

**STUDIES ON INDEXING THE ECONOMIC CHARACTERS OF  
VARIETIES AND HYBRIDS FOR THE GENETIC IMPROVEMENT  
OF COCONUT ( *Cocos nucifera* L. ) THROUGH SELECTION.**

*Thesis submitted in part fulfillment of the requirements for the degree of  
Doctor of Philosophy in Horticulture to the  
Tamil Nadu Agricultural University, Coimbatore*

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**1999**

## CERTIFICATE

*This is to certify that the thesis entitled "Studies on indexing the economic characters of varieties and hybrids for the genetic improvement of Coconut ( Cocos nucifera L.) through selection" submitted in partial fulfillment of the requirements for the award of the degree of Doctor of Philosophy (Horticulture) to the Tamil Nadu Agricultural University, Coimbatore is a record of bona fide research work carried out by Miss. M. Renuga under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.*

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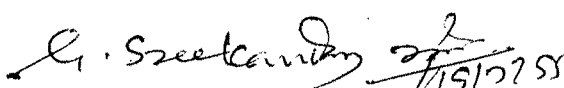
  
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# *Abstract*

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## ABSTRACT

### STUDIES ON INDEXING THE ECONOMIC CHARACTERS OF VARIETIES AND HYBRIDS FOR GENETIC IMPROVEMENT OF COCONUT (*Cocos nucifera* L.) THROUGH SELECTION

By

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Investigations were carried out with ten genotypes of coconut (*Cocos nucifera* L.) to study the *per se* performance, extent of variability, heritability genetic advance, degree of association of characters and direct and indirect effects of various component traits for yield and also to fix the selection criteria in the coconut seedlings at four growth intervals namely fourth, sixth, eighth and tenth month of sowing. Stability and metroglyph analysis were also carried out for identification of genotypes which is phenotypically stable over environments. Classification of genotypes through metroglyph analysis would be helpful in identifying the diversified genotypes those with high index score for various characters that can be further used in the hybridization programme to obtain superior hybrids.

The mean *per se* performance of Tall genotypes Andaman Ordinary, Laccadive Ordinary, Strait Settlement Green and West Coast Tall and hybrids WCT x MDY, MDY x WCT and WCT x Gangabondam were high for nut yield per palm. The high yielding genotypes also recorded high mean values for vegetative, reproductive and nut characters studied. In the present study the hybrids performed better than the varieties for vegetative, reproductive and nut characters.

The estimates of variability and heritability for nut yield per palm indicated that number of nuts per palm, weight of dehusked nut, whole nut weight, plant height, length of petiole, thickness of shell, number of female flowers and number of nuts per bunch had high genotypic coefficient of variation coupled with high heritability and high genetic advance. The association of these characters with nut yield per palm were also positive and significant and their direct and indirect effects emphasised the importance of these characters in a selection programme. Stability analysis revealed that the genotypes Laccadive Ordinary, West Coast Tall and East Coast Tall were highly stable over three seasons.

The mean *per se* performance for embryonic and growth characters of coconut seedlings revealed that the genotype Andaman Ordinary and the hybrids WCT x MDY and WCT x Gangabondam exhibited high mean value for seedling height, collar girth and number of embryonic leaves. These genotypes also showed high values for embryonic characters.

The estimates of variability, heritability and genetic advance for seedling characters indicated that plant height, length of first embryonic leaf, width of second embryonic leaf, width of first laminate leaf and width of first embryonic leaf had high genotypic and phenotypic coefficient of variation. High heritability coupled with high genetic advance was also observed for the above mentioned characters.

The correlation studies for number of leaves per seedling showed significant and positive correlation at both genotypic and phenotypic level with length of second embryonic leaves, plant height, collar girth, length and width of laminate leaf and length of petiole in the first laminate leaf.

The study has also revealed that the embryonic and growth characters studied at all the stages remained unchanged, emphasising the reliability of these characters to speed up the selection process.

Highly significant positive correlation was observed for most of the seedling characters with nut yield per palm. Studies on index scoring revealed that the selection of best seedling could be achieved by selecting the seednuts from the superior adult palm.

Multiple regression analysis for seedling revealed that importance should be given for the characters *viz.*, duration taken for germination, width of first embryonic leaf, collar girth, height of the seedling, width of first laminate leaf and second embryonic leaf as they had direct influence on number of leaves per seedling.

Metroglyph analysis showed that the genotypes Andaman Ordinary, Laccadive Ordinary and the hybrids WCT x MDY and WCT x Gangabondam recorded high mean values for embryonic and growth characters.

Those tall genotypes Andaman Ordinary, Laccadive Ordinary, Philippines Ordinary and the hybrids WCT x MDY, WCT x Gangabondam that performed better in the present study could be well recommended for commercial cultivation and the genotypes identified could be utilised as such in the hybridisation programmes.

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# *Introduction*

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## CHAPTER I

### INTRODUCTION

Coconut (*Cocos nucifera* L.) is a highly useful perennial crop because of the enormous uses of its products and by-products and hence it is rightly termed 'Kalpa vriksha'. All coconut based industries besides supporting value addition provide sizeable employment opportunities. India, despite its restricted genetic base ranks third in the production of coconut.

Though the area, production and productivity of coconut have increased steadily over the years to the level of 1.9 million ha, 13 billion nuts and 6,863 nuts per hectare respectively (Anon., 1996), coconut improvement still seems to be a cumbersome, time consuming and expensive process because of the heterozygous nature of the crop, long gestation period, large area and resources required for experimentation etc.

The main objective of any crop improvement programme is the identification of promising genotypes under a given set of environment for further exploitation in the breeding programme. In coconut, selection of mother palms is the primary criterion aiming at the retention of the desired genotypes and elimination of undesirable ones. Harland (1957) defined pre-potent palm as mother palm which in spite of having been indiscriminately pollinated by miscellaneous males are sufficiently possessed of dominant yield factors to ensure that their off springs are also high yielding. Hence identification of palms that exhibit a consistently higher rate of transmission of their

characters to the progeny would be highly useful for improvement of yield. Further studies on variability components were important for fixing up the suitable characters for selection.

Identification of pre-potent palms based on yield performance would take several years, hence correlation studies between yield and its components and also the nursery selection correlating seedling characters with adult palm pre-potency would be of vital importance in coconut improvement programme.

Since yield in coconut is a complex character governed by a number of components, studies on path coefficient and regression analyses would be of great help in selection programme. Stability analysis will be helpful in the identification of genotypes producing consistent yield over various environmental conditions. Metroglyph analysis confirms the presence of genetic diversity among the genotypes which can be utilised in the breeding programme.

Keeping this in view, the present investigation involving ten genotypes was carried out under Coimbatore conditions where the area, production and productivity are 56,839 ha, 9,063 lakh tonnes and 15,945 nuts per hectare respectively (Anon, 1996), with the following objectives.

1. To ascertain the extent of genetic variability existing among the germplasm;
2. to assess the mean, heritability and genetic advance of different traits;
3. to study the genotypic and phenotypic correlation between yield and it's components;

4. to measure the direct and indirect effects of each of the components on yield through path coefficient analysis;
5. to identify a suitable genotype which is phenotypically stable over various environments;
6. to identify a suitable selection index for seedling vigour and growth;
7. to find out the extent of relationship of mother palm and it's seedling performance;
8. to assess the genetic divergence among the different genotypes with the aid of metroglyph analysis.

# *Review of Literature*

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## CHAPTER II

### REVIEW OF LITERATURE

The success of breeding programme mainly depends upon the extent of genetic variability available in the population. So the selection of parents from a population for further propagation of coconut is dependent on the parental performance. This will also permit the identification of genotypes with superior transmission of their traits to their progeny. Besides, the pattern of genetic variation will enable a breeder to know the magnitude of genetic variation available for selection and the breeding procedure to be adopted (Charles, 1961) for crop improvement. In a crop like coconut where large generation interval exists, the study on relationship of early growth features with adult palm performance will help to eliminate the inferior genotypes at an early stage and it is very important that only genetically superior seedlings should be used as a planting material. Many authors have reported the genetic analysis of seedling characters, yield of nuts and other characters associated with productivity. A brief account of the biometrical studies reported are presented.

1. Variability
2. Heritability and genetic advance
3. Correlation
4. Path analysis
5. Stability analysis
6. Index scoring
7. Multiple regression
8. Metroglyph analysis

## 2.1. Variability studies

### 2.1.1. Variability studies in adult palm

Ninan *et al.* (1961) compared the performance of 15 strains and their F<sub>1</sub> progenies. Significant variation was observed for all the characters studied. Among the different strains Laccadive Ordinary performed best and produced maximum number of nuts followed by Strait Settlement Green (SSG). Nambiar *et al.* (1970) in their studies found substantial additive genetic variation for the traits number of female flowers and setting percentage. Wide range of variation for nut characters and copra content in Tall type was reported by Anon (1976).

Evaluation of two Dwarf and three Tall varieties by Chamorro and Sanchez (1978) revealed wide variability for percentage of oil and copra per nut. Among the Dwarf cultivars, Malayan Dwarf produced the highest percentage of oil (64.1) and Pacific Tall recorded 320.4 g of copra per nut.

Luntungun and Liyanage (1978) conducted a variability study. They found that D x T hybrids produced significantly higher rates of leaf than the male Tall parents. Abeywardena and Mathew (1980) suggested the characters like trunk girth, number of nuts per bunch and number of fronds per palm as indices for selection of vigorous seed parents.

Iyer (1980) reported that the increase in trunk height with simultaneous increase in number of leaves contributed to the overall yield of the palm.

Potty *et al.* (1980) compared the performance of eight coconut varieties and found that Genotypic x Environmental interaction decreased the setting percentage in Andaman Ordinary and Laccadive Ordinary and reduced the female flower production in Laccadive Ordinary and Laccadive small. While both the characters were affected in Bombay and Cochin China.

Variability studies by Louis (1981) involving 25 varieties and two hybrids exhibited a wide range of phenotypic variation for the characters, number of female flowers, setting percentage, number of nuts per year and number of spathes per year.

Santos *et al.* (1981) observed a considerable variation for nut components and copra recovery rates in the population involving different Tall and Dwarf varieties. They also found that Tall varieties exhibited the heaviest nut components than Dwarf varieties and indicated that weight of the fresh meat or weight of split nut are more reliable than the weight of whole or husked nuts for estimating the copra yield.

Shanthamallaiyah *et al.* (1981) studied the growth and yield performance of 19 exotic and local accessions and reported high variability for nut yield per palm. The hybrid T x D recorded the highest yield over four years of study.

Evaluation study was conducted to compare the performance of exotic and indigenous cultivars available in the country. The results revealed a wide variation for

vegetative and floral characters. At Ambajepeta the varieties Philippines, East Coast Tall and Laccadive Ordinary were more vigorous. Among these varieties, Philippines ordinary recorded the maximum girth of the trunk and produced maximum number of leaves. While number of inflorescence per palm per year was highest in Andaman Ordinary. Among all the varieties, maximum nut yield was obtained in Laccadive Ordinary. The varieties Laccadive Ordinary and Philippines ordinary also proved promising at Arsikera and Ratnagiri by producing maximum nuts per palm per year. Among the hybrids T x D recorded the highest number of nuts per palm per yield (Anon, 1983).

Highest copra yield per palm was observed by Chan (1983) from the crosses between Malayan Red Dwarf or Malayan Yellow Dwarf and West African Tall coconut. He suggested that future breeding work should be aimed at reducing the proportion of husk and increasing the endosperm content rather than increasing the nut size.

Genetic studies of the characters governing nut yield among three sets of T x D hybrids and a reciprocal hybrid by Ramanathan and Louis (1983) revealed that the cross ECT x Ayiramkachi was high yielding. While ECT x MDG hybrids produced bigger nuts which gave the highest copra and oil yield. The hybrids ECT x MDY produced an increased nut and copra yield than its reciprocal. Sangare *et al.* (1983) confirmed that the hybrids Red Dwarf x West African Tall and West African Tall x Renell Tall were promising hybrids producing maximum number of nuts with lesser husk.

Satyabalan and Rajagopal (1983) studied the performance of green, yellow and red forms of Malayan Dwarf and green orange forms of Chowghat Dwarf. The results revealed that Chowghat Dwarf is different from Malayan Dwarf. They observed that fruit and copra traits varied considerably between the yellow and red forms.

Mathew *et al.* (1984) evaluated the coconut palms and found that wide range of variation exists for number of leaves, spadices, bunches per palm, number of nuts per bunch and germination per cent of seed nuts. Progeny analysis proved that T<sub>4</sub> palm was superior both as a mother palm and for transmitting its traits to their seedling progeny.

High phenotypic coefficient of variation and genotypic coefficient of variation for plant height and bunch number, while the variation was low for rachis length among the various characters studied (Muluk, 1987).

Balakrishnan and Kannan (1988) evaluated 15 hybrids along with WCT as standard. The results showed that all the T x D hybrids were superior to WCT for the characters studied. The crosses WCT x MDY and WCT x CD produced maximum number of leaves, nuts and copra yield per palm per year. In general T x D hybrids exceeded D x T hybrids for leaf production rate and nuts produced per palm per year.

Significant variation among 16 hybrid combinations revealed that nuts per palm showed high estimates for phenotypic and genotypic variance. While number of leaves per palm were on the lowest side for phenotypic and genotypic variance (Balakrishnan *et al.*, 1991).

Genetic studies by Pillai *et al.* (1991) revealed that WCT palms are more vigorous in vegetative growth than Laccadive Ordinary. They also observed that increased production of inflorescence per palm per year, number of female flowers per inflorescence and higher setting percentage would increase the nut yield per palm per year.

Evaluation of the nut characters of Laccadive Ordinary and West Coast Tall varieties revealed that better nut qualities like higher nut weight, thicker meat, higher copra out turn per nut and a slightly higher oil percentage were found in Laccadive Ordinary. The performance of hybrids of Laccadive Ordinary and West Coast Tall with the same male parent Gangabondam (Laccadive Ordinary x Gangabondam and West Coast Tall x Gangabondam) showed that Laccadive Ordinary x Gangabondam was superior than West Coast Tall x Gangabondam for nut yield per palm per annum. So among two, Laccadive Ordinary was considered to be a better choice than WCT both as seed material and as parental material for hybrid seed production (Joseph *et al.*, 1992).

Ramanathan *et al.* (1992) recorded a significant difference for nut weight and kernel weight while comparing the performance of coconut cultivars and hybrids. Among the hybrids, West Coast Tall x Malayan Dwarf Yellow and Malayan Dwarf Yellow x West Coast Tall were found to perform better with maximum nuts per palm per annum. Among the varieties Andaman Ordinary registered higher yield per palm per year.

Luke Rathna Kumar *et al.* (1993) in their analysis of data on 18 growth, reproductive and yield related traits in 25 years old palm of East Coast Tall indicated that during selection programme importance should be given for the traits like number of leaves per crown, petiole length and leaf lets per leaf, kernel weight thickness of kernel and number of nuts per palm for increased copra yield.

In the variability studies on nut characters of coconut, maximum phenotypic coefficient of variation was noticed for nuts per palm followed by volume of husked nut. While maximum genotypic coefficient of variation was noticed for volume of husked nuts followed by nuts per palm (Patil *et al.*, 1993b).

Satyabalan (1993) analysed the yield variation in West Coast Tall palm and has indicated that high female flower production and high setting percentage accounts for high yield.

Akpan (1994) evaluated the Tall coconut genotypes and reported a considerable variation for bunches per palm, nuts per palm and weight of nuts per palm and a wide range of variation for weight of dehusked nut and weight of shell.

Genetic variability for the characters governing nut yield among 18 genotypes of coconut was studied by Indires *et al.* (1997) and have reported a significant variation for various nut characters studied. Among the different genotypes Fiji registered the highest

mean yield per palm. While Andaman Ordinary produced maximum kernel weight and Laccadive Ordinary exhibited the maximum husk thickness.

Kumaran *et al.* (1997) studied the performance of four hybrids T x D, T x T, D x T and D x D involving Chowghat Orange Dwarf and West Coast Tall as parents. Among the hybrids T x T and T x D hybrid showed significantly higher yield than D x T or D x D. These hybrids also showed wide variation for flower number and number of nuts per palm.

#### **2.1.2. Variability studies in adult palm and seedling characters**

Liyanage and Abeywardena (1957) concluded that early germination was always associated with higher yields of the adult palm. The selection of adult palms with high yielding traits results in the production of Tall vigorous seedlings with early sprouting of nuts, high percentage of germination, early flowering and with high initial yield.

Harland (1957) advocated that high yielding mother palms could be identified on the basis of their progeny performance and further added that it should be possible to identify prepotent high yielders from a comparative study of sufficiently large numbers of progenies from open pollinated mothers.

Sundaram (1975) in his crop improvement programme observed that vigour index of Tall seedlings was contributed by a set of characters namely, seedling girth, petiole and leaf length and time taken for germination. Ngsiewkee and Edward Chan (1976)

while studying the potentiality of hybrid coconuts in Malaysia found that hybrids produced more number of leaves with moderate height when compared to their parents.

Kannan and Nambiar (1979) reported that selection of mother palms yielding more than 80 nuts per tree lead to the production of vigorous seedlings. Considerable variation in rate of germination between different cultivars of coconut was reported by Wuidart (1979).

Satyabalan and Rajagopal (1985) collected seed nuts from high yielding (>80 nuts per palm per year) mother palms. Those seeds were used for raising seedlings. The parameters like collar girth and leaf production rate was studied from the fifth month of germination. They found that prepotency of the three high yielding palms was not transmitted to their progeny.

