the number of primary branches per plant and seed yield in the present study, in contrast to the findings of Yadava _et al_. (1980), Chavan and Chopde (1981) and John (1985) during the summer season, whose reports speak of positive genotypic correlation between these two characters. But the present finding is in agreement with the report of Gomathinayagam _et al_. (1988) whose study revealed that in rice grown under upland condition, negative correlation existed between grain yield and total tillers per plant. The present study has revealed a high negative correlation of number of leaves per plant with seed yield, contrary to the reports of Ali and Naidu (1982) in maize grown under moisture stress and Jindal (1989) in forage cowpea grown under rainfed conditions. The high negative correlation of number of capsules per plant with seed yield, observed in this study, disagrees with the reports of positive correlation of this character with seed yield at the genotypic level, by John (1985) during the two seasons of rabi and summer and Bhele _et al_. (1987). In the present study, both the length and breadth of the capsule were positively correlated with seed yield, confirming the finding of a similar genotypic relationship between these two characters, during the rabi season, by John (1985). It was observed in the present study that a high positive correlation existed between root-shoot ratio and seed yield. This is in consonance with the results obtained by Venkataramana and Naidu (1989) in water-stressed sugarcane, wherein it was reported that shoot-root ratio has a positive association with growth and yield. The correlation of number of seeds per capsule with seed yield was positive in this study, which lends confirmation to the findings of John (1985) during the rabi season and Bhele et al. (1987), that a similar relationship existed among these two characters in the genotypic level. Days to first flowering was another character in the present study, which exhibited a high positive correlation with seed yield. This is in line with the finding of Chavan and Chopde (1981), but contrary to the report of John (1985) that during both rabi and summer seasons, the yield of seeds was negatively correlated with number of days to flowering, at the genotypic level.

This study had revealed that plant height at maturity was positively correlated with oil content of seeds in sesamum, which is in consonance with the observations of Chandramony (1984) and John (1985) during the rabi season. The finding of Chandramony (1984) that the number of primary branches per plant was positively associated with oil content of seeds, has been confirmed by the results of this study. The present study had indicated that the length of the capsule was positively associated with the oil content of seeds, confirming the finding of John (1985) during the rabi season, and that the breadth of the capsule was negatively associated with the oil content of seeds, contrary to the finding of John (1985) during the summer season. The number of seeds per capsule was positively correlated with the oil content of seeds in this study also, similar results being reported by Chandramony (1984). In the present study, days to first flowering had a positive relationship with oil content of seeds, as was earlier reported by John (1985) during the summer season. There existed a positive association between seed yield and oil content of seeds of Sesamum, as brought out by this study, thus confirming the reports of Thangavelu and Rajasekaran (1983), Tayoler et al. (1986) and Bhele et al. (1987) on similar lines. The character root-shoot ratio had a relatively high negative correlation with oil content of seeds in this study, while the characters number of leaves per plant and number of capsules were positively associated with oil content of seeds.

Inter-correlations of plant height at maturity with number of primary branches per plant and number of capsules per plant were positive, similar to the reports of Chavan and Chopde (1981). The finding of Ramachandran et al. (1972) that plant height at maturity was positively correlated with size of the capsule, is confirmed by this study, since the length of the capsule and breadth of the capsule were seen to have a positive relationship with plant height at maturity. This character had positive correlations with number of leaves per plant, number of seeds per capsule and days to first flowering and a negative correlation with root-shoot ratio. The number of primary branches, in this study, was positively associated with number of capsules per plant and negatively with number of seeds per capsule, in accordance with the finding of Chavan and Chopde (1981). This trait was negatively correlated with length of the capsule, root-shoot ratio and days to first flowering and positively correlated with number of leaves per plant and breadth of the capsule. The number of leaves had a positive association with number of capsules per plant and negative associations with length and breadth of the capsule, root-shoot ratio, number of seeds per capsule and days to first flowering. The number of capsules per plant had a positive correlation with number of primary branches per plant, which confirms the reports of Yadava et al. (1980) and Gupta and Chopra (1984). It was seen to be positively correlated with plant height at maturity, which confirms the finding of Rai et al. (1981). Positive correlations existed between this character, namely number of capsules per plant, and length and breadth of the capsule, while negative correlations existed with root-shoot ratio, number of seeds per capsule and days to first flowering. The length of the capsule was positively associated with number of capsules per plant, converse to the finding of Chavan and Chopde (1981). The correlations of length of the capsule were positive with root-shoot ratio and number of seeds per capsules and negative with breadth of the capsule and days to first flowering. At the same time, the correlation of breadth of the capsule was negative with root-shoot ratio and positive with number of seeds per capsule and days to first flowering. The genotypic correlation coefficients of leaf area index were not estimable in this study because its genotypic variance was not estimable. It was observed that root-shoot ratio, in this study, was negatively correlated with number of seeds per capsule and days to first flowering. The report of Chavan and Chopde (1981), indicating that the number of seeds per capsule was positively correlated with plant height at maturity and with length of the capsule, has been confirmed through the results of this study. This character had a positive association with breadth of the capsule and days to first flowering, but negative associations with number of primary branches per plant, number of leaves per plant, number of capsules per plant and root-shoot ratio. Days to first flowering in *Sesamum* was positively correlated, with plant height at maturity and negatively correlated with length of the capsule, which agrees with the report of Chavan and Chopde (1981). This character was negatively correlated with number of capsules per plant and positively correlated with number of seeds per capsule, which runs contrary to the above report. Besides, negative correlations were observed between days to first flowering and number of primary branches per plant, number of leaves per plant, breadth of the capsule and root-shoot ratio.