Luke Rathna Kumar (1989) recorded high coefficient of variation for time taken for germination, length of petiole of first laminate leaf, width of first laminate leaf, girth of the seedlings and number of leaves per seedling. However, width of first and second embryonic leaf of Dwarf ecotypes showed low range of variability.

Kumaran *et al.* (1997) evaluated different hybrid combinations along with WCT as check variety. The results showed no significant difference among the hybrids for various morphological growth characters, except for the hybrid Chowghat Orange Dwarf x Andaman Ordinary which registered an increased leaf length.

## 2.2. Heritability and genetic advance

Heritability estimates provide information on the degree of inheritance of character from parent to progeny. A knowledge on the heritability of different characters in relation to their contribution towards yield is a prerequisite for an efficient breeding programme. Lush (1940) defines heritability as that fraction of total variance. Characters having high heritability value could be improved directly through selection since they are less affected by environment.

Genetic advance is another important breeding parameter for determining the amount of expected genetic change that could occur due to selection. High heritability along with high genetic gain could be considered to determine the amount of heritable variation with accuracy (Johnson *et al.*, 1955). Genetic advance is a product of heritability and indicates the potentiality of selection intensity. The available reports on heritability and genetic advance for the different characters are given below.

### 2.2.1. Heritability and genetic advance of adult palm

Lakshmanachar (1959) and Nambiar *et al.* (1970) estimated the heritability values for yield of nuts. The results showed that the heritability values varied from 0.48 to 0.63 and its importance in selection based on yield alone seemed to be negligible.

Liyanage and Sakai (1960) reported high heritability of 0.67 and 0.97 for yield attributing characters such as copra yield per palm per year and weight per husked nut

respectively. They also indicated that selection of seedlings should be based on heritability of economic characters such as time to first flowering, number of nuts produced per annum, copra yield per palm and weight of husked nuts. Charles (1961) observed low heritability for yield of nuts per palm and indicated that selection on yield basis was ineffective.

The highest estimates of heritability for the percentage of flower set followed by number of female flowers was recorded by Nambiar and Nambiar (1970). They also indicated that importance should be given for these characters in selection programme.

Louis (1981) reported high genetic advance for number of leaves per palm, spathes per year, nuts per year and setting percentage. Genetic studies by Meunier *et al.* (1984) for yield characters in hybrid coconut (T x D and D x T) revealed that heritability estimates were high for copra yield per nut, oil yield per nut and number of nuts per palm. Heritability estimates did not show any difference between Dwarf and Tall types.

High heritability for the characters plant height and bunch number was reported by Muluk (1987). Balakrishnan *et al.* (1991) registered high heritability coupled with high genetic advance for nut yield per palm.

Patil *et al.* (1993b) noticed that weight of husked nut, shell and kernel and volume of husked nut showed high magnitudes of heritability. While kernel thickness possessed

very low heritability. The genetic advance expressed in per cent mean basis was also high for volume of husked nut, weight of husked nut, shell and kernel and yield per palm.

### **2.2.2. Heritability and genetic advance of seedling**

Louis (1981 and 1983) while examining the genetic variability in coconut palms recorded high heritability values for collar girth (43.18%), plant height (41.05%) and number of leaves (39.06%) in one year old coconut seedlings. He obtained high genetic gain over per cent mean for collar girth (65.0%) and height of seedlings (65.0%). Moderate heritability and genetic gain for days to germination, number of leaves, height of the seedlings and collar girth was reported by Mathew and Gopimony (1988).

Luke Rathna Kumar (1989) observed high heritability for length of first and second embryonic leaves, width of first embryonic leaf, length of petiole in the first laminate leaf, girth at collar, height of the seedling and number of leaves in the seedling. While studies on genetic gain revealed that the length of first embryonic leaf, width of first embryonic leaf and duration taken for germination recorded high values. He further suggested that selection for these characters would be helpful for genetic improvement of this crop.

## **2.3. Correlation studies**

### **2.3.1. Correlation studies in adult palm**

Patel (1937), Menon and Pandalai (1958) and Abeywardena (1976) observed that number of leaves per palm and girth of the trunk were positively correlated with number of nuts per year in coconut palm of Tall type. Increase in plant height with simultaneous

increase in number of leaves will lead to production of maximum nuts per palm was reported by Iyer (1980). Satyabalan (1972) and Ramanathan (1984) reported a positive correlation between nut yield per palm and stem height of the adult palm.

Sukumaran *et al.* (1981) observed that number of leaf lets and length of leaf were positively associated with the number of nuts produced per year. Louis (1983) also observed that number of leaf lets in the adult palm was positively associated with the number of nuts produced per year.

Correlation studies by Nampoothiri *et al.* (1975) and Louis (1983) revealed a negative association between pre-flowering period and number of nuts produced per year. Abeywardena (1976) observed that the number of spathes produced per year and number of nuts produced were positively associated. Thampan (1970) found a positive correlation between number of male flowers produced and number of nuts per palm. While Balingasa and Carpio (1976) reported that the number of female flowers produced and number of nuts were positively associated.

Nampoothiri *et al.* (1975) reported that the number of spathes produced and number of female flowers produced exhibited a positive correlation with preflowering period. Louis (1983) confirmed that the number of female flowers produced and setting percentage were negatively correlated.

The association studies by Patil *et al.* (1993a) indicated that the spadix length had a highly significant positive correlation with the length of bunch stalk and strong negative association with yield per palm, number of female flowers and spikelets with one female flower.

Studies on relationship between yield of nuts, copra content per nut, total yield of copra per palm and yield of oil per palm in WCT palm by Bavappa and Sukumaran (1976) have shown that mean yield of nut is significantly and positively correlated with both outturn of copra and oil, while a negative and significant relationship with mean copra content per nut was observed.

Sukumaran *et al.* (1981) revealed a positive correlation between number of bunches per year and number of nuts per year. They also reported that number of nuts produced per year and the total outturn of copra had a significant positive correlation.

Balakrishnan and Vijayakumar (1988) concluded that equatorial diameter of nut, weight of unhusked nut and husked nut weight were positively correlated with copra content. But shell weight showed no relationship with copra content. Mathew and Gopimony (1988) pointed out that the nuts per bunch and copra content was negatively correlated.

Correlation studies among different traits by Patil *et al.* (1993b) revealed a significant positive correlation for husked nut weight with nut volume and weight of shell and copra. But it showed negative correlation with nuts per bunch and nut per palm.

### **2.3.2. Correlation studies in seedling**

Correlation studies by Patel (1938) and Liyanage (1955a) revealed a negative association between time taken for germination and the number of leaves produced in Tall coconut seedlings. Positive correlation between girth of the seedlings and the number of leaves produced in West coast Tall seedlings was reported by Pankajakshan and Minnie George (1961).

Satyabalan and Mathew (1976) reported a strong significant positive correlation between the traits, number of leaves and height of the seedlings. In West Coast Tall seedlings Balakrishnan *et al.* (1988) reported a positive correlation between number of leaves and height of the seedling with girth of the seedling and a negative association between germination of nuts and number of leaves produced. Luke Rathna Kumar (1989) registered positive association between girth at collar, height of the seedlings with number of leaves.

### **2.3.3. Correlation studies in seedling characters and adult palm**

Liyanage (1967) observed a positive correlation between number of leaves produced in seedlings with the yield of copra in the adult palm. Number of leaves

produced in one year old seedling was positively associated with the number of nuts produced per year (Nampoothiri *et al.*, 1975 and Satyabalan and Mathew, 1976).

Sundaram (1975) observed that girth of the seedlings, length of the petiole, length of the leaf, breadth of the leaf and time taken for germination contributed to the vigour index in three year old Tall seedlings.

#### 2.4. Path Coefficient analysis

Study on path coefficient analysis developed by Wright (1921) provides an effective means of partitioning the total correlation into direct and indirect effects of various characters on yield. The available literature on path analysis studies is reviewed here.

Sukumaran *et al.* (1981) reported that number of female flowers, number of functional leaves and internodal length at a fixed mark had the greatest direct effects on the average yield of nuts per palm. Studies on path coefficient analysis by Bhagavan and Nair (1989) showed that plant height, internodal distance, stem girth and leaf length exhibited a direct effects on yield.

Louis and Chopra (1993) assessed the cause and effect relationship factors that contribute to the copra weight. They found kernel weight, length of petiole and thickness of shell had a positive direct effect on copra weight. While thickness of kernel and pre-flowering period showed a negative direct effect on copra weight.

Genetic improvement studies on coconut by Luke Rathna Kumar *et al.* (1993) revealed that the traits kernel weight, thickness of kernel and number of nuts per palm showed direct effects on weight of copra per nut.

Pamin and Asmono (1993) reported direct effects for number of nuts per palm and nut weight. They indicated that oil yield per palm could be increased by direct selection for these traits or by simultaneous progeny selection for fruit number per tree or oil content and number of nuts per tree. . Ataga (1995) found that the number of bunches per palm and bunch weight had a direct effect on oil yield.

## **2.5. Stability analysis**

### **Genotype x Environment Interactions**

Stability in performance is one of the most desirable properties of a genotype before it is released as a variety for wide cultivation. For this purpose the multilocation trials over a number of years are conducted.

Johannson (1909) explained the meaning of phenotype which is related to the appearance or form arising as a result of interaction of genotype with the environment in which it is grown. He was the pioneer in considering the importance of environment in the expression of a phenotype. The existence of genotype x environment interaction was first reported by Fisher and Mackenzie (1923) from the results of varietal trials in potatoes.

The absolute phenotypic stability would be expressed by  $b=0$  and the ideal variety in respect of adaptation would be the one having maximum yield potential on the most favourable environment and maximum phenotypic stability. According to Eberhart and Russel (1966) deviation from regression should be given importance in addition to mean and regression. A brief account of the work done in this study is presented.

Louis and Chandra Sekharan (1976) reported that the growth and yield characters of coconut palm were highly influenced by environment. The yield stability for 32 cultivars was analysed by Balakrishnan *et al.* (1988). The results revealed that WCT, Laccadive Ordinary, Philippines Ordinary and Andaman Ordinary were stable for annual production of nuts at Pilicode.

Patil *et al.* (1991) evaluated nine genotypes of coconut for nature and degree of genotypic x environmental interaction. They observed a significant linear genotypic x environmental interaction for all the traits. Among the genotypes Pratap was considered as the best genotype for cultivation whereas, T x D and Banawali Yellow Round were found to adopt better under fluctuating environmental condition.

Vijayaraghavan *et al.* (1993) studied the seasonal variation in the production of spadix in coconut hybrids and parents. The results revealed that the hybrid combination Malayan Dwarf Yellow (MDY) x East Coast Tall (ECT) and its reciprocal was found to be the best, producing highest number of spathes. They also reported that Tall types produced maximum number of spathes during March and August while Dwarf types had single peak during August.

## 2.6. Multiple regression

Pankajakshan and Minnie George (1961) during their association studies in coconut seedlings observed positive relationship between number of leaves and girth at collar and indicated that important should be given for these characters. Multiple regression analysis worked out with number of leaves as primary interest by Luke Rathna Kumar (1989) revealed that importance should be given for the characters duration taken for germination, height of the seedling and collar girth as an index of vigour.

## 2.7. Metroglyph analysis

Metroglyph analysis proposed by Anderson (1957) is useful to study the pattern of variation in coconut seedlings and also to solve the problems of classification.

Raveendran *et al.* (1987) studied metroglyph analysis in 23 genotypes of coconut. The results revealed that the varieties came under two groups based on morphological characters. While the nut characters were recognized into three groups on their classification. They also indicated that the exotic cultivars had higher expression for morphological and nut characters which could be utilized for obtaining heterotic hybrids.

# *Materials and Methods*

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## CHAPTER III

### MATERIALS AND METHODS

A field study was conducted to assess the extent of genetic variability existing among the germplasm, to construct selection indices for the Tall, Semitall, Dwarf and Hybrid seedlings of coconut based on their performance in the nursery. This experiment was conducted at coconut nursery, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore – 641 003. The experimental material and methods followed are presented in this chapter.

#### 3.1. Materials

Ten genotypes of coconut with diverse geographical origins were chosen for the study and they are as follows.

Variety	Ecotype
1. Tall	i) Andaman Ordinary ii) Laccadive Ordinary  iii) Philippines Ordinary iv) East Coast Tall v) West Coast Tall
2. Semi tall	Strait Settlement Green
3. Dwarf	Chowghat Orange Dwarf
4. Hybrid	i) Malayan Dwarf Yellow x West Coast Tall ii) West Coast Tall x Malayan Dwarf Yellow iii) West Coast Tall x Gangabondam

## **3.2. Method**

### **Experiment I**

#### **3.2.1. Field plot technique to study genetic variability in adult palm**

The present investigation was carried out during October 1996 to March 1999 at coconut nursery Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore which is situated at 11°N latitude and 77°E longitude and at an elevation of 426.26 m above mean sea level.

All the genotypes had been planted at a distance of 10 x 10 m during 1973. The experiment was laid out in a randomized block design with three replications. Four palm per genotype represented one replication. Recommended package of practices were followed for all the genotypes (Kumar *et al.*, 1993).

All the palms in each genotype per replication were used for recording observations on vegetative, reproductive and nut characters and the mean values were subjected to statistical analysis.

## **3.3. Observations**

### **3.3.1. Vegetative characters**

#### **3.3.1.1. Plant height**

The height of the palm was measured from the collar region to the base of crown region and the mean values were expressed in cm.

**3.3.1.2. Stem girth**

The stem girth at one metre above collar region was measured and expressed in centimetre

**✓3.3.1.3. Number of internodes present per meter**

The number of internodes present per metre at a height of a meter above the ground level was counted and recorded.

**3.3.1.4. Total number of leaves**

The number of leaves per palm during each harvest were counted and recorded.

**3.3.1.5. Length of the petiole**

The petiolar length was measured for three leaves per palm and mean length of the petiole was arrived and expressed in centimetre.

**3.3.1.6. Length of the leaf**

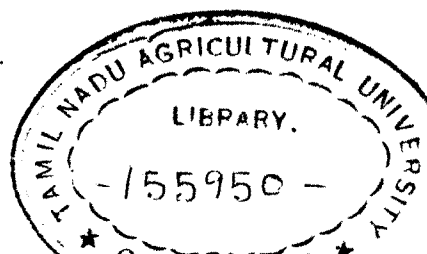
The length of the leaf was measured in three leaves per palm and mean values was worked out and expressed in centimetre.

**3.3.1.7. Number of leaflets (right)**

The number of leaflets on the right side of the leaf was counted in the same three leaves and the mean was worked out .

**3.3.1.8. Number of leaflets (left)**

The number of leaflets on the left side of the same three leaves were counted and mean values was calculated .



### **3.3.2. Reproductive characters**

#### **3.3.2.1. Number of inflorescences produced per year**

The number of inflorescence produced per month was counted and the sum of inflorescences produced per year was recorded.

#### **3.3.2.2. Length of spadix**

Length of spadix was measured from the base of the stalk to the inflorescence tip and the mean values were expressed in centimetre .

#### **✓3.3.2.3. Length of spikelet bearing portion**

The length of spikelet bearing portion was measured from the base of the spikelet bearing portion to its tip and the mean values were expressed in centimetre .

#### **3.3.2.4. Length of stalk**

The length of the stalk was measured from the base of the stalk to its tip and the mean values were expressed in centimetre .

#### **3.3.2.5. Number of female flowers**

The number of female flower present per inflorescence was counted and the mean values were recorded.

### **3.3.3. Nut characters**

#### **3.3.3.1. Number of bunches produced per palm per year**

The number of bunches produced during each harvest was counted and the sum of bunches produced per year was recorded.

### **3.3.3.2. Number of nuts per bunch**

The number of nuts per bunch per harvest was counted and mean values was recorded.

### **✓ 3.3.3.3. Setting percentage**

It is the ratio of the nuts produced to the number of female flowers present per inflorescence and expressed in percentage.

### **3.3.3.4. Length of nut**

The length of 20 nuts per replication on a vertical plane was measured and the mean values were expressed in centimetre .

### **✓ 3.3.3.5. Equatorial diameter of nut**

The equatorial diameter was measured at the widest region for the same 20 nuts on a horizontal plane and the mean values were expressed in centimetre .

### **3.3.3.6. Whole nut weight**

The harvested nuts were dried as such and their weight was recorded for 20 nuts per replication and their mean values were expressed in g.

### **3.3.3.7. Thickness of husk**

Husk thickness at the widest portion for the same 20 nuts were measured and the mean values were expressed in centimetre.

### **3.3.3.8. Weight of dehusked nut**

Dried nuts were dehusked and their mean weight was expressed in g.

✓ **3.3.3.9. Weight of kernel (endosperm)**

The kernel weight was recorded for 20 nuts and their mean values were expressed in g.

✓ **3.3.3.10. Weight of shell**

The shells of 20 nuts were weighed and the mean values were expressed in g.

**3.3.3.11. Thickness of kernel (endosperm)**

Dehusked nuts were deshelled and the kernel (endosperm) was split into two halves to measure the thickness and the mean values were expressed in centimetre.

**3.3.3.12. Thickness of shell**

The shell thickness was measured at the middle region of the nut and the mean values were expressed in centimetre.

**3.3.3.13. Oil content**

✓ **Estimation of oil content**

For estimating oil, the copra was cut into small pieces and dried at 50 C for 16 hours and allowed to cool in a dessicator. Five grams of copra were taken and placed in a filter paper and fastened in such a way to prevent escape of the meal and then carefully transferred to an extraction thimble. The thimble was then placed in a Soxhlet extractor to which sufficient quantity of solvent petroleum ether (40-60°C) was added and heated until seven siphonings were completed. The oil content was recorded by evaporating the petroleum ether at 60°C. The entire extraction procedure was carried out

in Soxhlet extractor to AOAC (1970). The percentage of oil content was then calculated by using the formula

$$\text{Oil per cent} = \frac{\text{Oil weight (g)}}{\text{Sample weight (g)}} \times 100$$

#### **3.3.3.14. Number of nuts produced per palm per year**

The number of nuts produced per palm per harvest was recorded and the sum of the nuts produced per palm per year was calculated.

### **Experiment II**

#### **3.4. Nursery techniques**

This experiment was conducted during September 1997 to July 1998 at Coconut nursery, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore with the aim of constructing selection indices among different varieties and hybrids. The experimental materials consisted of same genotypes used for the experiment 1.

The seed nuts were harvested at full maturity from respective mother palms and were shade dried for a month before sowing them in the nursery. All the recommended nursery practices were adopted before and after raising them in the nursery. The seed nuts were sown in beds of size 1.5 m x 6 m at a spacing of 30 cm x 30 cm. The design adopted was randomized block design with three replications.

In each of the genotypes chosen for study, 30 nuts were sown per replication. Ten seedlings were selected randomly per replication and they were tagged for recording observations. The mean values were subjected to statistical analysis. Observations were recorded at different growth intervals viz., fourth, sixth, eighth and tenth month of sowing.

### **3.5. Observations**

#### **3.5.1. Percentage of germination**

Percentage of germination was calculated from the number of seeds sown and number of seeds germinated and expressed in per cent.

#### **3.5.2. Duration taken for germination**

The days taken from the date of sowing to the date of germination was recorded as duration taken for germination.

#### **3.5.3. Height of the seedlings**

The height of the seedlings was recorded from the pedicel end of the nut to the tip of the first formed laminate leaf and the mean values were expressed in centimetre.

#### **3.5.4. Collar girth**

The girth of the seedlings was measured at the collar region and expressed in centimetre

#### **3.5.5. Number of embryonic leaves**

The first formed few rudimentary and conical shaped leaves without any lamina known as embryonic leaves were counted and recorded.

**3.5.6. Length of embryonic leaf**

The length of the embryonic leaves were measured from pedicel end of the nut upwards and recorded in centimetre.

**3.5.7. Width of the embryonic leaf**

The width of the embryonic leaves were measured at the widest region and expressed in centimetre.

**3.5.8. Length of petiole in the first laminate leaf**

The length of petiole in the first laminate leaf was measured and the mean values were expressed in centimetre .

**3.5.9. Length of the first laminate leaf**

The length of the first laminate leaf was measured and expressed in centimetre.

**3.5.10. Width of first laminate leaf**

The width of the first laminate leaf at the widest part was measured and recorded in centimetre .

**3.5.11. Number of roots**

The seedlings were uprooted at different growth intervals of fourth, sixth, eighth and tenth month of sowing and the number of roots per seedling were counted and recorded.

### 3.5.12. Number of leaves

The number of laminate leaves in the seedlings was counted and recorded.

## 3.6. Statistical analysis

### 3.6.1. Unit analysis

The statistical parameters like mean, standard error and coefficient of variation were calculated according to (Panse and Sukhatme, 1961).

$$1. \text{ General Mean (G.M)} = \frac{\text{Total of all values}}{n}$$

Where, n = number of observations

$$2. \text{ Variance} = \frac{\text{SS-CF}}{\text{DF}}$$

Where, SS = Sum of squares of all the observations of a variate

$$\text{CF} = \frac{(\text{Grand total})^2}{n}$$

DF = Degrees of freedom

$$3. \text{ Standard deviation (SD)} = \sqrt{\text{variance}}$$

$$4. \text{ Standard error (SE)} = \frac{\text{SD}}{\sqrt{n}}$$

$$5. \text{ Coefficient of variation (CV)} = \frac{\text{SD}}{\text{Varietal mean}} \times 100$$

### 3.6.2. Variability studies

#### (i) Analysis of variance

The analysis of variance was carried out for all the characters as per the procedure suggested by Panse and Sukhatme (1961).

The analysis of variance table was constructed as follows.

Source	D.F.	S.S.	M.S.
Replications	r-1	RMS	m
Genotypes	g-1	GMS	M <sub>1</sub>
Error	(r-1)(g-1)	EMS	M <sub>2</sub>
Total	(gr-1)		

Where,

r = number of replications

g = number of genotypes

m = replication mean square

M<sub>1</sub> = Genotypic mean square

M<sub>2</sub> = Error variance

#### (ii) Genotypic and phenotypic variances

The genotypic and phenotypic variances were calculated as suggested by Johnson *et al.* (1955).

$$1) \text{ Genotypic variance } \sigma^2_g = \frac{M_1 - M_2}{r}$$

where,

M<sub>1</sub> = Mean sum of squares of genotypes

$M_2$  = Mean sum of squares of error

$r$  = Number of replications

$$2) \text{ Genotypic variance } (\sigma^2P) = \sigma^2g + \sigma^2e$$

where,

$\sigma^2e$  = error variance

**(iii) Phenotypic and genotypic coefficient of variations**

The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were calculated as suggested by Burton (1952).

$$PCV = \sqrt{\frac{\text{Phenotypic variance}}{\text{Grand mean}}} \times 100$$

$$GCV = \sqrt{\frac{\text{Genotypic variance}}{\text{Grand mean}}} \times 100$$

**(iv) Heritability**

Heritability ( $h^2$ ) in broad sense was calculated according to Lush (1940) and expressed as per cent.

$$\text{Heritability (broad sense)} = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}} \times 100$$

Range of heritability was categorized into low (0-60 per cent, moderate (60-80 per cent) and high (80 per cent and above).

**(v) Genetic advance**

Genetic advance was computed according to the method suggested by Johnson *et al.* (1955). ✓

$$\text{Genetic advance (GA)} = K \times \sqrt{\sigma^2P} \times h^2$$

Where,  $\sigma^2P$  is the phenotypic variance

$h^2$  is the heritability in broad sense

$k = 2.06$  at 5 per cent level

**(vi) Genetic advance as per cent mean**

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

Where, GA is the genetic advance and

GM is the grand mean

**3.6.3. Correlations**

Phenotypic, genotypic and environmental coefficients of correlations were worked out according to Panse and Sukhatme (1967).

**a) Phenotypic correlation coefficient**

$$r_{xy}(P) = \frac{\text{Cov. xy (P)}}{V_x(P) \cdot V_y(P)}$$

Where, Cov. xy(P) = Phenotypic covariance between character x and y and  $V_x(P)$  and  $V_y(P)$  are the respective phenotypic variance

**b) Genotypic correlation coefficient**

$$r_{xy}(G) = \frac{\text{Cov. xy (G)}}{V_x(G) \cdot V_y(G)}$$

Where, Cov. xy(G) = Genotypic covariance between x and y and  $V_x(G)$  and  $V_y(G)$  are the respective genotypic variances.

c) Environmental correlation coefficient

$$r_{xy}(E) = \frac{\text{Cov. } xy(E)}{V_x(E) \cdot V_y(E)}$$

Where, Cov. xy(E) = Environmental covariance between character x and y and V<sub>x</sub>(E) and V<sub>y</sub>(E) are the respective phenotypic variance.

The significance of correlation was tested by referring to the table given by Snedecor and Cochran (1967). It was tested at 5% and 1% levels.

### 3.6.4. Path coefficient analysis

The path coefficients were worked out with the genotypic correlations coefficients as suggested by Dewey and Lu (1959). This was utilised to partition the genotypic correlation coefficients into direct and indirect effects.

### 3.6.5. Stability analysis

#### Estimation of stability parameters

Following the methodology of Eberhart and Russell (1966) three parameters of stability namely mean, regression coefficient 'b' and mean square deviation (Sd<sup>2</sup>) were estimated for each genotype.

The linear model proposed by Eberhard and Russell (1966) was

$$Y_{ij} = \mu_i + b_i I_j + \delta_{ij}$$

where,

$Y_{ij}$  = Mean performance of  $i^{\text{th}}$  genotype in  $j^{\text{th}}$  environment,  
( $I = 1, 2, \dots, v, j = 1, 2, \dots, n$ )

$\mu_i$  = Average performance of  $i^{\text{th}}$  genotype over all environments

$b_i$  = Regression coefficient that measures the response of the  $i^{\text{th}}$  genotype to varying environments

$I_{ij}$  = Environmental index, as the deviation of the mean of all genotypes in  $j^{\text{th}}$  season from grand mean

$b_{ij}$  = The deviation from regression of the  $i^{\text{th}}$  genotype at  $j^{\text{th}}$  environment

$I_j$  =  $\frac{\sum_i Y_{ij}}{V} - (\sum_i \sum_{ij} Y_{ij})/Vn$ ,  $\sum_i I_j = 0$   
such that

$$\sum_{j=1}^n I_j = 0$$

a) The regression coefficient for each genotype was estimated as follows

$$b_i = \frac{\sum_{j=1}^n Y_{ij} I_j}{\sum_{j=1}^n I_j^2}$$

b) The mean square deviation from linear regression ( $S^2d$ ) for each genotype was estimated as follows

$$S^2d = [\sum_j d_{ij}^2 / (n-2)] - (S^2e/r)$$

where,

$$\sum_j d_{ij}^2 = \sum_i Y_{ij}^2 \frac{Y_i^2}{t} - \frac{(\sum_j Y_{ij} I_j)^2}{\sum_j I_j^2}$$

$Se^2$  = Pooled error mean square

$n$  = Number of environments

$r$  = Number of replications

$t$  = Number of genotypes

$I_j$  =  $(Y_i \dots - Y_{..})$

### Analysis of variance for phenotypic stability

The analysis of variance as suggested by Eberhart and Russell (1966) is as given below.

#### Analysis of variance

Source	D.F.	S.S.	MS
Genotypes (G)	(g-1)	$\frac{1}{2} \sum_i Y_i^2 - C.F.$	MS <sub>1</sub>
Environments (E)	(n-1)	$\frac{1}{g} \sum_j Y_j^2 - C.F.$	
G x E	(g-1)(n-1)	$\sum_i \sum_j Y_{ij}^2 - \sum Y_i^2 / n - \sum Y_j^2 / g + C.F.$	
E (linear)	1	$\frac{1}{g} [(\sum_j Y_{.j} I_j)^2 / \sum_j I_j^2] - A$ (say)	
G x E (linear)	(g-1)	$i[(\sum_j Y_{ij} I_j)^2 / \sum_j I_j^2] - A$	MS <sub>2</sub>
Pooled deviation	g(n-2)	$\sum_i \sum_j d_{ij}^2$	MS <sub>3</sub>
Pooled deviation due to genotype (i)	(n-2)	$[(\sum_j Y_{ij}^2 - (Y_i.)^2 / n) - \sigma^2 e (\sum_j Y_{ij} I_j^2)^2 / \sum_j I_j^2]$	
Pooled error	n(r-1)(g-1)	$\sum_j d_{ij}^2$	

#### Test of significance

- a) In order to test the significance of the differences among the genotype means

i.e.  $H_0 - U_1 = U_2 = U_3 \dots = U_n$ , the appropriate 'F' test is defined as

$$F = MS_1 / MS_3$$

- b) To test that the genotypes do not differ for their regression on the environmental

index. i.e.  $H_0 = b_1 = b_2 \dots = b_n$

$$F = MS_2 / MS_3$$

c) Individual deviation from linear regression was tested as follows.

$$F = \frac{(\sum_j d_{ij}^2) / (n-2)}{S^2 e/r}$$

### 3.6.6. Index scoring

For constructing the index scores the method adopted by Anderson (1957) was used. For scoring the index, the variation for each characters was divided into three groups, viz., low, medium and high. The genotypes with low, medium and high values were given index scores of 1, 2 and 3 respectively. The worth of a genotype was calculated by adding the index values of all the characters. Thus the maximum and minimum score of an individual will be 3n and n, where n is the total number of characters included in the study.

The class interval was then found out by using the relationship.

$$C = \frac{\text{Maximum value in the data set} - \text{Minimum value in the data set}}{\text{Number of classes}}$$

The lower limit was fixed by adding the class interval and the minimum value for that particular trait.

The upper limit was fixed by subtracting the class interval from the maximum value for that particular trait.

The range between the lower and upper limits forms the medium score.

### 3.6.7. Multiple regression function

Multiple regression function was worked out for number of leaves as a dependent variable with embryonic and growth characters in all the genotypes and in hybrids by adopting the procedure given by Goulden (1959).

The relationship of the dependent variate 'Y' in terms of the dependent variates in a linear relation is of the type.

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 \dots\dots$$

Where, a is a constant,  $x_1$ ,  $x_2$ ,  $x_3$  are the independent characters and  $b_1$ ,  $b_2$ ,  $b_3 \dots\dots$  are the corresponding partial regression coefficients and Y is the estimate given by this relation.

By minimising the residual variation, a set of normal equations were obtained of the type:

$$b_1 \Sigma x_1^2 + b_2 \Sigma x_1 x_2 + b_3 \Sigma x_1 x_2 x_3 \dots\dots = \Sigma x_1 y$$

$$b_1 \Sigma x_1 x_2 + b_2 \Sigma x_2^2 + b_3 \Sigma x_2 x_3 \dots\dots = x_2 \Sigma y$$

$$b_1 \Sigma x_1 x_3 + b_2 \Sigma x_2 x_3 + b_3 \Sigma x_3^2 \dots\dots = x_3 \Sigma y$$

By solving these equation and arranging them in a covariance matrix, the partial regression coefficients were computed as follows:

$$b_1 = C_{11} \Sigma x_1 y + C_{12} \Sigma x_2 y + C_{13} x_3 y \dots\dots$$

$$b_2 = C_{21} \Sigma x_1 y + C_{22} \Sigma x_2 y + C_{23} \Sigma x_3 y \dots\dots$$

$$b_3 = C_{31} \Sigma x_1 y + C_{32} \Sigma x_2 y + C_{33} \Sigma x_3 y \dots\dots$$

The significance of multiple regression was determined by setting up analysis of variance.

#### **3.6.8. Metroglyph analysis**

Metroglyph analysis was done according to the method suggested by Anderson (1957) to investigate the pattern of morphological variation in coconut seedlings. The analysis of variation was based on the mean values for different traits of the seedlings. Among the different characters, two characters exhibiting the highest variability were taken for analysis. Since plant height and per cent germination showed highest variability these two characters were allotted to x and y axis. For each genotype, the mean values of x and y were used to determine its position, which is marked by a small circle or glyph. The index values for each character namely collar girth, number of leaves per seedling and width of first embryonic leaf were divided into three classes low, medium and high. These characters were represented by a rays running in different directions on the glyph.

# *Experimental Results*

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## CHAPTER IV

### RESULTS

The observations made on the ten genotypes of coconut (*Cocos nucifera* L.) for growth, reproductive and nut characters were statistically analysed. The analysis of variance revealed significant difference for all the characters studied. Further, information on heritability, genetic advance, correlation coefficients, path analysis and stability analysis were also worked out and the results are presented.

#### 4.1. Mean performance of adult palm

##### 4.1.1. Vegetative characters

The data on mean performance, range and variability for vegetative, reproductive and nut characters are given in Tables 1 and 2. The genotypes exhibited significant difference among themselves for all these characters studied.

##### 4.1.1.1. Plant height

The mean height of the plant ranged from 5.31 m to 9.20 m with a general mean of 7.96 m. Among the Tall, Semi Tall, Dwarf and hybrid genotypes of coconut, East Coast Tall recorded the maximum plant height of 9.20 m. The minimum height of 5.31 m was recorded by Chowghat Orange Dwarf. Seven genotypes exceeded the general mean. The coefficient of variation was 8.40 per cent.

Table 1. Mean performance of ten coconut genotypes for vegetative, reproductive and nut characters

No.	Variety/ Ecotype	Plant height (cm)	Stem girth (cm)	Number of inter- nodes per meter	Number of leaves	Length of petiole (cm)	Length of leaf (cm)	Number of leaflets (right)	Number of leaflets (left)	Number of inflores- cence per year	Length of spadix (m)	Length of spikelet bearing portion (cm)	Length of stalk (cm)	Number of female flowers/ palm/ year	Number of bunches /palm /year
1.	Andaman Ordinary	8.17	85.0	22.71	34.57	1.36	4.77	110.80	108.13	13.37	1.25	68.67	49.27	512.60	13.8
2.	Laccadive Ordinary	7.92	91.7	20.79	32.37	1.18	4.42	106.17	104.27	11.57	1.11	53.70	47.70	470.81	14.1
3.	Philippines Ordinary	7.87	94.8	19.53	36.23	1.25	5.23	122.03	119.07	11.80	1.17	57.90	53.20	488.92	13.0
4.	East Coast Tall	9.20	89.7	21.90	31.03	1.23	4.78	125.87	124.37	11.08	1.23	70.70	50.60	472.00	14.11
5.	West Coast Tall	8.74	91.3	21.70	29.33	1.25	4.79	118.50	114.43	12.20	1.30	65.20	59.20	428.70	14.03
6.	Strait Settlement Green	8.20	94.3	18.26	32.93	1.18	4.32	101.20	98.43	12.51	1.19	61.60	54.33	476.00	14.08
7.	Chowhat Orange Dwarf	5.31	76.0	26.03	28.23	1.17	4.16	97.87	96.40	10.23	1.02	51.47	45.30	400.31	12.90
8.	MDY x WCT	7.25	80.0	23.07	31.57	1.11	3.95	102.17	97.83	11.33	1.12	60.60	50.10	502.70	14.00
9.	WCT x MDY	8.31	92.3	25.07	37.03	1.67	4.40	113.30	108.77	13.70	1.20	62.30	49.87	596.60	16.71
10.	WCT x Gangabondam	8.63	86.3	23.57	35.70	1.42	4.08	105.83	104.27	11.62	1.19	67.53	52.47	407.37	14.58
	Grand Mean	7.96	88.10	22.26	32.90	1.28	4.49	110.37	107.60	11.94	1.18	61.97	51.20	475.59	14.12
	SED	0.547	0.039	0.339	0.295	0.041	0.044	0.856	0.910	0.765	0.022	0.855	0.817	15.171	0.222
	CD(P=0.05)	1.148	0.082	0.712	0.619	0.085	0.093	1.797	1.912	1.607	0.046	1.790	1.717	31.874	0.466

Table 1. (Contd....)