5.4.3. Environmental correlations

At the environmental level, seed yield had highly significant positive correlations with number of leaves per plant and number of capsules per plant, and a significant positive correlation with number of primary branches per plant in the present study. The associations of seed yield with plant height at maturity, length of the capsule and breadth of the capsule were positive but non-significant, while those with leaf area index, root-shoot ratio, number of seeds per capsule and days to first flowering were negative but non-significant.

The oil content of seeds was not significantly correlated with any of the characters included in this study. Nevertheless this trait was positively correlated with plant height at maturity, number of primary branches, leaf area index and days to first flowering, while being negatively correlated with number of leaves per plant, number of capsules per plant, length of the capsule, breadth of the capsule, root-shoot ratio, number of seeds per capsule and seed yield.

Plant height at maturity had significant correlations with number of primary branches per plant, number of leaves per plant and number of capsules per plant in a positive manner and with root-shoot ratio in a negative manner. The positive correlation of this character with days to first flowering and negative correlations with length of the capsule, breadth of the capsule, leaf area index and number of seeds per capsule were not significant. The number of primary branches per plant was significantly and positively associated with number of leaves per plant and number of capsules per plant and similarly negatively associated with root-shoot ratio. This character had non-significant positive correlations with number of seeds per capsule and days to first flowering and similar negative correlations with length of the capsule, breadth of the capsule and leaf area index. The number of leaves per plant was observed to be positively and significantly correlated with number of capsules per plant. Negative non-significant correlations was observed between the number of leaves per plant and length of the capsule, breadth of the capsule, leaf area index, number of seeds per capsule and days to first flowering while positive non-significant correlation was seen with root-shoot ratio. Significant negative correlation existed between number of capsules and length of the capsule, and non-significant negative correlations between number of capsules and breadth of the capsule, leaf area index, root-shoot ratio, number of seeds per capsule and days to first flowering. The correlation of length of the capsule with leaf area index was positive and significant and the correlations with breadth of the capsule and root-shoot ratio were positive but not significant, while those with number of seeds per capsule and days to first flowering were negative and non-significant. As in the case of length of the capsule, the breadth of the capsule also had a significant positive association with leaf area index. The non-significant positive correlation of this character with root-shoot ratio and the non-significant negative correlations with number of seeds per capsule and days to first flowering, were similar to the correlations of length of the capsule with these characters. The correlation of leaf area index with number of seeds per capsule was positive and highly significant, while those with root-shoot ratio and days to first flowering were non-significant, the former being a positive relationship and the latter being a negative relationship. Root-shoot ratio had non-significant positive associations with number of seeds per capsule and days to first flowering. The environmental correlation of number of seeds per capsule with days to first flowering was positive, but not significant.