S.No.	Variety/ Ecotype	Number of nuts/ bunch	Setting percen- tage	Length of nut (cm)	Equator ial diamete r of nut (cm)	Whole nut weight (g)	Thick- ness of husk (cm)	Weight of dehusked nut (g)	Weight of kernel (g)	Weight of shell (g)	Thick- ness of kernel (cm)	Thick- ness of shell (cm)	Oil content (%)	Nuts/ palm/ year
1.	Andaman Ordinary	8.32	24.70	27.53	47.91	873.85	2.37	525.43	228.91	154.93	1.30	0.33	69.30	127.00
2.	Laccadive Ordinary	7.07	22.50	26.97	46.10	727.57	2.34	424.83	197.30	124.80	1.21	0.28	69.90	109.67
3.	Philippines Ordinary	6.78	20.40	25.63	46.70	793.60	2.28	472.47	253.40	137.73	1.23	0.27	68.70	98.67
4.	East Coast Tall	6.80	25.50	26.43	44.23	707.13	2.29	386.23	210.77	141.60	1.36	0.32	68.00	94.37
5.	West Coast Tall	6.68	22.40	26.10	45.32	1024.03	2.41	322.37	178.40	129.93	1.19	0.31	68.50	103.82
6.	Strait Settlement Green	6.83	17.80	27.67	46.50	884.60	2.32	442.63	237.37	128.40	1.32	0.29	67.60	104.07
7.	Chowghat Orange Dwarf	5.21	25.90	22.60	39.30	594.77	2.13	301.87	214.60	115.37	1.18	0.24	68.50	84.73
8.	Dwarf x Tall	8.40	24.80	23.90	44.20	668.13	2.07	377.48	220.63	126.77	1.20	0.32	70.10	128.77
9.	Tall x Dwarf	9.90	26.60	25.41	46.17	813.97	2.19	454.10	235.87	144.90	1.26	0.35	68.40	147.30
10.	Tall x Gangabondam	7.67	19.80	28.53	42.30	784.87	2.25	404.37	218.37	136.63	1.25	0.30	68.10	118.73
	Grand Mean	7.35	28.63	26.07	44.87	787.13	2.26	411.18	219.56	134.20	1.25	0.30	56.00	108.06
	SEd	0.202	0.403	0.234	0.205	0.792	0.018	0.415	2.329	1.060	0.024	0.020	0.130	15.857
	CD(P=0.05)	0.425	0.847	0.491	0.431	1.664	0.038	0.873	4.893	2.237	0.050	0.041	0.273	33.31

Table 2. Analysis of variance in ten genotypes of coconut for vegetative, reproductive and nut characters

S.No.	Characters	Mean	Range	CV%	Mean squares	'F' value
1.	Plant height (cm)	7.96	5.31-9.20	8.40	3.47	7.76**
2.	Stem girth (cm)	88.10	76.0-94.8	5.43	0.01	4.98**
3.	Number of internodes for 1 meter	22.26	18.26-26.07	1.86	17.95	104.30**
4.	Number of leaves per palm	32.90	28.23-37.03	1.10	26.29	201.86**
5.	Length of petiole (m)	1.28	1.11-1.67	3.87	0.08	32.99**
6.	Length of leaf (m)	4.49	3.95-5.23	1.20	0.48	162.68**
7.	Number of leaflets (right)	110.37	97.87-125.87	0.95	265.67	241.99**
8.	Number of leaflets (left)	107.60	96.40-124.37	1.04	262.72	211.55**
9.	Number of inflorescence per palm per year	11.94	10.23-13.70	7.85	3.27	3.73**
10.	Length of spadix (m)	1.18	1.02-1.30	2.28	0.02	26.18**
11.	Length of spikelet bearing portion (cm)	61.97	51.47-70.70	1.69	119.96	109.44**
12.	Length of stalk (cm)	51.20	45.30-59.20	1.95	44.52	44.44**
13.	Number of female flowers/palm/year	475.59	400.31-596.60	3.91	9826.77	28.46**
14.	Number of bunches per palm per year	14.12	12.90-16.71	1.92	3.234	43.90**

\* Significant at 5 per cent level

\*\* Significant at 1 per cent level

Table 2. (Contd...)

S.No.	Characters	Mean	Range	CV%	Mean squares	'F' value
15.	Number of nuts per bunch	7.35	5.21-9.90	3.37	2.231	36.43**
16.	Setting percentage	28.63	17.8-26.6	1.73	12.44	51.03**
17.	Length of nut (cm)	26.07	22.6-28.53	1.10	9.641	117.67**
18.	Equatorial diameter of nut (cm)	44.87	39.30-47.91	0.56	19.017	301.50**
19.	Whole nut weight (g)	787.13	594.77-1024.03	0.12	44965.89	47788.53**
20.	Thickness of husk (cm)	2.26	2.07-2.54	0.99	0.05	103.66**
21.	Weight of dehusked nut (g)	411.18	301.87-525.43	0.12	13823.43	53402.86**
22.	Weight of kernel (g)	219.56	178.40-253.40	1.30	1369.82	168.38**
23.	Weight of shell (g)	134.20	115.37-154.93	0.97	385.23	228.39**
24.	Thickness of kernel (cm)	1.25	1.18-1.36	2.33	0.01	12.90**
25.	Thickness of shell (cm)	0.30	0.24-0.35	7.92	0.03	5.47**
26.	Oil content (%)	56.00	67.6-70.1	0.28	0.79	31.27**
27.	Number of nuts per palm per year	108.06	84.73-143.30	17.97	1288.88	3.42*

\* Significant at 5 per cent level

\*\* Significant at 1 per cent level

#### 4.1.1.2. Stem girth

Stem girth ranged from 76.0 cm (Dwarf x Tall) hybrid to 94.8 cm (Philippines Ordinary). The general mean of this attribute was 88.10 cm. Increased stem girth over general mean was recorded by five genotypes *viz.*, Philippines Ordinary, Strait Settlement Green, Laccadive Ordinary, West Coast Tall and East Coast Tall. The coefficient of variation for stem girth was 5.43 per cent.

#### 4.1.1.3. Number of internodes per meter

The number of internodes for one meter varied from 18.26 to 26.07. Number of internodes per meter was maximum in the Chowghat Orange Dwarf (26.07). Among the Tall, it was maximum in the genotype Andaman Ordinary (22.71), while it was minimum in Semi Tall genotype, Strait Settlement Green (18.26). The variability was found to be 1.86 per cent.

#### 4.1.1.4. Number of leaves per palm

Number of leaves were ranging from 28.23 to 37.03 and the hybrid WCT x MDY recorded the maximum number of leaves (37.03). It was low in the genotype, Chowghat Orange Dwarf (28.23). The general mean for this character was 32.90. Six genotypes exceeded the general mean. Among the Tall genotypes, Philippines Ordinary had maximum number of leaves (36.23). While it was minimum in West Coast Tall 29.33. Low coefficient of variation of 1.10 per cent was recorded for number of leaves per palm.

#### 4.1.1.5. Length of petiole

The length of petiole ranged from 1.11 to 1.67. The hybrid WCT x MDY recorded maximum petiole length of 1.67 m followed by WCT x Gangabondam (1.42 m) and it was minimum in MDY x WCT (1.11 m). Among the Tall genotypes Andaman Ordinary registered maximum length of 1.36 m followed by Philippines Ordinary and West Coast Tall with the same length of 1.25 m. The CV per cent was 3.87.

#### 4.1.1.6. Length of leaf

The length of leaf ranged from 3.95 to 5.23 m, with a general mean of 4.49 m. Among Tall, Semi Tall, Dwarf and Hybrids the Tall genotype Philippines Ordinary recorded the maximum leaf length of 5.23 m and it was the minimum in hybrid MDY x WCT (3.95 m). The variability recorded for this trait was 1.20 per cent.

#### 4.1.1.7. Number of leaflets (right)

It ranged from 97.87 to 125.87. The general mean was found to be 110.37. The genotype East Coast Tall recorded the maximum number of leaflets on the right side of the lamina (125.87) and the type Chowghat Orange Dwarf recorded the minimum number of leaflets (97.87). Five genotypes exceeded the general mean.

#### 4.1.1.8. Number of leaflets (left)

Number of leaflets on left side of the lamina ranged from 96.40 – 124.37 with a general mean of (107.60). The number of leaflets on the left side of lamina was also the maximum in East Coast Tall and the minimum in Chowghat Orange Dwarf. In general

leaflets on the right side was high when compared to leaflets on leftside. It also showed low coefficient of variation of 1.04 per cent.

#### **4.1.2. Reproductive characters**

##### **4.1.2.1. Number of inflorescences per palm per year**

The number of inflorescence among the genotypes ranged from 10.23 and 13.70 with general mean of 11.94. Among the hybrids, the maximum number of inflorescence was produced by WCT x MDY (13.70) followed by WCT x Gangabondam (11.62) and it was the minimum in MDY x WCT (11.33). Among Tall, the genotypes Andaman Ordinary recorded the highest number of inflorescence per palm (13.37) followed by West Coast Tall (12.20). The Semi Tall genotype Strait Settlement Green also produced increased number of inflorescences per year (12.51). But the Chowghat Orange Dwarf produced the least number of inflorescence per year (10.23). High CV of 7.85 per cent was recorded for this trait.

##### **4.1.2.2. Length of spadix**

The length of spadix varied from 1.02 m (Chowghat Orange Dwarf) to 1.30 m (West Coast Tall) with a general mean of 1.18 cm. Five genotypes viz., Andaman Ordinary, East Coast Tall, WCT x MDY, Strait Settlement Green and WCT x Gangabondam had significantly higher mean than the general mean. The CV was found to be 2.28 per cent.

#### 4.1.2.3. Length of spikelet bearing portion

It ranged from 51.47 to 70.70 cm. The general mean for this attribute was found to be 61.97 cm. Among Tall, Semi Tall, Dwarf and Hybrids, the genotype East Coast Tall registered the maximum length of 70.70 cm followed by Andaman Ordinary with 68.67 cm. The length of spikelet bearing portion was the minimum in the type Chowghat Orange Dwarf (51.47 cm). The variability of 1.65 per cent was recorded for this trait.

#### 4.1.2.4. Length of stalk

The length of stalk ranged from 45.30 to 59.20 cm with general mean of 51.20 cm. The type East Coast Tall recorded the maximum length of 59.20 cm followed by a Semi Tall genotype Strait Settlement Green 54.33 cm and WCT x Gangabondam with 52.47 cm and the ecotype Chowghat Orange Dwarf recorded the minimum length of 45.30 cm. The general mean of 51.20 cm was exceeded by four genotypes. The CV for stalk length was 1.95 per cent.

#### 4.1.2.5. Number of female flowers per palm per year

The number of female flowers per palm per year showed wide variation and it ranged from 400.31 (Chowghat Orange Dwarf) to 596.60 (WCT x MDY). Among the Tall, the genotype Andaman Ordinary registered the highest number of female flowers (512.60) followed by Philippines Ordinary (488.92). The minimum number of female flowers in Tall type was recorded by West Coast Tall (428.70). The CV was found to be 3.91 per cent.

### 4.1.3. Nut characters

#### 4.1.3.1. Number of bunches per palm per year

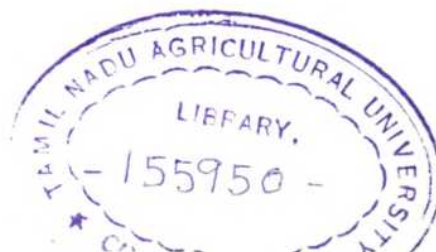
It ranged from 12.90 to 16.71 with a general mean of 14.12. The highest number of bunches per palm per year was produced by the hybrid WCT x MDY (16.71) and was followed by WCT x Gangabondam (14.58). The lowest number of bunches per palm 12.90 was produced by Chowghat Orange Dwarf. Among the Tall, the type East Coast Tall recorded the highest number of bunches per palm (14.21). The CV was found to be 1.92 per cent.

#### 4.1.3.2. Number of nuts per bunch

Number of nuts per bunch ranged from 5.21 to 9.92 with a general mean of 7.35. The maximum number of nuts per bunch was observed in the hybrid WCT x MDY (9.92) followed by MDY x WCT (8.40). Among the Talls, Andaman Ordinary (8.32) showed the maximum number of nuts per palm followed by Laccadive Ordinary (7.07). The Dwarf genotype Chowghat Orange Dwarf had the minimum number of nuts per bunch (5.21). The CV was 3.37 per cent.

#### 4.1.3.3. Setting percentage

It ranged from 17.80 (Strait Settlement Green) to 26.60 (WCT x MDY). The general mean was found to be (24.04). Four ecotypes *viz.*, Chowghat Orange Dwarf, East Coast Tall, MDY x WCT and Andaman Ordinary exceeded the general mean. The variability was found to be 1.73 per cent.



#### 4.1.3.4. Length of nut

Length of nut ranged from 22.60 cm to 28.53 cm with a mean range of 26.07 cm. The hybrid WCT x Gangabondam recorded the maximum length of 28.53 cm followed by Strait Settlement Green (27.67 cm). The lowest length of 22.60 cm was noticed in Chowghat Orange Dwarf. This trait recorded 1.10 per cent of variability.

#### 4.1.3.5. Equatorial diameter of nut

It ranged from 39.40 to 47.91 cm. The general mean was found to be 44.87 cm. Equatorial diameter of nut was found to be maximum in Tall genotype Andaman Ordinary (47.91 cm) followed by Philippines Ordinary (46.70 cm). Among the hybrids, WCT x MDY registered maximum diameter of 46.17 cm. The equatorial diameter was found to be minimum in Dwarf genotype, Chowghat Orange Dwarf (39.30 cm). The CV was 0.56 per cent.

#### 4.1.3.6. Whole nut weight

Whole nut weight ranged from 594.77 g (Chowghat Orange Dwarf) to 1024.03 g (West Coast Tall) with a general mean of 787.13 g. Four genotypes viz., Strait Settlement Green, Andaman Ordinary, WCT x MDY and Philippines Ordinary recorded high values over general mean. This trait recorded 0.12 per cent of variability.

#### 4.1.3.7. Thickness of husk

It ranged from 2.07 cm to 2.54 cm. The general mean for this attribute was 2.26 cm. Thickness of husk was high above the general mean in six genotypes. The maximum husk thickness was exhibited by Laccadive Ordinary (2.54 cm), while it was minimum in the hybrid MDY x WCT (2.07 cm). The CV was 0.99 per cent.

#### 4.1.3.8. Weight of dehusked nut

The weight of dehusked nut showed wide variation. It ranged from 301.87 g to 525.43 g. Among the genotypes, Andaman Ordinary recorded the highest weight of 525.43 g followed by Philippines Ordinary 472.47 g. Among the hybrids, WCT x MDY recorded the maximum weight of 454.10 g. The minimum weight of 301.87 g was observed in Chowghat Orange Dwarf. Five genotypes exceeded the general mean of 411.18 g. The CV was found to be 0.12 per cent.

#### 4.1.3.9. Weight of kernel

The range of weight of kernel was between 178.40 g (WCT) to 253.40 g (Philippines Ordinary). The general mean for this attribute was 219.56 g. Among the Talls, Philippines Ordinary recorded the maximum weight of 253.40 g and in hybrids, WCT x MDY exerted the maximum weight of 235.87 g. Four genotypes exceeded the general mean. Coefficient of variation was 1.30 per cent.

#### 4.1.3.10. Weight of shell

It ranged from 115.37 g to 154.93 g. The weight of shell was higher than the general mean of 134.20 g in five genotypes. The maximum weight of 154.93 g was noticed in Andaman Ordinary followed by WCT x MDY (144.90 g). While Chowghat Orange Dwarf recorded the minimum weight of 115.37 g. This trait showed 0.97 per cent of variation.

#### 4.1.3.11. Thickness of kernel

Thickness of kernel varied from 1.18 cm to 1.36 cm with a general mean of 1.25 cm. The genotype East Coast Tall recorded the maximum kernel thickness of 1.36 cm followed by Strait Settlement Green (1.32 cm). Among the hybrids, WCT x MDY had the maximum kernel thickness of 1.26 cm and it was the lowest in Dwarf genotype Chowghat Orange Dwarf (1.18 cm). The CV was found to be 2.33 per cent.

#### 4.1.3.12. Thickness of shell

It ranged from 0.24 cm to 0.35 cm. The general mean was found to be 0.30 cm. The maximum thickness of shell was observed in the hybrid WCT x MDY (0.35 cm) followed by Andaman Ordinary (0.33 cm). The type Chowghat Orange Dwarf recorded the lowest thickness of 0.24 cm. Five genotypes exceeded the general mean. The CV was 7.92 per cent.

#### 4.1.3.13. Oil content

The oil content ranged from 67.60 to 70.10 per cent with general mean of 68.71 per cent. The highest oil content was recorded in the hybrid MDY x WCT (70.10 per cent) followed by Laccadive Ordinary (69.90 per cent) and it was the lowest in Strait Settlement Green 67.60 per cent. The CV was 0.28 per cent.

#### 4.1.3.14. Number of nuts per palm per year

The range of nut yield was from 84.73 to 147.30. The hybrid WCT x MDY had the maximum nut yield of 147.30 nuts per palm followed by MDY x WCT with 128.11 nuts per palm. Among the Tall, the genotype Andaman Ordinary recorded the maximum nut yield of 127.00 nuts per palm and it was the lowest in Chowghat Orange Dwarf (84.73 nuts per palm). High variability of 17.97 per cent was recorded by nut yield per palm (Fig 1).

### 4.2. Genetic parameters of adult palm

The genetic parameters like phenotypic variance, genotypic variance, phenotypic and genotypic coefficient of variations, heritability, genetic advance and genetic advance as per cent mean for vegetative, reproductive and nut characters are presented in Table 3.

#### 4.2.1. Phenotypic and genotypic variance

Phenotypic variances estimated for all the characters were greater in magnitude than the genotypic variances. The phenotypic and genotypic variances were the highest for whole nut weight (14989.27 and 14988.33) followed by weight of dehusked nut

Table 3 Variance, heritability and genetic advance for the vegetative, reproductive and nut characters in coconut genotypes

S No	Characters	Genotypic variance	Phenotypic variance	CV		Heritability	Genetic advance	Genetic advances per cent mean
				Genotypic coefficient of variation	Phenotypic coefficient of variation			
1	Plant height (cm)	1 01	1 46	12 66	15 16	69 25	1 73	21 62
2	Stem girth (cm)	0 003	0 005	6 25	8 29	56 99	0 09	9 73
3	Number of internodes for 1 meter	5 93	6 09	10 93	11 09	97 18	4 95	22 20
4	Number of leaves per palm	8 72	8 85	8 98	9 04	98 53	6 03	18 35
5	Length of petiole (m)	0 026	0 029	12 65	13 23	91 43	0 32	24 92
6	Length of leaf (m)	0 157	0 160	8 83	8 91	97 17	0 80	18 02
7	Number of leaflets (right)	88 19	89 29	8 51	8 56	98 17	19 16	17 42
8	Number of leaflets (left)	87 15	88 40	8 68	8 74	98 59	19 09	17 75
9	Number of inflorescence per palm per year	0 80	1 68	7 48	10 84	47 60	1 27	10 63
10	Length of spadix (m)	0 006	0 008	6 61	6 99	89 36	1 64	12 87
11	Length of spikelet bearing portion (cm)	39 62	40 72	10 16	10 30	97 30	12 79	20 64
12	Length of stalk (cm)	14 51	15 51	7 44	7 69	93 53	7 59	14 82
13	Number of female flowers/palm/year	3160 49	3505 74	11 82	12 45	90 15	110 02	23 12
14	Number of bunches per palm per year	1 05	1 13	7 27	7 52	93 48	2 04	14 48

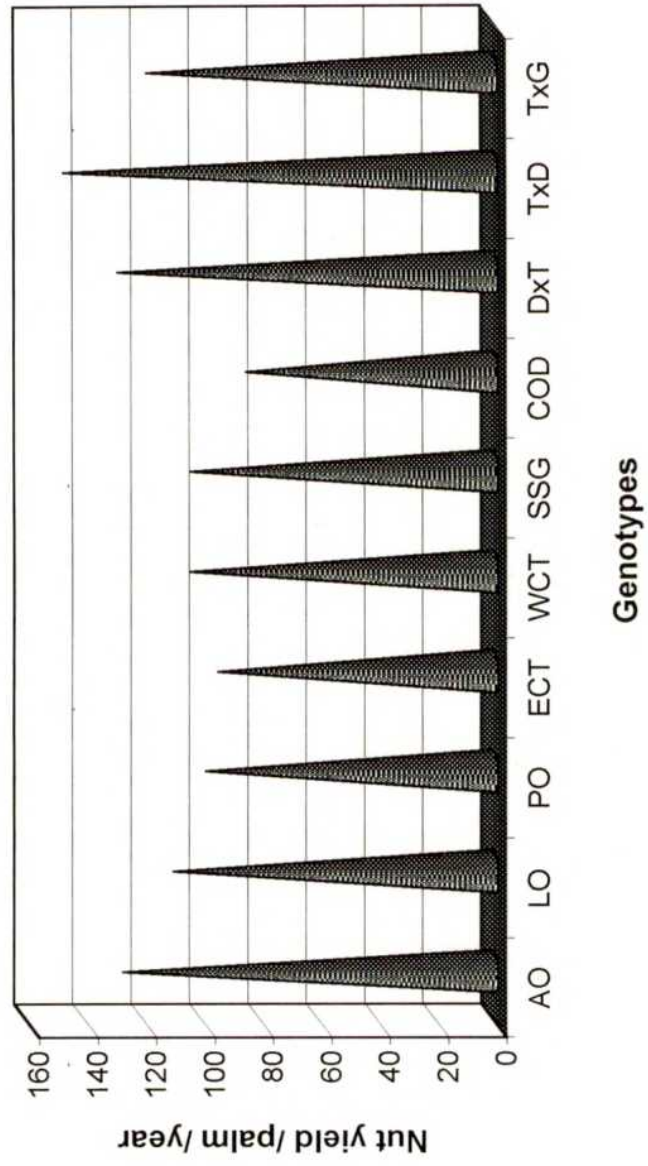
Table 3 (Contd )

S No	Characters	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability	Genetic advance	Genetic advances per cent mean
15	Number of nuts per bunch	0.72	0.78	11.58	12.06	92.19	1.67	23.89
16	Setting percentage	4.07	4.31	7.04	7.25	94.35	4.04	14.09
17	Length of nut (cm)	3.19	3.27	6.85	6.93	97.50	3.64	13.93
18	Equatorial diameter of nut (cm)	6.32	6.38	5.60	5.63	98.12	5.11	11.48
19	Whole nut weight (g)	14988.33	14989.27	15.55	15.57	96.19	242.62	32.04
20	Thickness of husk (cm)	0.017	0.018	5.77	5.86	97.17	0.27	11.73
21	Weight of dehusked nut (g)	4607.70	4609.98	16.51	16.57	98.08	137.18	34.01
22	Weight of kernel (g)	453.89	462.03	9.70	9.79	98.24	43.09	19.81
23	Weight of shell (g)	127.84	129.54	8.43	8.48	98.69	23.00	17.24
24	Thickness of kernel (cm)	0.003	0.004	4.65	5.20	79.88	0.08	8.56
25	Thickness of shell (cm)	0.001	0.002	9.68	12.51	59.86	0.04	15.42
26	Oil content (%)	0.26	0.28	0.90	0.95	90.88	0.95	1.77
27	Number of nuts per palm per year	303.91	681.07	16.73	24.15	44.62	16.01	22.20

**FIG. 1. MEAN PERFORMANCE OF COCONUT GENOTYPES FOR NUMBER OF NUTS / PALM / YEAR**

AO	-	Andaman Ordinary
LO	-	Laccadive Ordinary
PO	-	Philippines Ordinary
ECT	-	East Coast Tall
WCT	-	West Coast Tall
SSG	-	Strait Settlement Green
COD	-	Chowghat Orange Dwarf
DxT	-	West Coast Tall x Malayan Dwarf Yellow
TxD	-	Malayan Dwarf Yellow x West Coast Tall
TxG	-	West Coast Tall x Gangabondam

Fig.1. Mean performance of coconut genotypes for number of nuts/palm/year



(4609 98 and 4607 70), number of female flowers (3505 74 and 3160 49) nuts per palm (681 07 and 303 91), weight of kernel (462 03 and 453 89) and weight of shell (129 54 and 127 84)

Phenotypic and genotypic variances were low for length of spikelet bearing portion (40 72 and 39 62), length of stalk (15 51 and 14 51), number of leaves (8 85 and 8 72), equatorial diameter of nut (6 38 and 6 32), number of internodes for one meter (6 09 and 5 93), plant height (1 46 and 1 01) and number of bunches per year (1 13 and 1 05) While the phenotypic and genotypic variances were the least for thickness of kernel (0 004 and 0 003) and thickness of shell (0 002 and 0 001)

#### **4.2.2. Phenotypic and genotypic coefficient of variation, heritability and genetic advance**

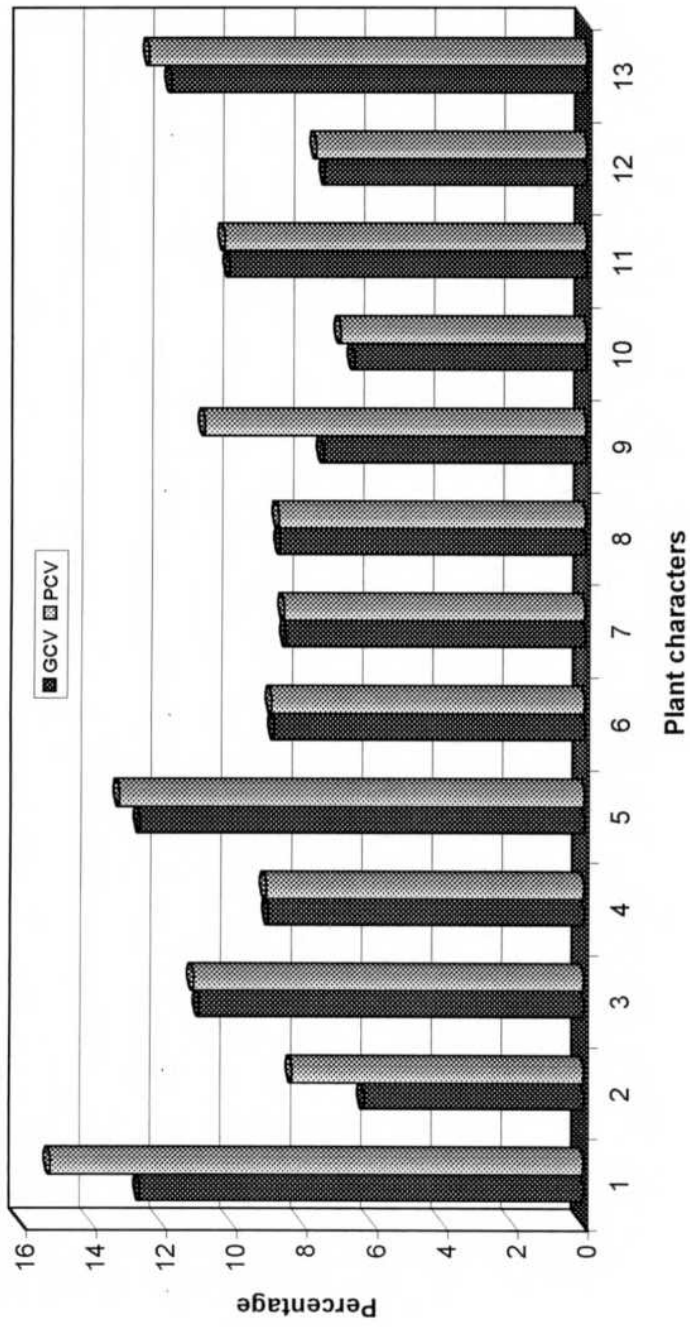
##### **4.2.2.1. Vegetative characters**

Among the morphological parameters, plant height recorded maximum GCV and PCV of (12 66 and 15 16 per cent) followed by length of petiole and number of internodes for one meter (12 65 and 13 23 and 10 93 and 11 09 per cent respectively) Regarding heritability, number of leaflets on left side of lamina and number of leaves per palm recorded higher values showing 98 59 per cent and 98 53 per cent respectively Mean length of petiole recorded a high value for genetic advance as per cent of mean (24 92 per cent) closely followed by number of internodes for one meter (22 20 per cent) and plant height (21 62 per cent) (Fig 2 and 4)

**FIG. 2. PCV AND GCV FOR VEGETATIVE AND REPRODUCTIVE CHARACTERS IN COCONUT GENOTYPES**

- 1 Plant height
- 2 Stem girth
- 3 Number of internodes for one meter
- 4 Number of leaves/palm
- 5 Length of petiole
- 6 Length of leaf
- 7 Number of leaflets (right)
- 8 Number of leaflets (left)
- 9 Number of inflorescences/palm
- 10 Length of spadix
- 11 Length of spikelet bearing portion
- 12 Length of stalk
- 13 Number of female flowers

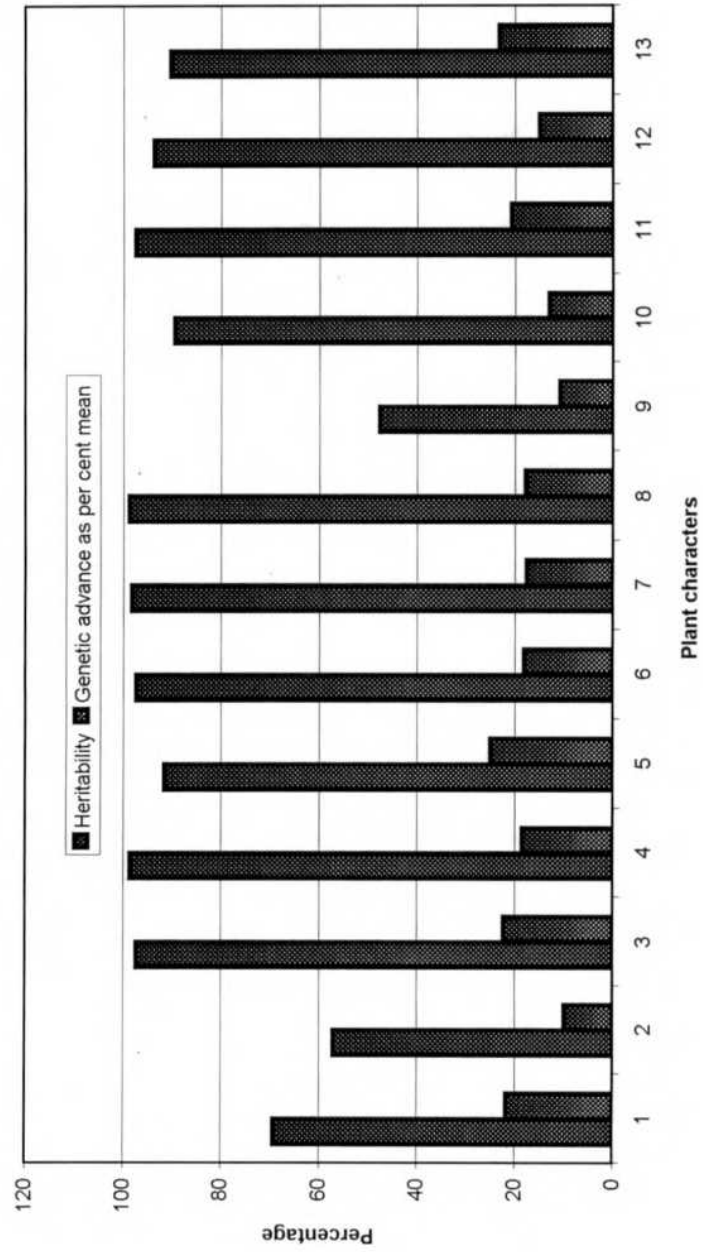
Fig.2 .PCV and GCV for vegetative and reproductive characters in coconut genotypes



**FIG. 4. HERITABILITY, GENETIC ADVANCE AS PER CENT MEAN FOR VEGETATIVE AND REPRODUCTIVE CHARACTERS IN COCONUT GENOTYPES**

- 1 Plant height
- 2 Stem girth
- 3 Number of internodes for one meter
- 4 Number of leaves/palm
- 5 Length of petiole
- 6 Length of leaf
- 7 Number of leaflets (right)
- 8 Number of leaflets (left)
- 9 Number of inflorescences/palm
- 10 Length of spadix
- 11 Length of spikelet bearing portion
- 12 Length of stalk
- 13 Number of female flowers

Fig.4. Heritability and genetic advance as percent mean for vegetative and reproductive characters in coconut genotypes



#### 4.2.2.2. Reproductive characters

The trait number of inflorescences per palm recorded a high value for GCV (11.82 %) and PCV (12.45 %) followed by length of spikelet bearing portion and number of inflorescences per palm per year with GCV of 10.16 and 7.48 per cent and PCV of 10.30 and 10.84 per cent. The low values for GCV and PCV were recorded by length of spadix (6.61 and 6.99 %) respectively (Fig 2 and 4)

Regarding heritability length of spikelet bearing portion recorded the highest heritability of 97.30 per cent followed by length of stalk (93.53 %) and number of female flowers (90.15 %). Number of inflorescence per palm per year showed low heritability value of 47.60 per cent. GA as per cent mean was high for the trait number of female flowers (23.12 %) followed by length of spikelet bearing portion (20.64 %). Length of spadix showed a low value of 12.87 for GA as per cent mean.