5.5. Path Analysis

Path analysis technique, developed by Wright (1921), is used to understand the causal basis of the association between two characters, which is measured by the correlation coefficients. In this study also, path analysis was used to estimate the direct and indirect effects of the different plant characters on seed yield and oil content of seeds separately. The characters plant height at maturity, number of capsules per plant, length of the capsule, breadth of the capsule, root-shoot ratio, number of seeds per capsule, days to first flowering and oil content of seeds were used to estimate the direct and indirect effects on seed yield. Similarly, the characters plant height at maturity, number of primary branches, number of leaves per plant, number of capsules per plant, number of seeds per capsule and seed yield were used to estimate the direct and indirect effects on oil content of seeds. In the first case, a residual value of 1.67 and in the second case, a residual value of 0.92 were obtained. The high residual values observed indicate that the characters selected for path analysis are not sufficient to explain the correlations of plant characters on seed yield and oil content, in the present study.

5.6. Selection Indices and Genetic gain

Identification of superior genotypes of Sesamum under rainfed conditions, possessing high oil content and seed yield, was done by employing discriminant function analysis. The characters plant height at maturity, number of primary branches per plant, number of capsules per plant, number of seeds per capsule, seed yield and oil content of seeds were considered to fit the discriminant function, based on which the selection indices were worked out. The genotype showing the highest estimate of selection criterion was ranked first and that showing the lowest estimate of selection criterion was ranked the last.

Among the twenty five varieties included in this study, five varieties were identified as superior genotypes under 20 per cent intensity of selection, of which, the variety ACV-2 ranked first, followed by the varieties TNAU-12, TNAU-10, NPG-3 and TSS-6 in that order. This indicates that these varieties are capable of yielding higher proportions of seed oil and seed yield, under rainfed conditions in rabi uplands.

Genetic gain obtainable under selection was estimated following the relation proposed by Singh and Choudhary (1976). It was observed that under a selection intensity of 20 per cent, the expected genetic gain was 37.25.

5.7. Drymatter production

The quantity of drymatter produced per plant was estimated in the case of the twenty five genotypes included in this study. The results indicate that the maximum quantity of drymatter was produced by the variety ACV-2, followed by TNAU-12 and that the minimum quantity of drymatter was produced by the variety Vayalellu. In general, the quantities of drymatter produced in all the twenty five genotypes were relatively low, which could be attributed to the rainfed condition under which the crop was raised. Talukder (1982) had reported that the total drymatter production seemed to decrease when the early stages of Sappo spring wheat were exposed to water stress. Similarly, in pearl millet, it was reported by Ibrahim et al. (1985) that the dry weights were significantly reduced by water stress, which was later confirmed by Sadasivum et al. (1988) in greengram.

5.8. Proline accumulation

Under water stress condition the metabolic process of the plant is affected in that the protein synthesis is inhibited and amino acid metabolism is modified leading to a rapid and extensive accumulation of proline, according to Barnett and Naylor (1966). Reports of accumulation of substantial amounts of the amino acid proline in response to water stress in crop plants, have been propounded, Kaufmann (1972) in oranges, Blum and Ebercon (1976) in Sorghum, Khvostova (1981) in castor, Bhale et al.(1982) in Sorghum and Goyal et al. (1985) and Ram et al. (1988) both in rice. In the present study, free proline contents in the twenty five varieties of Sesamum were estimated. The variety NPG-3 accumulated the maximum amount of proline per gram of its dry weight, followed by Kayamkulam-1.

Singh et al. (1972), Waldren et al. (1974) and Hurd (1976) had opined that proline accumulation potential could be an index of drought tolerance in plants, while Hanson et al. (1977) observed that proline accumulation potential cannot be an index of drought tolerance.

According to Palfi et al. (1974), a species can be regarded as 'proline accumulating', if the amount of free proline in the leaves at the time of strong water deficit reached at least one per cent of the dry weight. In the present study, the maximum extent of proline accumulation was observed to be to the tune of 0.6 per cent of the dry weight, in the variety NPG-3, followed by 0.55 per cent in the variety Kayamkulam-1. This means that none of the Sesamum varieties included in this study could be regarded as a 'proline accumulating' genotype as per the criterion proposed by Palfi et al. (1974). At the same time, Waldren et al. (1974) found that in soybean, accumulation of free proline was not significant until the plants were suffering severe moisture stress and were wilting visibly. In soybean itself, Fukutoku and Yamada (1981) observed that proline accumulated only under severe water stress and attained 0.86 per cent of the dry weight. In the present study, the crop was not subjected to severe moisture stress, as is evinced in the ensuing sections, and was not wilting visibly during any of its growth stages. This could be the probable reason for the failure of proline to accumulate in substantial amounts in any of the Sesamum genotypes included in this study.