#### 4.2.2.3. Nut characters

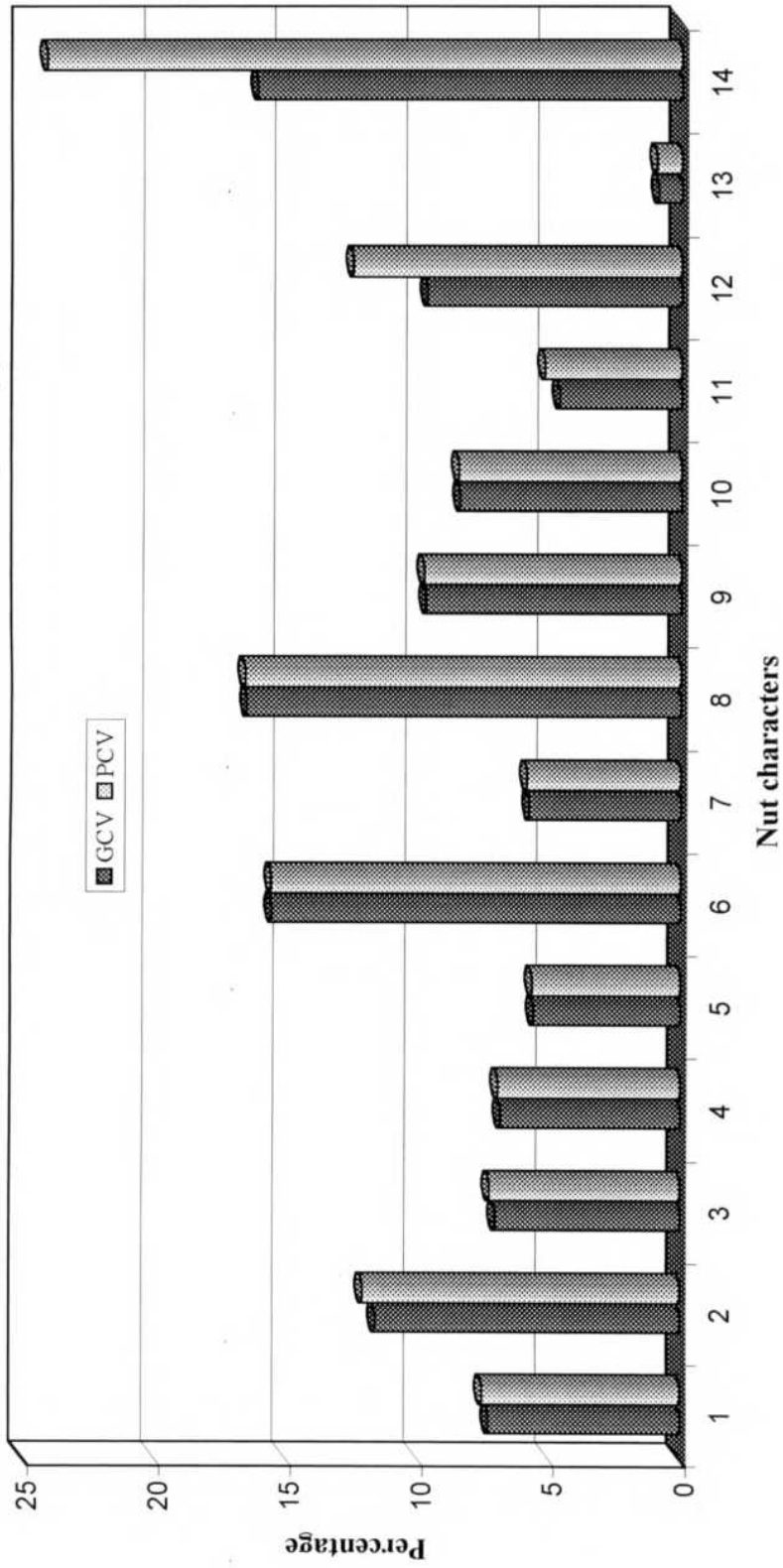
Among the nut characters studied, nut yield per palm per year recorded high GCV (16.73) and PCV (24.15) followed by weight of dehusked nut, whole nut weight and number of nuts per bunch. All other characters showed low values for both the parameters.

Regarding heritability, most of the characters showed high heritability values. The trait weight of shell exhibited the highest value (98.69 %) closely followed by

**FIG. 3. PCV AND GCV FOR NUT CHARACTERS IN COCONUT GENOTYPES**

- 1 Number of bunches/palm
- 2 Number of nuts/bunch
- 3 Setting percentage
- 4 Length of nut
- 5 Equatorial diameter of nut
- 6 Whole nut weight
- 7 Thickness of husk
- 8 Weight of dehusked nut
- 9 Weight of kernel
- 10 Weight of shell
- 11 Thickness of kernel
- 12 Thickness of shell
- 13 Oil content
- 14 Number of nuts/palm/year

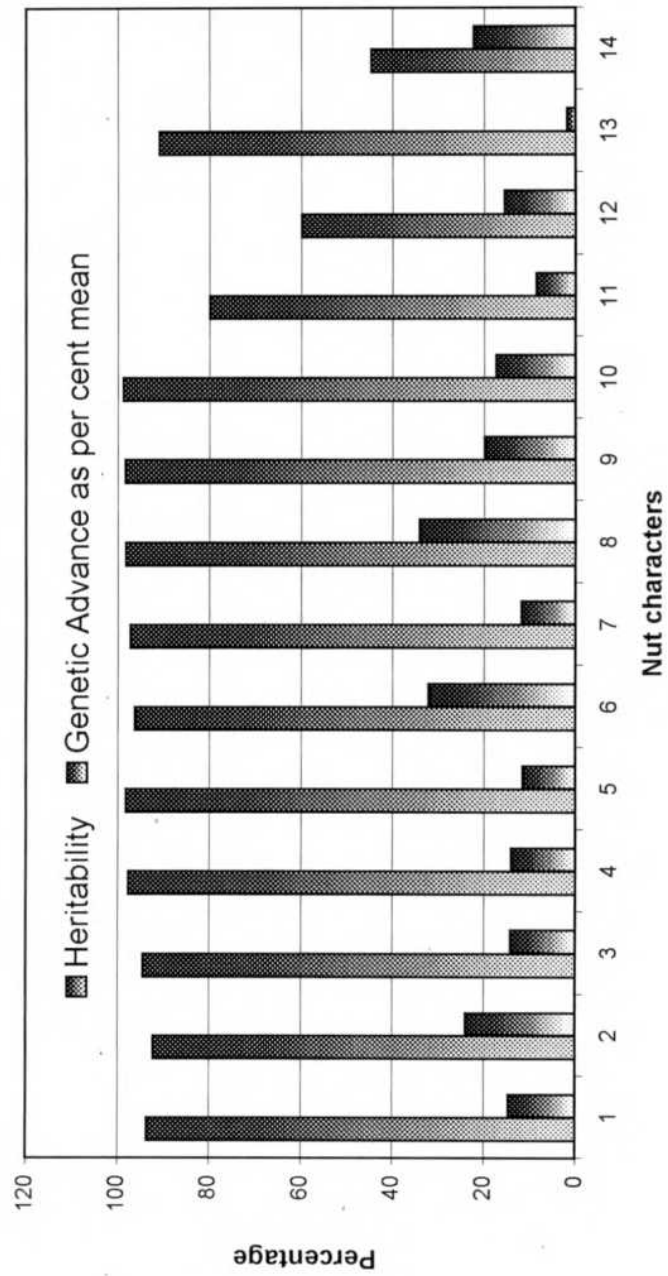
Fig.3.GCV and PCV for nut characters in coconut genotypes



**FIG. 5. HERITABILITY AND GENETIC ADVANCE AS PER CENT MEAN FOR NUT CHARACTERS IN COCONUT GENOTYPES**

- 1 Number of bunches/palm
- 2 Number of nuts/bunch
- 3 Setting percentage
- 4 Length of nut
- 5 Equatorial diameter of nut
- 6 Whole nut weight
- 7 Thickness of husk
- 8 Weight of dehusked nut
- 9 Weight of kernel
- 10 Weight of shell
- 11 Thickness of kernel
- 12 Thickness of shell
- 13 Oil content
- 14 Number of nuts/palm/year

Fig.5. Heritability and genetic advance as percent mean for nut characters in coconut genotypes



weight of kernel (98.24 %), equatorial diameter of nut (98.12 %) and weight of dehusked nut (98.08). The characters viz, length of nut, thickness of husk, whole nut weight, setting percentage, number of branches per palm, number of nuts per bunch also showed high heritability values. Whereas number of nuts per palm per year (44.62 %) and thickness of shell (59.86 %) recorded low heritability values.

Weight of dehusked nut exhibited a moderate value for GA as per cent of mean (34.01 %) followed by whole nut weight (34.04 %). All other characters recorded low values for GA as per cent of mean. Oil content showed a low value for GCV (0.90 %), PCV (0.95 %) and GA as per cent of mean (1.77 %). But this character showed high heritability value 90.88 per cent (Fig 3 and 5).

### **4.3. Correlation studies in adult palm**

The genotypic, phenotypic and environmental correlation coefficients were worked out for 27 parameters to determine the nature of association existing between the characters. The data obtained are furnished in (Tables 4, 5 and 6) and the results are presented below.

#### **4.3.1. Association between nut yield and other component characters**

Both at genotypic and phenotypic levels, nut yield per palm showed positive and significant association with number of female flowers (1.158 and 0.619) followed by number of inflorescence per year (1.032 and 0.492), number of nuts per bunch (0.912 and

Table 4 Genotypic correlation coefficients for various growth and yield characters of ten coconut genotypes

Character	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	X <sub>7</sub>	X <sub>8</sub>	X <sub>9</sub>	X <sub>10</sub>	X <sub>11</sub>	X <sub>12</sub>	X <sub>13</sub>	X <sub>14</sub>	X <sub>15</sub>	X <sub>16</sub>	X <sub>17</sub>	X <sub>18</sub>	X <sub>19</sub>	X <sub>20</sub>	X <sub>21</sub>	X <sub>22</sub>	X <sub>23</sub>	X <sub>24</sub>	X <sub>25</sub>	X <sub>26</sub>	X <sub>27</sub>	X <sub>28</sub>	X <sub>29</sub>	X <sub>30</sub>	Y				
X <sub>1</sub>	0.293																															0.176			
X <sub>2</sub>	0.246	0.448																														0.769	0.316		
X <sub>3</sub>	0.590	0.045	0.383																														0.656	-0.235	
X <sub>4</sub>		0.068	0.236	0.676																													0.891	0.031	
X <sub>5</sub>			0.633	0.367	0.593																													0.279	0.183
X <sub>6</sub>			0.709	-0.154	0.054	0.165																												0.428	0.461
X <sub>7</sub>				0.185	0.753	0.244	0.251																											0.324	0.553
X <sub>8</sub>				0.207	0.812	0.369	0.353	0.001																										0.643	0.650
X <sub>9</sub>				0.834	0.286	0.557	0.225	0.368	0.166																									0.480	0.035
X <sub>10</sub>				0.996	0.223	0.684	0.511	0.433	0.236	0.091																								0.556	0.406
X <sub>11</sub>					0.133	0.659	0.509	0.374	0.156	0.036																								0.412	0.131
X <sub>12</sub>						0.721	0.446	0.343	0.853	0.739																								0.537	0.093
X <sub>13</sub>							0.848	0.756	0.201	0.312																								0.448	-0.110
X <sub>14</sub>								0.454	0.140	0.305																							0.849	0.783	
X <sub>15</sub>									-0.113	0.060																							0.792	1.032	
X <sub>16</sub>										0.060																							0.431	0.088	
X <sub>17</sub>										0.060																							0.705	0.271	
X <sub>18</sub>										0.060																							0.727	0.150	
X <sub>19</sub>										0.060																							0.080	-0.267	
X <sub>20</sub>										0.060																							0.138	-0.053	
X <sub>21</sub>										0.060																							0.407	1.158	
X <sub>22</sub>										0.060																							0.773	0.833	
X <sub>23</sub>										0.060																							0.324	0.624	
X <sub>24</sub>										0.060																							0.407	0.766	
X <sub>25</sub>										0.060																							0.886	0.606	
X <sub>26</sub>										0.060																							0.745	0.259	
X <sub>27</sub>										0.060																							0.341	0.912	
X <sub>28</sub>										0.060																							0.296	0.259	
X <sub>29</sub>										0.060																							0.338	0.250	
X <sub>30</sub>										0.060																							0.526	-0.118	
Y																																	0.624	0.708	
																																	0.388	0.553	
																																	0.409	0.101	
																																	0.222	0.272	
																																	0.760	-0.092	
																																	0.308	0.412	
																																	0.498	0.688	
																																	0.760	0.529	
																																	0.657	0.467	
																																	0.562	0.161	
																																	0.356	0.903	
																																	0.827	0.827	

X<sub>1</sub> Plant height (cm)  
 X<sub>2</sub> Stem girth (cm)  
 X<sub>3</sub> Number of meristemes per meter  
 X<sub>4</sub> Number of leaves  
 X<sub>5</sub> Length of petiole (cm)  
 X<sub>6</sub> Length of leaf (cm)  
 X<sub>7</sub> Number of leaflets (right)  
 X<sub>8</sub> Number of leaflets (left)  
 X<sub>9</sub> Number of inflorescence per year  
 X<sub>10</sub> Length of spadix (cm)  
 X<sub>11</sub> Length of spatulate bearing portion (cm)  
 X<sub>12</sub> Length of stalk (cm)  
 X<sub>13</sub> Number of female flowers/palm/year  
 X<sub>14</sub> Number of bunches per palm per year  
 X<sub>15</sub> Number of nuts per bunch  
 X<sub>16</sub> Setting percentage  
 X<sub>17</sub> Length of nut (cm)  
 X<sub>18</sub> Equatorial diameter of nut (cm)  
 X<sub>19</sub> Whole nut weight (g)  
 X<sub>20</sub> Thickness of husk (cm)  
 X<sub>21</sub> Weight of dehusked nut (g)  
 X<sub>22</sub> Weight of kernel (g)  
 X<sub>23</sub> Weight of shell (g)  
 X<sub>24</sub> Thickness of kernel (cm)  
 X<sub>25</sub> Thickness of shell (cm)  
 X<sub>26</sub> Oil content (%)  
 Y Genotypic correlation coefficient with nut yield per palm

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

Table 5 Phenotypic correlation coefficients for various growth and yield characters of ten coconut genotypes

Character	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	X <sub>7</sub>	X <sub>8</sub>	X <sub>9</sub>	X <sub>10</sub>	X <sub>11</sub>	X <sub>12</sub>	X <sub>13</sub>	X <sub>14</sub>	X <sub>15</sub>	X <sub>16</sub>	X <sub>17</sub>	X <sub>18</sub>	X <sub>19</sub>	X <sub>20</sub>	X <sub>21</sub>	X <sub>22</sub>	X <sub>23</sub>	X <sub>24</sub>	X <sub>25</sub>	X <sub>26</sub>	X <sub>27</sub>	X <sub>28</sub>	X <sub>29</sub>	X <sub>30</sub>	Y		
X <sub>1</sub>	0.347																															0.105	
X <sub>2</sub>	0.496	0.240																														0.231	
X <sub>3</sub>		0.011	0.285																													0.523	
X <sub>4</sub>		0.070	0.121	0.337																												0.493	
X <sub>5</sub>			0.250	0.387	0.101																												0.101
X <sub>6</sub>			0.663	0.204	0.519	0.180																											0.185
X <sub>7</sub>				0.062	0.540	0.196	0.229																										0.047
X <sub>8</sub>					0.216	0.820	0.229	0.819																									0.275
X <sub>9</sub>					0.163	0.983																											0.185
X <sub>10</sub>																																	0.470
X <sub>11</sub>																																	0.218
X <sub>12</sub>																																	0.040
X <sub>13</sub>																																	0.302
X <sub>14</sub>																																	0.243
X <sub>15</sub>																																	0.456
X <sub>16</sub>																																	0.193
X <sub>17</sub>																																	0.424
X <sub>18</sub>																																	0.517
X <sub>19</sub>																																	0.608
X <sub>20</sub>																																	0.205
X <sub>21</sub>																																	0.296
X <sub>22</sub>																																	0.541
X <sub>23</sub>																																	0.191
X <sub>24</sub>																																	0.623
X <sub>25</sub>																																	0.558
X <sub>26</sub>																																	0.149
X <sub>27</sub>																																	0.262
X <sub>28</sub>																																	0.276
X <sub>29</sub>																																	0.650
X <sub>30</sub>																																	0.407
Y																																	0.097
																																	0.238
																																	0.487
																																	0.656
																																	0.114
																																	0.241
																																	0.442
																																	0.118
																																	0.375

X<sub>1</sub> Plant height (cm)  
 X<sub>2</sub> Stem girth (cm)  
 X<sub>3</sub> Number of meristodes per meter  
 X<sub>4</sub> Number of leaves  
 X<sub>5</sub> Length of petiole (cm)  
 X<sub>6</sub> Length of leaf (cm)  
 X<sub>7</sub> Number of leaflets (right)  
 X<sub>8</sub> Number of leaflets (left)  
 X<sub>9</sub> Number of inflorescence per year

X<sub>10</sub> Length of spathe (cm)  
 X<sub>11</sub> Length of spathe bearing portion (cm)  
 X<sub>12</sub> Length of stalk (cm)  
 X<sub>13</sub> Number of female flowers/palm/year  
 X<sub>14</sub> Number of bunches per palm per year  
 X<sub>15</sub> Number of nuts per bunch  
 X<sub>16</sub> Seeding percentage  
 X<sub>17</sub> Length of nut (cm)  
 X<sub>18</sub> Equatorial diameter of nut (cm)

X<sub>19</sub> Whole nut weight (g)  
 X<sub>20</sub> Thickness of husk (cm)  
 X<sub>21</sub> Weight of dehusked nut (g)  
 X<sub>22</sub> Weight of kernel (g)  
 X<sub>23</sub> Weight of shell (g)  
 Y<sub>1</sub> Thickness of kernel (cm)  
 Y<sub>2</sub> Thickness of shell (cm)  
 Y<sub>3</sub> Oil content (%)  
 Y<sub>4</sub> Genotypic correlation coefficient with nut yield per palm

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

Table 6 Environmental correlation coefficients for various growth and yield characters of ten coconut genotypes

Character	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	X <sub>7</sub>	X <sub>8</sub>	X <sub>9</sub>	X <sub>10</sub>	X <sub>11</sub>	X <sub>12</sub>	X <sub>13</sub>	X <sub>14</sub>	X <sub>15</sub>	X <sub>16</sub>	X <sub>17</sub>	X <sub>18</sub>	X <sub>19</sub>	X <sub>20</sub>	X <sub>21</sub>	X <sub>22</sub>	X <sub>23</sub>	X <sub>24</sub>	X <sub>25</sub>	X <sub>26</sub>	X <sub>27</sub>	X <sub>28</sub>	X <sub>29</sub>	X <sub>30</sub>	X <sub>31</sub>	X <sub>32</sub>	X <sub>33</sub>	X <sub>34</sub>	X <sub>35</sub>	X <sub>36</sub>	X <sub>37</sub>	X <sub>38</sub>	X <sub>39</sub>	X <sub>40</sub>	X <sub>41</sub>	X <sub>42</sub>	X <sub>43</sub>	X <sub>44</sub>	X <sub>45</sub>	X <sub>46</sub>	X <sub>47</sub>	X <sub>48</sub>	X <sub>49</sub>	X <sub>50</sub>	X <sub>51</sub>	X <sub>52</sub>	X <sub>53</sub>	X <sub>54</sub>	X <sub>55</sub>	X <sub>56</sub>	X <sub>57</sub>	X <sub>58</sub>	X <sub>59</sub>	X <sub>60</sub>	X <sub>61</sub>	X <sub>62</sub>	X <sub>63</sub>	X <sub>64</sub>	X <sub>65</sub>	X <sub>66</sub>	X <sub>67</sub>	X <sub>68</sub>	X <sub>69</sub>	X <sub>70</sub>	X <sub>71</sub>	X <sub>72</sub>	X <sub>73</sub>	X <sub>74</sub>	X <sub>75</sub>	X <sub>76</sub>	X <sub>77</sub>	X <sub>78</sub>	X <sub>79</sub>	X <sub>80</sub>	X <sub>81</sub>	X <sub>82</sub>	X <sub>83</sub>	X <sub>84</sub>	X <sub>85</sub>	X <sub>86</sub>	X <sub>87</sub>	X <sub>88</sub>	X <sub>89</sub>	X <sub>90</sub>	X <sub>91</sub>	X <sub>92</sub>	X <sub>93</sub>	X <sub>94</sub>	X <sub>95</sub>	X <sub>96</sub>	X <sub>97</sub>	X <sub>98</sub>	X <sub>99</sub>	X <sub>100</sub>	X <sub>101</sub>	X <sub>102</sub>	X <sub>103</sub>	X <sub>104</sub>	X <sub>105</sub>	X <sub>106</sub>	X <sub>107</sub>	X <sub>108</sub>	X <sub>109</sub>	X <sub>110</sub>	X <sub>111</sub>	X <sub>112</sub>	X <sub>113</sub>	X <sub>114</sub>	X <sub>115</sub>	X <sub>116</sub>	X <sub>117</sub>	X <sub>118</sub>	X <sub>119</sub>	X <sub>120</sub>	X <sub>121</sub>	X <sub>122</sub>	X <sub>123</sub>	X <sub>124</sub>	X <sub>125</sub>	X <sub>126</sub>	X <sub>127</sub>	X <sub>128</sub>	X <sub>129</sub>	X <sub>130</sub>	X <sub>131</sub>	X <sub>132</sub>	X <sub>133</sub>	X <sub>134</sub>	X <sub>135</sub>	X <sub>136</sub>	X <sub>137</sub>	X <sub>138</sub>	X <sub>139</sub>	X <sub>140</sub>	X <sub>141</sub>	X <sub>142</sub>	X <sub>143</sub>	X <sub>144</sub>	X <sub>145</sub>	X <sub>146</sub>	X <sub>147</sub>	X <sub>148</sub>	X <sub>149</sub>	X <sub>150</sub>	X <sub>151</sub>	X <sub>152</sub>	X <sub>153</sub>	X <sub>154</sub>	X <sub>155</sub>	X <sub>156</sub>	X <sub>157</sub>	X <sub>158</sub>	X <sub>159</sub>	X <sub>160</sub>	X <sub>161</sub>	X <sub>162</sub>	X <sub>163</sub>	X <sub>164</sub>	X <sub>165</sub>	X <sub>166</sub>	X <sub>167</sub>	X <sub>168</sub>	X <sub>169</sub>	X <sub>170</sub>	X <sub>171</sub>	X <sub>172</sub>	X <sub>173</sub>	X <sub>174</sub>	X <sub>175</sub>	X <sub>176</sub>	X <sub>177</sub>	X <sub>178</sub>	X <sub>179</sub>	X <sub>180</sub>	X <sub>181</sub>	X <sub>182</sub>	X <sub>183</sub>	X <sub>184</sub>	X <sub>185</sub>	X <sub>186</sub>	X <sub>187</sub>	X <sub>188</sub>	X <sub>189</sub>	X <sub>190</sub>	X <sub>191</sub>	X <sub>192</sub>	X <sub>193</sub>	X <sub>194</sub>	X <sub>195</sub>	X <sub>196</sub>	X <sub>197</sub>	X <sub>198</sub>	X <sub>199</sub>	X <sub>200</sub>	X <sub>201</sub>	X <sub>202</sub>	X <sub>203</sub>	X <sub>204</sub>	X <sub>205</sub>	X <sub>206</sub>	X <sub>207</sub>	X <sub>208</sub>	X <sub>209</sub>	X <sub>210</sub>	X <sub>211</sub>	X <sub>212</sub>	X <sub>213</sub>	X <sub>214</sub>	X <sub>215</sub>	X <sub>216</sub>	X <sub>217</sub>	X <sub>218</sub>	X <sub>219</sub>	X <sub>220</sub>	X <sub>221</sub>	X <sub>222</sub>	X <sub>223</sub>	X <sub>224</sub>	X <sub>225</sub>	X <sub>226</sub>	X <sub>227</sub>	X <sub>228</sub>	X <sub>229</sub>	X <sub>230</sub>	X <sub>231</sub>	X <sub>232</sub>	X <sub>233</sub>	X <sub>234</sub>	X <sub>235</sub>	X <sub>236</sub>	X <sub>237</sub>	X <sub>238</sub>	X <sub>239</sub>	X 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0.664), thickness of shell (0.903 and 0.545), oil content (0.827 and 0.541), number of bunches per palm (0.766 and 0.477), equatorial diameter of nut (0.708 and 0.471), weight of dehusked nut (0.599 and 0.375), setting percentage (0.547 and 0.367)

The parameters like length of petiole (0.553), weight of shell (0.529), number of leaves (0.461), and weight of kernel (0.357) showed positive and significant association with nut yield per palm at genotypic level alone

Positive and non-significant correlation both at genotypic and phenotypic levels was observed for whole nut weight (0.272 and 0.183), length of spadix (0.21 and 0.160), number of internodes for one meter (0.183 and 0.081), plant height (0.176 and 0.105), thickness of kernel (0.161 and 0.047) and length of spikelet bearing portion (0.150 and 0.091)

The nut yield per palm recorded negative and significant correlation with stem girth (-0.909 and -0.439) both at genotypic and phenotypic levels and negative and non-significant correlation were observed with the characters, thickness of husk (-0.164 and -0.051), length of nut (-0.118 and -0.049), number of leaflets on left side of the lamina (-0.110 and -0.069), length of leaf (-0.085 and -0.041) and length of stalk (-0.053 and -0.038)

The environmental correlation of nut yield per palm with thickness of husk (0.454) and number of nuts per bunch were positive and significant. While it was negative and significant for number of female flowers (-0.494)

Positive and non significant environmental correlation were observed for weight of dehusked nut, length of nut, thickness of shell, whole nut weight, setting percentage, oil content, number of leaflets on left side, stem girth, weight of shell, number of inflorescence per year and plant height. All other characters showed negative and non significant correlation.

#### **4.3.2. Association among component characters**

##### **4.3.2.1. Plant height**

Plant height exhibited positive and significant genotypic as well as phenotypic correlation with length of spadix, length of spikelet bearing portion, length of nut, thickness of shell, number of leaflets (right), weight of shell, number of leaflets (left), length of stalk, whole nut weight, thickness of kernel, equatorial diameter of nut and number of inflorescences (0.939, 0.701, 0.840, 0.708, 0.822, 0.684, 0.769, 0.523, 0.699, 0.591, 0.683, 0.566, 0.679, 0.592, 0.673, 0.503, 0.661, 0.548, 0.656, 0.493, 0.628, 0.524 and 0.593, 0.373 respectively).

The association of plant height with stem girth, number of female flowers and number of nuts per bunch were positive at both the levels, but non significant. But it showed negative and non significant association with number of internodes and weight of kernel.

Environmental correlation of plant height with number of leaflets on left side of lamina (0.507), nuts per bunch (0.466), stem girth (0.448) and number of female flowers (0.434) were positive and significant. Whereas it showed negative and significant environmental correlation with number of leaves, whole nut weight and number of internodes per meter (-0.497, -0.421 and -0.408 respectively). The influence of other characters were either positive or negative and non significant.

#### 4.3.2.2. Stem girth

A positive significant genotypic and phenotypic correlations were expressed by stem girth with thickness of husk (0.650 and 0.454), length of nut (0.614 and 0.488) and length of leaf (0.517 and 0.317). This trait showed a negative significant association with nuts per bunch (-0.815 and -0.532), number of internodes for one meter (-0.590 and -0.496) and number of female flowers (-0.568 and -0.421).

The characters *viz*, number of leaflets (left), length of spadix, thickness of kernel, equatorial diameter of nut, weight of dehusked nut, number of leaves and length of spikelet bearing portion had positive and non significant correlation at both levels and it exhibited negative and non significant association with length of petiole, number of inflorescences per year, weight of shell and weight of kernel.

The environmental correlation of stem girth with setting percentage (0.663), thickness of shell (0.455) and number of bunches per palm (0.364) were significant and positive. But its association with number of internodes per meter was negative and

significant (-0.516) Stem girth registered positive and non significant environmental correlation with equatorial diameter of nut, weight of kernel, nuts per bunch, length of nut, length of petiole, length of spikelet bearing portion and number of leaflets (right) Other characters had negative and non significant correlation

#### 4.3.2.3. Number of internodes per meter

This parameter exhibited a positive significant genotypic and phenotypic correlation with length of petiole, bunches per palm and number of nuts per bunch (0.635, 0.590, 0.477, 0.455 and 0.409, 0.375, respectively) The correlation was positive and non significant for number of internodes per meter with thickness of shell, setting percentage, weight of shell, number of female flowers, number of leaves, length of spikelet bearing portion, number of inflorescence per palm and oil content

The genotypic and phenotypic correlation for number of internodes with equatorial diameter (-0.513 and -0.506), length of stalk (-0.455 and -0.476) and thickness of husk (-0.433 and -0.420) were negative and significant Negative and non significant correlation was observed for other characters

Positive and non significant environmental correlation was observed for thickness of kernel, length of leaf, number of leaves, weight of shell, whole nut weight, length of spadix, thickness of husk and number of bunch per palm All other characters showed negative and non significant environment correlation

#### 4.3.2.4. Number of leaves

The genotypic and phenotypic correlation of number of leaves with all other characters were found to have only positive association (either significant or non significant) Highly significant and positive association were exhibited for weight of dehusked nut (0.812 and 0.806), number of inflorescences (0.753 and 0.519), length of petiole (0.709 and 0.663), weight of shell (0.672 and 0.657), oil content (0.611 and 0.584), number of female flowers (0.610 and 0.567), nuts per bunch (0.610 and 0.568), weight of kernel (0.597 and 0.583), equatorial diameter of nut (0.528 and 0.521), number of bunches per palm (0.505 and 0.440), length of nut (0.485 and 0.469) and setting percentage (0.386 and 0.363) While positive and non significant correlation at both levels were obtained by the other characters

The environmental correlation coefficient of this character with length of leaf (0.379) alone was positive and significant Whereas negative and significant correlation was observed for number of nuts per bunch (-0.475) and weight of shell (-0.405) All other characters showed either positive and non significant or negative and non significant influence on yield

#### 4.3.2.5. Length of petiole

Highly significant positive correlation both at genotypic and phenotypic levels were obtained for length of petiole with number of bunches per palm, number of inflorescences per palm, thickness of shell, weight of shell, nuts per bunch, female flowers and oil content (0.824, 0.759, 0.812, 0.540, 0.684, 0.379, 0.650, 0.457, 0.643,

0.612, 0.598, 0.536, 0.557, 0.511 and 0.531, 0.472 respectively) Except thickness of husk (-0.026) all other characters had positive and non significant correlation

The environment correlation for length of leaf with thickness of husk (-0.574) was negative and significant and with the traits *viz.*, setting percentage (0.318), length of spadix (0.270) and length of stalk (0.255) it had positive and non significant environment correlation Other characters showed negative and non significant influence

#### 4.3.2.6. Length of leaf

Length of frond exhibited a positive and significant genotypic as well as phenotypic correlation with number of leaflets on left side of lamina (0.834 and 0.820), number of leaflets on right side of the lamina (0.833 and 0.819), length of spadix (0.557 and 0.502), equatorial diameter of nut (0.551 and 0.546), weight of shell (0.480 and 0.470), whole nut weight (0.440 and 0.436), weight of dehusked nut (0.377 and 0.374) and length of stalk (0.368 and 0.364) This trait registered negative and non significant association with number of nuts per bunch, setting percentage, number of bunches per palm and weight of kernel Its association with all other characters were positive and non significant at both levels

Length of leaf recorded a significant and negative environmental association with weight of kernel (-0.541) and length of spadix (-0.440) While it exhibited negative and non significant association with oil content, nuts per bunch, setting percentage, length of nut and weight of shell The association with length of stalk, bunches per palm, number

of inflorescence per palm and equatorial diameter of nut were positive and non significant

#### 4.3.2.7. Number of leaflets (right)

This trait showed a positive and significant genotypic and phenotypic correlations with number of leaflets (left) (0.996 and 0.983), length of spadix (0.694 and 0.652), weight of shell (0.558 and 0.543), length of spikelet bearing portion (0.511 and 0.509), length of stalk (0.433 and 0.399) and equatorial diameter of nut (0.408 and 0.404). Negative and non significant correlation at both levels were exhibited with weight of kernel, nuts per bunch and setting percentage. Its association with other characters were positive and non significant.

Number of leaflets on left side of the lamina registered significant and positive environmental correlation with length of spikelet bearing portion (0.440). While its association with length of stalk (-0.606), weight of shell (-0.604) and whole nut weight (-0.440) were significant but negative. The environmental correlation with other characters were either positive and non significant or negative and non significant.

#### 4.3.2.8. Number of leaflets (left)

A positive and significant correlation was obtained both at genotypic and phenotypic level for number of leaflets on left side of lamina with length of spadix, weight of shell, length of spikelet bearing portion, thickness of kernel and length of stalk (0.659, 0.612, 0.537, 0.529, 0.509, 0.498, 0.412, 0.365 and 0.374, 0.367 respectively). Whereas

the correlation was positive and non significant for thickness of shell, whole nut weight, length of nut, thickness of husk, weight of dehusked nut, number of female flowers and number of inflorescences per palm

Negative and non significant correlation was obtained, both at genotypic and at phenotypic levels for weight of kernel, nuts per bunch and setting percentage

The environmental correlation for whole nut weight (-0.443) and bunch per palm (-0.377) were negative and significant. But it showed positive and non significant environmental correlation with number of inflorescences per palm, length of stalk, number of female flowers, nuts per bunch and weight of dehusked nut while all other characters showed negative and non significant environmental correlation

#### **4.3.2.9. Number of inflorescence per palm per year**

At genotypic level, this parameters showed a positive significant correlation with thickness of kernel (0.448), length of spikelet bearing portion (0.446) and weight of kernel (0.434). At phenotypic level, it exhibited positive but non significant correlation with length of spikelet bearing portion (0.353), weight of kernel (0.267), length of stalk (0.234), thickness of kernel (0.193) and thickness of husk (0.160). Both at genotypic and phenotypic levels the remaining characters showed positive and significant correlations

Positive and significant environmental correlation was obtained for number of inflorescences with length of spikelet bearing portion (0.419), its influence on other characters were either positive or negative but non significant

#### 4.3.2.10. Length of spadix

Highly significant and positive correlation was obtained, both at genotypic and phenotypic level for length of spadix with length of spikelet bearing portion (0.848 and 0.783), whole nut weight (0.847 and 0.801), thickness of shell (0.792 and 0.517), length of stalk (0.756 and 0.677), weight of shell (0.705 and 0.666), length of nut (0.595 and 0.559), equatorial diameter of the nut (0.584 and 0.545), setting percentage (0.512 and 0.481) and thickness of kernel (0.431 and 0.429). The association was positive and non significant for length of spadix with number of branches per palm, weight of dehusked nut, nuts per bunch, number of female flowers, thickness of husk and oil content

The trait, weight of kernel (-0.192 and -0.178) alone exerted negative and non significant correlation at genotypic and phenotypic levels

Positive and significant environmental correlation was recorded for length of spadix with oil per cent (0.402) and thickness of kernel (0.411). While the traits viz., thickness of shell, length of stalk, thickness of husk, length of spikelet bearing portion, equatorial diameter of nut and number of branches per palm recorded negative and non significant correlation with length of spadix. While positive and non significant environmental correlation was exerted through other characters with length of spadix

#### 4.3.2.11. Length of spikelet bearing portion

Length of spikelet bearing portion recorded positive and significant genotypic and phenotypic correlation with thickness of shell, weight of shell, thickness of kernel, length of nut, setting percentage, whole nut weight and length of stalk (0.794, 0.631, 0.751, 0.729, 0.727, 0.608, 0.586, 0.579, 0.472, 0.464, 0.470, 0.464 and 0.454, 0.425 respectively) The above characters exhibited positive and non significant correlation at both levels with nuts/bunch, number of bunches per palm, equatorial diameter of nut, weight of dehusked nut and number of female flowers While it exhibited negative and non significant genotypic and phenotypic correlation with oil content alone

This parameter had significant negative association with thickness of kernel (-0.438) at environmental level All other characters showed non significant positive or negative correlation with length of spikelet bearing portion

#### 4.3.2.12. Length of stalk

Highly significant positive correlation both at genotypic and phenotypic levels was observed between length of stalk and whole nut weight (0.840 and 0.813) This parameter also showed a positive and significant correlation with setting percentage (0.424 and 0.393) and length of nut (0.408 and 0.392 respectively) both at genotypic and phenotypic levels The association of length of stalk with thickness of shell, weight of shell, thickness of kernel and number of bunches per palm were positive at both levels, but non significant The oil content, weight of kernel, number of nuts per bunch, number

of female flowers, thickness of husk, weight of dehusked nut showed negative and non significant correlation

Positive and non significant environmental correlation was obtained for length of stalk with weight of shell (0.209), whole nut weight (0.163), equatorial diameter of nut (0.064), length of nut (0.057) and weight of dehusked nut (0.008), while other characters showed negative and non significant environmental correlation

#### 4.3.2.13. Number of female flowers

Number of female flowers exhibited positive significant genotypic and phenotypic correlation with oil content (0.883, 0.742), thickness of shell (0.773, 0.541), number of nuts per bunch (0.740, 0.680), number of bunches per palm (0.675, 0.619), equatorial diameter of nut (0.666, 0.628), weight of dehusked nut (0.647, 0.614), weight of shell (0.588, 0.561) and weight of kernel (0.477, 0.443). This character with thickness of kernel, setting percentage, whole nut weight, husk thickness recorded positive but non significant results at both levels. At phenotypic level, the trait length of nut (-0.011) alone exerted negative and non significant correlation.