5.9. Soil moisture percentage

Moisture availability in the soil has a profound effect on the growth and yield of any crop. Kunju and Salam (1980) observed that Sesamum seeds registered the maximum germination percentage when the soil moisture level was at 30 per cent. In the present study, the mean soil moisture level 7 days after sowing was only 6.93, which indicates that the soil moisture level was sub-optimal for the germination of the seeds sown. This could have affected the germination percentage of the seeds sown and consequently resulted in a variation in the crop stand. Singh and Yusuf (1981) reported that the oil content in safflower had a quadratic relationship with moisture supply. Likewise, Patel and Mistry (1981) found that the relationship between the percentage moisture available days during the growth period and the reported yield, in groundnut, was fairly linear. In the present study, soil moisture percentage showed a large variation, recording the minimum value during the third week after sowing and the maximum value during the eighth week after sowing.

5.10. Weather parameters

Shastry and Kumar (1983) found that the weather prevailing during the growth phases of Indian mustard had a considerable influence on seed yield and percentage of oil. Anderson et al. (1978) had reported that the decline in seed yield of sunflower was associated with a reduced mean temperature regime during the vegetative stages of growth. Studies by Shipler and Blum (1986) indicated that in wheat, hot day temperature affected the yield components. In the present study the maximum mean air temperature did not vary much during the cropping season, while the minimum mean air temperature showed a wide variation during the later stages of the cropping period, especially from the 11th to the 14th week after sowing. It could be noted that the pattern of variation in the maximum and minimum air temperatures was more or less similar during a greater part of the cropping period, excepting the 11th, 12th, 13th and 14th weeks after sowing. During the 13th week after sowing, both the maximum and minimum air temperatures recorded the highest value in the entire cropping period.

Subramanian et al. (1988) observed that in rainfed Sorghum, the grain yield, grain number and harvest index were affected by weather parameters like rainfall, relative humidity and cumulative total of daily mean air temperature.

In the present study, rainfall was observed to be one of the most variable weather parameter during the cropping period. The maximum mean rainfall was received during the 3rd week after sowing and the minimum rainfall during the 11th week after sowing. In general, moderate to good amounts of rainfall was received during the initial cropping period and a lesser amount of rainfall during the later cropping period. Consequently, high percentages of relative humidity were observed during the 1st, 2nd, 3rd, 4th and 5th weeks after sowing and low percentages of relative humidity were observed during the 10th, 11th, 12th, 13th and 14th weeks after sowing. A maximum of 87 per cent relative humidity was noticed during the 2nd week after sowing and a minimum of 65 per cent relative humidity was noticed during the 11th week after sowing. The duration of sunshine, measured from 6 am to 6 pm, also showed much variation. During the 5th week after sowing, there was sunshine for only 2.9 hours, which was the minimum during the entire cropping period. On the other hand, the duration of sunshine was maximum during the 11th week after sowing, when 8.9 hours of sunshine was received. A shorter duration of sunshine may be indicative of cloudiness and a longer duration of sunshine may be indicative of a less-clouded sky, which will facilitate more amount of the sun's radiation to reach the surface of the earth.

SUMMARY

SUMMARY

A field experiment was conducted at the College of Agriculture, Vellayani, during the rabi season of 1989, with the objective of evaluation of sesamum genotypes in order to identify superior ones possessing high oil content and to assess the relationship between yield and other plant characters through correlation and path analysis under rainfed conditions in rabi uplands. Twentyfive varieties of sesamum were raised as a purely rainfed crop, laid out in a randomised block design with three replications. Observations were recorded on the plant characters days to first flowering, height of the plant, number of primary branches, number of capsules per plant, size of the capsule, number of seeds per capsule, number of leaves per plant, leaf area index, seed yield, oil content of seeds, drymatter production, root-shoot ratio and proline content and on the weather parameters like soil moisture percentage, maximum and minimum atmospheric temperatures, rainfall, relative humidity and duration of sunshine.

Significant differences existed among varieties with respect to the six characters studied, viz., plant height, number of primary branches, number of leaves, number of capsules per plant, number of seeds per capsule and oil content of seeds. The variety C-6 had the maximum

seed oil percentage, followed by the variety TSS-6. The variations in number of leaves, number of capsules per plant, number of seeds per capsule and oil content of seeds were influenced by genotypic differences, oil content of seeds being the most influenced by genotype. High estimates of heritability were observed for oil content of seeds and number of seeds per capsule, while moderate heritability was noticed for number of capsules per plant, number of leaves per plant, number of primary branches and plant height at maturity. High genetic advance was coupled with either high or moderate estimates of heritability in the case of number of seeds per capsule, oil percentage of seeds, number of capsules per plant, plant height and number of leaves per plant.

Seed yield was positively correlated at the genotypic level with plant height at maturity, length of the capsule, breadth of the capsule, root-shoot ratio, number of seeds per capsule, days to first flowering and oil content of seeds and negatively correlated with number of leaves per plant and number of capsules per plant. The oil content of seeds was positively correlated at the genotypic level with number of seeds per capsule, days to first flowering and seed yield and was negatively correlated with root-shoot ratio. Path analysis was not found suitable to estimate the direct and indirect effects of characters since the residual values obtained were high. The varieties ACV-2, TNAU-12, TNAU-10, NPG-3 and TSS-6 were identified as the superior genotypes at 20 per cent selection and the expected genetic gain was estimated as 37.25.

Drymatter production was highest in the case of the variety ACV-1, followed by TNAU-12. The maximum amount of proline was accumulated by the variety NPG-3, followed by Kayamkulam-1, which accounted for 0.60 per cent and 0.55 per cent of the dry weights respectively. Hence none of the varieties could be regarded as a 'proline accumulating' genotype.

The soil moisture available was the highest at 56 days after sowing and the lowest at 21 days after sowing. The maximum and minimum atmospheric temperature were the highest during the 52nd standard meteorological week and were the lowest during the 41st and 50th standard weeks respectively. Rainfall received was the highest during the 42nd standard week and lowest during the 50th standard week, while relative humidity showed the highest value during the 41st standard week and the lowest during the 50th standard week. The duration of sunshine was maximum during the 50th standard week and was minimum during the 44th standard week.

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*Original not seen

APPENDICES

ABSTRACT

A research programme was carried out at the College of Agriculture, Vellayani with twentyfive varieties of sesamum during the rabi season of 1989, in order to identify superior sesamum genotypes possessing high oil content and to assess the relationship between yield and other plant characters through correlation and path analysis under rainfed conditions in the rabi uplands. The design adopted was a randomised block design with three replications and observations were recorded from randomly tagged plants on 13 plant characters and the major weather parameters.

Significant differences existed among varieties with respect to six characters studied. The variety C-6 had the maximum seed oil percentage of 56.96 per cent. The variation in oil content of seeds was largely due to genotypic differences. The highest estimate of 94 per cent heritability was shown by the character oil content of seeds, while the highest genetic advance under 5 per cent selection was shown by the character number of seeds per capsule. At the genotypic level, seed yield was positively correlated with plant height, length of the capsule, breadth of the capsule, root-shoot ratio, number of seeds per capsule, days to first flowering and oil content of

seeds and negatively with number of leaves per plant and number of capsules per plant. The oil content of seeds showed positive genotypic correlations with number of seeds per capsule, days to first flowering and seed yield and a negative correlation with root-shoot ratio. Path analysis technique was not found to be satisfactory to explain the direct and indirect effects of plant characters since the residual values obtained were high. The variety ACV-2 ranked first among the five varieties identified as superior genotypes at 20 per cent selection. The expected genetic gain was estimated as 37.25. The maximum amount of dry-matter was produced by the variety ACV-1. The variety NPG-3 had the highest amount of proline in its leaves. None of the varieties could be regarded as a 'proline accumulating' genotype. The highest percentage of soil moisture available was at 56 days after sowing. The sesamum crop received the highest amount of 25.5 mm rainfall during the 42nd standard meteorological week and the lowest amount of 1 mm rainfall during the 50th standard meteorological week.

APPENDICES

APPENDIX I

Weather parameters during the cropping period (5-10-1989 to 9-1-1990)

Date	Time (hours)	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Rainfall (mm)	Sunshine (hours)
1	2	3	4	5	6	7
5-10-1989	0722 1422	30.5 31.0	23.5 24.0	76 80	- -	5.0
6-10-1989	0722 1422	30.5 31.0	24.0 24.5	84 84	12.00 -	2.1
7-10-1989	0722 1422	30.2 30.5	23.0 23.5	88 90	33.2 -	3.0
8-10-1989	0722 1422	28.5 29.0	23.5 23.4	96 90	21.2 -	2.4
9-10-1989	0722 1422	28.5 29.0	23.2 23.0	84 85	- -	7.9
10-10-1989	0722 1422	29.5 30.0	23.8 23.8	77 94	- -	8.9
11-10-1989	0722 1422	30.2 29.6	24.5 24.5	83 94	- -	7.3
12-10-1989	0722 1422	29.5 29.6	23.0 24.0	87 95	- -	4.1

APPENDIX I (Contd.

1	2	3	4	5	6	7
13-10-1989	0722 1422	29.6 29.8	23.5 23.5	80 92	0.4 -	6.5
14-10-1989	0722 1422	30.0 30.5	23.5 24.0	84 81	- -	5.1
15-10-1989	0722 1422	30.0 30.5	23.5 24.0	80 85	- -	8.8
16-10-1989	0722 1422	31.0 30.5	24.0 24.0	84 95	- -	8.3
17-10-1989	0722 1422	30.7 30.5	23.4 23.4	71 95	2.2 -	5.5
18-10-1989	0722 1422	30.6 31.0	24.0 24.0	82 89	- -	5.4
19-10-1989	0722 1422	30.7 31.0	24.2 24.5	87 80	0.2 -	1.4
20-10-1989	0722 1422	29.4 29.2	24.0 24.0	95 78	16.1 -	3.6
21-10-1989	0722 1422	25.5 26.4	23.4 23.4	96 92	13.4 -	2.7
22-10-1989	0722 1422	27.4 29.5	22.5 23.2	70 78	5.2 -	7.8

APPENDIX I (Contd.)

1	2	3	4	5	6	7
23-10-1989	0722 1422	29.6 30.0	24.0 24.0	80 75	- -	9.6
24-10-1989	0722 1422	30.0 30.2	24.0 24.0	83 73	- -	8.4
25-10-1989	0722 1422	30.2 30.0	23.2 23.2	89 74	- -	7.2
26-10-1989	0722 1422	30.2 30.5	23.4 23.4	77 94	- -	9.6
27-10-1989	0722 1422	30.6 30.7	23.8 23.8	82 85	- -	5.7
28-10-1989	0722 1422	31.1 31.5	23.8 24.0	84 81	19.1 -	5.5
29-10-1989	0722 1422	29.7 29.4	24.0 24.0	90 92	- -	5.1
30-10-1989	0722 1422	30.0 30.5	23.2 23.2	84 92	1.0 -	3.7
31-10-1989	0722 1422	30.5 30.0	23.0 23.0	84 92	1.3 -	3.5
1-11-1989	0722 1422	30.2 30.5	23.0 23.0	92 76	21.4 -	2.7

APPENDIX I (Contd.)

1	2	3	4	5	6	7
2-11-1989	0722 1422	30.5 30.2	23.0 23.0	97 65	3.4 -	3.0
3-11-1989	0722 1422	30.0 29.8	23.8 23.6	82 78	2.1 -	0.8
4-11-1989	0722 1422	29.0 31.0	24.0 23.6	92 81	- -	1.7
5-11-1989	0722 1422	31.0 30.8	24.0 23.5	97 85	7.2 -	4.0
6-11-1989	0722 1422	30.5 29.8	26.8 26.8	84 78	1.1 -	2.3
7-11-1989	0722 1422	29.8 30.5	23.5 23.5	87 75	5.2 -	2.5
8-11-1989	0722 1422	31.0 31.0	24.0 23.0	87 69	- -	8.6
9-11-1989	0722 1422	31.0 31.0	24.0 23.5	78 78	- -	8.5
10-11-1989	0722 1422	32.0 32.2	26.0 24.0	92 74	16.0 -	9.0
11-11-1989	0722 1422	32.0 32.5	24.0 24.5	89 85	30.0 -	7.2

APPENDIX I (Contd.)

1	2	3	4	5	6	7
12-11-1989	0722	32.0	24.0	89	5.6	0.2
	1422	31.0	23.0	86	–	
13-11-1989	0722	28.5	22.5	90	5.3	6.1
	1422	30.4	22.5	90	–	
14-11-1989	0722	30.5	23.6	87	–	3.8
	1422	30.5	23.6	89	–	
15-11-1989	0722	30.7	24.0	89	–	2.8
	1422	30.5	24.0	77	–	
16-11-1989	0722	30.5	24.2	75	–	7.8
	1422	31.5	24.2	88	–	
17-11-1989	0722	31.8	24.0	85	–	6.8
	1422	31.5	24.0	50	–	
18-11-1989	0722	32.0	24.5	89	–	2.7
	1422	31.5	24.0	79	–	
19-11-1989	0722	31.2	24.0	83	2.4	2.9
	1422	30.4	24.0	77	–	
20-11-1989	0722	30.7	24.0	77	0.4	0.8
	1422	30.4	23.5	81	–	
21-11-1989	0722	30.3	23.0	90	–	9.7
	1422	30.7	22.5	67	–	

APPENDIX I (Contd.)

1	2	3	4	5	6	7
22-11-1989	0722 1422	30.8 30.2	22.8 22.5	69 68	- -	9.3
23-11-1989	0722 1422	30.5 31.1	23.0 22.8	77 62	- -	9.0
24-11-1989	0722 1422	31.4 31.5	22.0 22.0	70 60	- -	9.6
25-11-1989	0722 1422	31.5 30.2	21.2 21.5	92 60	- -	9.9
26-11-1989	0722 1422	31.2 30.5	20.2 20.5	80 66	- -	9.4
27-11-1989	0722 1422	31.5 30.6	21.0 22.2	79 66	- -	9.4
28-11-1989	0722 1422	31.0 31.5	23.5 23.5	80 66	- -	7.3
29-11-1989	0722 1422	31.2 31.2	23.7 23.5	73 61	- -	10.5
30-11-1989	0722 1422	31.2 31.1	23.8 23.5	76 67	- -	10.9
1-12-1989	0722 1422	31.2 31.8	24.5 24.5	65 67	0.3 -	7.8

APPENDIX I (Contd.)

1	2	3	4	5	6	7
2-12-1989	0722 1422	31.8 30.7	24.0 24.0	80 69	5.0 -	5.1
3-12-1989	0722 1422	30.8 30.8	23.4 23.4	89 65	23.1 -	11.1
4-12-1989	0722 1422	31.1 31.4	23.0 23.0	66 78	- -	8.7
5-12-1989	0722 1422	31.2 30.2	23.0 23.0	78 74	3.1 -	2.9
6-12-1989	0722 1422	30.1 31.5	22.5 22.5	66 53	- -	7.4
7-12-1989	0722 1422	31.2 31.5	23.5 23.5	72 69	- -	7.6
8-12-1989	0722 1422	31.5 31.5	23.0 22.0	65 58	- -	9.1
9-12-1989	0722 1422	31.0 31.5	22.0 23.0	71 59	- -	8.3
10-12-1989	0722 1422	31.2 31.5	21.5 22.0	88 70	- -	9.8
11-12-1989	0722 1422	31.1 31.1	21.0 21.0	72 55	- -	9.6

APPENDIX I (Contd.)

1	2	3	4	5	6	7
12-12-1989	0722	31.2	21.4	73	-	9.2
	1422	30.5	21.4	59	-	
13-12-1989	0722	30.4	20.5	59	-	9.5
	1422	31.4	21.0	55	-	
14-12-1989	0722	31.5	21.5	77	-	9.3
	1422	31.0	21.0	51	-	
15-12-1989	0722	31.1	20.5	73	7.0	5.9
	1422	31.0	20.8	63	-	
16-12-1989	0722	31.0	21.5	61	-	8.2
	1422	31.4	21.5	54	-	
17-12-1989	0722	31.2	22.0	93	8.0	7.7
	1422	30.4	22.0	63	-	
18-12-1989	0722	30.5	22.0	64	-	8.7
	1422	31.2	22.0	62	-	
19-12-1989	0722	31.0	21.9	58	-	7.6
	1422	30.6	21.9	65	-	
20-12-1989	0722	30.8	22.0	73	-	7.5
	1422	30.5	22.0	62	-	
21-12-1989	0722	30.5	22.4	69	1.0	6.9
	1422	30.5	22.4	63	-	

APPENDIX I (Contd.)

1	2	3	4	5	6	7
22-12-1989	0722 1422	30.5 31.4	21.5 21.4	63 69	- -	8.3
23-12-1989	0722 1422	31.4 31.0	21.5 21.5	71 60	- -	7.3
24-12-1989	0722 1422	31.0 31.5	22.0 22.5	74 63	- -	8.3
25-12-1989	0722 1422	31.4 31.6	22.0 22.5	77 65	- -	8.0
26-12-1989	0722 1422	32.0 30.9	23.0 23.5	81 66	10.0 -	7.9
27-12-1989	0722 1422	31.0 31.5	23.4 23.4	77 64	- -	8.2
28-12-1989	0722 1422	31.4 31.2	23.0 23.0	76 68	- -	6.6
29-12-1989	0722 1422	32.0 31.0	23.2 23.2	71 69	- -	6.3
30-12-1989	0722 1422	31.0 31.5	23.4 23.4	71 63	- -	6.4
31-12-1989	0722 1422	31.5 31.5	23.2 23.0	80 70	- -	9.6

APPENDIX I (Contd.)

1	2	3	4	5	6	7
1-1-1990	0722 1422	31.8 31.0	22.2 22.2	68 63	2.3 -	8.1
2-1-1990	0722 1422	31.0 31.5	23.5 23.5	79 63	- -	6.7
3-1-1990	0722 1422	31.4 31.5	23.0 23.0	74 60	- -	7.8
4-1-1990	0722 1422	31.5 31.3	22.9 22.9	84 56	3.0 -	5.9
5-1-1990	0722 1422	31.5 30.5	22.5 21.5	62 52	- -	0.2
6-1-1990	0722 1422	30.5 30.0	21.5 21.0	52 51	3.2 -	1.0
7-1-1990	0722 1422	28.5 27.5	23.0 22.5	91 90	8.4 -	1.6
8-1-1990	0722 1422	28.8 30.5	22.9 22.7	79 59	- -	6.8
9-1-1990	0722 1422	31.8 31.2	22.4 22.2	77 64	- -	8.5

Source: Meteorological Observatory, College of Agriculture, Vellayani.

CORRELATION AND PATH ANALYSIS IN SESAMUM (*Sesamum indicum* L.) UNDER RAINFED CONDITIONS

BY

KURIAKOSE CONIL

ABSTRACT OF A THESIS

submitted in partial fulfilment of the requirement
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DEPARTMENT OF PLANT BREEDING
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ABSTRACT

A research programme was carried out at the College of Agriculture, Vellayani with twentyfive varieties of sesamum during the rabi season of 1989, in order to identify superior sesamum genotypes possessing high oil content and to assess the relationship between yield and other plant characters through correlation and path analysis under rainfed conditions in the rabi uplands. The design adopted was a randomised block design with three replications and observations were recorded from randomly tagged plants on 13 plant characters and the major weather parameters.

Significant differences existed among varieties with respect to six characters studied. The variety C-6 had the maximum seed oil percentage of 56.96 per cent. The variation in oil content of seeds was largely due to genotypic differences. The highest estimate of 94 per cent heritability was shown by the character oil content of seeds, while the highest genetic advance under 5 per cent selection was shown by the character number of seeds per capsule. At the genotypic level, seed yield was positively correlated with plant height, length of the capsule, breadth of the capsule, root-shoot ratio, number of seeds per capsule, days to first flowering and oil content of

seeds and negatively with number of leaves per plant and number of capsules per plant. The oil content of seeds showed positive genotypic correlations with number of seeds per capsule, days to first flowering and seed yield and a negative correlation with root-shoot ratio. Path analysis technique was not found to be satisfactory to explain the direct and indirect effects of plant characters since the residual values obtained were high. The variety ACV-2 ranked first among the five varieties identified as superior genotypes at 20 per cent selection. The expected genetic gain was estimated as 37.25. The maximum amount of dry-matter was produced by the variety ACV-1. The variety NPG-3 had the highest amount of proline in its leaves. None of the varieties could be regarded as a 'proline accumulating' genotype. The highest percentage of soil moisture available was at 56 days after sowing. The sesamum crop received the highest amount of 25.5 mm rainfall during the 42nd standard meteorological week and the lowest amount of 1 mm rainfall during the 50th standard meteorological week.