Negative and significant environmental correlation was obtained for number of female flowers with whole nut weight (-0.418) alone. The environmental correlation with husk thickness, weight of shell, thickness of kernel and number of nuts per bunch were positive but non significant (0.195, 0.178, 0.151, 0.061 respectively).

#### 4.3.2.14. Number of bunches per palm per year

Positive and significant correlation was obtained, both at genotypic and phenotypic levels for number of bunches per palm with thickness of shell (0.802, 0.656), nuts per bunch (0.681, 0.629), oil content (0.621, 0.580), setting percentage (0.533, 0.524) and weight of shell (0.407, 0.389) whereas the correlation at both levels was positive and non significant for number of bunches per palm with equatorial diameter of nut, thickness of kernel, weight of dehusked nut, whole nut weight, length of nut and weight of kernel. Negative and non significant correlation was obtained for husk thickness (-0.064, -0.061) at both levels.

The environment correlation for bunches per palm was significant and positive with whole nut weight (0.480), equatorial diameter of nut (0.435) and setting percentage (0.388). But it was negative and non significant for thickness of kernel (-0.197), weight of shell (-0.077) and nuts per bunch (-0.052). All other characters showed positive and non significant correlation.

#### 4.3.2.15. Number of nuts per bunch

This parameter exhibited highly significant and positive correlation with thickness of shell (0.886, 0.623), setting percentage (0.726, 0.698), oil content (0.606, 0.554), weight of shell (0.589, 0.558) and weight of dehusked nut (0.528, 0.507). It also showed positive and significant correlation with equatorial diameter of nut (0.385, 0.364).

Positive and non significant correlation was obtained for nuts per bunch with weight of kernel, length of nut, thickness of kernel and whole nut weight at both levels. The trait husk thickness alone exhibited negative and non significant correlation (-0.156, -0.132 respectively) at both genotypic and phenotypic levels.

The environmental correlation for nuts per bunch with all other characters were found to exhibit only non significant influence. The characters viz., thickness of shell, equatorial diameter of nut and weight of shell registered negative and non significant correlation while other characters showed positive and non significant environmental correlation.

#### 4.3.2.16. Setting percentage

Setting percentage exhibited a positive and significant genotypic as well as phenotypic correlation with thickness of shell, length of nut and whole nut weight (0.749, 0.595, 0.726, 0.434 and 0.507, 0.492 respectively). This parameter also showed positive and significant correlation with weight of shell (0.364) at genotypic level alone. But its association with equatorial diameter of nut, weight of dehusked nut and oil content were positive but non significant and negative and non significant with weight of kernel and thickness of kernel.

The environmental correlation for setting percentage with length of nut (0.712) and equatorial diameter of nut (0.523) were highly significant and positive. Oil content, thickness of shell, whole nut weight and weight of kernel exhibited positive but non

significant correlation With husk thickness and thickness of kernel it showed negative and non significant environmental correlation

#### **4.3.2.17. Length of nut**

The genotypic and phenotypic correlation for length of nut with husk thickness, thickness of kernel, whole nut weight and weight of dehusked nut was positive and highly significant (0.665, 0.645, 0.566, 0.469, 0.562, 0.550, 0.549, 0.542) Positive and non significant correlation at both levels, were obtained for length of nut with thickness of shell, oil content and weight of kernel

Positive and significant environmental correlation was obtained for length of nut with equatorial diameter of nut (0.656) and oil content (0.570), while this parameter was negatively and significantly associated with thickness of kernel (-0.421) alone at environmental level Positive and non significant environment correlation was observed for length of nut with thickness of shell (0.182) and whole nut weight (0.087) All other characters showed negative and non significant environmental correlation

#### **4.3.2.18. Equatorial diameter of nut**

This character was found to exhibit a positive and significant genotypic and phenotypic correlation with weight of dehusked nut (0.787 and 0.783), oil content (0.675 and 0.650), weight of shell (0.629 and 0.621), whole nut weight (0.615 and 0.612), thickness of shell (0.553 and 0.458) and husk thickness (0.520 and 0.509) The trait,

weight of kernel alone (0.266, 0.260) exhibited positive and non significant correlation at both levels with equatorial diameter of nut

Positive and significant environmental correlation were observed for equatorial diameter of nut with thickness of shell (0.513). It's correlation with thickness of kernel (-0.427) was negative and significant. Except, weight of kernel and whole nut weight all other traits showed positive and non significant environmental correlation.

#### **4.3.2.19. Whole nut weight**

Whole nut weight exhibited positive and significant genotypic and phenotypic association with weight of shell (0.409 and 0.407). This parameter also showed positive and significant association with thickness of shell (0.458) at genotypic level alone. The association of whole nut weight with weight of dehusked nut, husk thickness, thickness of kernel and oil content were positive at both levels, but non significant. The parameter weight of kernel alone showed negative and non significant correlation at both levels.

The environmental correlation for whole nut weight with weight of kernel (0.448) alone was positive and significant. Except the trait husk thickness (-0.092) all other characters exerted positive and non significant environmental correlation.

#### **4.3.2.20. Thickness of husk**

Both at genotypic and phenotypic levels, thickness of husk showed positive and significant correlation with oil content (0.523 and 0.487) and weight of dehusked nut

(0.508 and 0.501) The trait thickness of kernel and weight of shell exhibited positive and non significant correlation at both levels. Negative and non significant correlation at both levels were observed for thickness of husk with thickness of shell and weight of kernel. The trait *viz*, weight of dehusked nut (0.253), weight of shell (0.063) and weight of kernel (0.040) showed positive and non significant environmental correlation with husk thickness while its association was negative and non significant with oil content, thickness of shell and thickness of kernel.

#### 4.3.2.21. Weight of dehusked nut

A positive and significant genotypic and phenotypic correlation was obtained for weight of dehusked nut with all the characters *viz*, weight of shell, oil content, weight of kernel, thickness of kernel and thickness of shell (0.760, 0.755, 0.688, 0.656, 0.615, 0.610, 0.580, 0.453, 0.412, 0.361), respectively.

Positive and non significant environmental correlation was obtained for weight of dehusked nut with thickness of shell alone (0.343). All other characters exhibited negative and non significant environmental correlation with weight of dehusked nut.

#### 4.3.2.22. Weight of kernel

This parameter was positively and significantly associated with thickness of kernel alone (0.498, 0.448) at genotypic and phenotypic levels, whereas its association with weight of shell, oil content and thickness of shell was positive at both levels but non significant.

#### 4.3.2.23. Weight of shell

The genotypic and phenotypic correlation of this trait with thickness of shell (0.769, 0.610), thickness of kernel (0.657, 0.594) and oil content (0.467, 0.442) were positive and highly significant. All other characters except thickness of kernel (0.204) showed negative and non significant environmental correlation with weight of shell.

#### 4.3.2.24. Thickness of kernel

At genotypic level, this parameter showed a positive and significant correlation with thickness of shell (0.562) but positive and non significant correlation with oil content (0.161).

Oil content was found to exhibit a positive and non significant correlation with thickness of shell (0.263) and oil content (0.118) at phenotypic level.

The environmental correlation for thickness of kernel with thickness of shell was negative and significant (-0.440) while its association with oil content was negative and non significant.

#### 4.3.2.25. Thickness of shell

This parameter was positively and significantly associated with oil content (0.536, 0.375).

Negative and non significant environmental correlation was registered for thickness of shell with oil content (-0.107).

#### 4.4. Path coefficient analysis

The genotypic correlation coefficients of nut yield with other morphological, reproductive and nut characters was partitioned into direct and indirect effects by path coefficient analysis and the results are presented in Table 7 and Fig 6

##### 4.4.1. Direct effects

The studies on path coefficient analysis revealed that 16 characters showed positive and direct effect on nut yield per palm. Among the 16 characters length of the leaf exhibited the maximum direct effect (10.84) closely followed by thickness of husk (8.33) and weight of kernel (7.13). The traits namely, setting percentage, length of petiole, plant height, length of spikelet bearing portion, oil content, number of leaves, weight of shell and equatorial diameter of nut also showed direct effect on yield of nuts. But the direct effect of the spadix length (0.759), thickness of kernel (0.759), thickness of shell (0.711) and number of nuts per bunch (0.711) on yield though positive was found to be low. Inflorescence per palm per year (0.217) showed the least positive direct effect on yield per palm.

While the characters weight of dehusked nut (-14.15), length of nut (-8.057), number of leaflets (Left) (-7.901), number of female flowers (-6.168), whole nut weight (-5.342), number of internodes (-4.435), number of leaflets on right side of lamina (-1.186), number of bunches per palm (-0.548) and length of stalk (-0.352) recorded a negative direct effect on yield.

Table 7 Path coefficient values for direct and indirect effects of different characters on yield in coconut genotypes

S.No	Characters	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	X <sub>7</sub>	X <sub>8</sub>	X <sub>9</sub>	X <sub>10</sub>	X <sub>11</sub>	X <sub>12</sub>	X <sub>13</sub>	X <sub>14</sub>
1	Plant height (cm)	X <sub>1</sub>	3 404	1 092	0 822	2 203	4 693	-0 829	-5 344	0 129	0 713	2 587	-0 237	-1 540	-0 267
2	Stem girth (cm)	X <sub>2</sub>	0 996	2 617	0 083	-1 359	5 606	-0 334	-2 897	-0 036	0 197	0 028	-0 175	3 507	0 243
3	Number of internodes per meter	X <sub>3</sub>	-0 838	1 621	-4 435	3 663	-4 339	0 180	1 217	0 012	-0 100	0 181	0 153	-0 517	-0 261
4	Number of leaves	X <sub>4</sub>	1 525	-0 125	-0 301	1 835	2 177	-0 249	-1 464	0 164	0 185	0 771	-0 018	-3 760	-0 276
5	Length of petiole (cm)	X <sub>5</sub>	1 301	0 648	-2 818	1 302	0 844	-0 284	-1 635	0 176	0 280	1 087	-0 001	-3 455	-0 451
6	Length of leaf (cm)	X <sub>6</sub>	1 473	1 420	1 775	0 368	10 843	-0 988	-6 586	0 062	0 423	0 692	-0 130	-1 024	0 132
7	Number of leaflets (right)	X <sub>7</sub>	2 379	-0 774	0 674	1 383	9 028	-1 186	-7 873	0 049	0 527	1 574	-0 152	-1 457	-0 050
8	Number of leaflets (left)	X <sub>8</sub>	2 302	-1 007	0 683	0 340	1 193	-1 182	-7 901	0 029	0 500	1 568	-0 132	-0 965	-0 020
9	Number of inflorescence per year	X <sub>9</sub>	2 017	0 453	-0 239	1 382	4 679	-0 265	-1 051	0 217	0 547	1 373	-0 121	-5 261	-0 404
10	Length of spadix (cm)	X <sub>10</sub>	3 198	-0 712	0 585	0 448	6 040	-0 823	-5 210	0 157	0 759	2 611	-0 266	-1 241	-0 171
11	Length of spikelet bearing portion (cm)	X <sub>11</sub>	2 860	-0 025	-0 261	0 460	2 438	-0 606	-4 024	0 097	0 644	3 079	-0 160	-0 863	-0 167
12	Length of stalk (cm)	X <sub>12</sub>	2 289	-1 368	1 927	0 092	3 993	-0 513	-2 954	0 075	0 574	1 398	-0 352	0 699	-0 033
13	Number of female flowers/palm/year	X <sub>13</sub>	0 850	1 562	-0 372	1 119	1 800	-0 280	-1 236	0 185	0 153	0 431	0 040	-6 168	-0 369
14	Number of bunches per palm per year	X <sub>14</sub>	1 662	1 219	-2 117	0 926	-2 616	-0 108	-0 282	0 161	0 237	0 939	-0 021	-4 161	-0 548
15	Number of nuts per bunch	X <sub>15</sub>	0 740	2 239	-1 813	1 120	3 448	0 103	1 235	0 167	0 158	1 084	0 054	4 564	-0 373
16	Setting percentage	X <sub>16</sub>	1 693	1 039	-0 783	0 708	2 216	0 071	1 020	0 140	0 388	1 454	-0 149	-1 627	-0 292
17	Length of nut (cm)	X <sub>17</sub>	2 796	-1 688	1 374	0 889	1 511	-0 244	-1 889	0 116	0 451	1 804	-0 144	-0 011	-0 119
18	Equatorial diameter of nut (cm)	X <sub>18</sub>	2 139	-0 320	2 274	0 969	5 975	-0 484	-2 806	0 196	0 443	0 935	-0 127	-4 109	-0 139
19	Whole nut weight (g)	X <sub>19</sub>	2 250	-1 096	1 314	0 375	4 769	-0 416	-2 350	0 172	0 643	1 448	-0 296	-0 744	-0 126
20	Thickness of husk (cm)	X <sub>20</sub>	1 325	-1 786	1 922	0 391	3 829	-0 169	-1 582	0 055	0 119	-0 007	0 025	-0 113	0 035
21	Weight of dehusked nut (g)	X <sub>21</sub>	1 380	-0 181	1 050	1 490	4 085	-0 229	-1 428	0 179	0 221	0 847	0 019	-3 990	-0 128
22	Weight of kernel (g)	X <sub>22</sub>	-0 292	0 211	0 716	1 095	-0 424	0 243	1 704	0 094	-0 146	0 007	0 056	-2 942	-0 072
23	Weight of shell (g)	X <sub>23</sub>	2 325	0 245	-0 496	1 233	5 203	-0 661	-4 240	0 185	0 535	2 313	-0 049	-3 625	-0 223
24	Thickness of kernel (cm)	X <sub>24</sub>	2 234	-0 616	0 983	0 594	2 703	-0 451	-3 258	0 098	0 327	2 237	-0 032	-1 998	-0 135
25	Thickness of shell (cm)	X <sub>25</sub>	2 602	-1 899	-1 237	0 785	3 384	-0 481	-2 580	0 205	0 601	2 444	-0 100	-4 767	-0 439
26	Oil content (%)	X <sub>26</sub>	1 076	0 646	-0 226	1 122	1 585	-0 155	-0 937	0 170	0 067	-0 146	0 094	-5 140	-0 343

Table 7 (Contd )

SNo	Characters	X <sub>15</sub>	X <sub>16</sub>	X <sub>17</sub>	X <sub>18</sub>	X <sub>19</sub>	X <sub>20</sub>	X <sub>21</sub>	X <sub>22</sub>	X <sub>23</sub>	X <sub>24</sub>	X <sub>25</sub>	X <sub>26</sub>	Genotypic correlation coefficient for nut yield per palm
1	Plant height (cm)	X <sub>1</sub>	0.155	2.824	0.945	-3.532	3.243	-5.736	-0.612	1.236	0.498	0.593	0.610	0.176
2	Stem girth (cm)	X <sub>2</sub>	-0.580	-2.148	0.175	-2.132	5.415	-0.932	-0.547	-0.162	0.170	-0.491	-0.453	-0.909**
3	Number of internodes per meter	X <sub>3</sub>	0.291	1.002	-0.771	1.583	-3.609	3.351	-1.151	0.202	-0.168	0.198	0.098	0.183
4	Number of leaves	X <sub>4</sub>	0.434	2.191	0.794	-1.091	1.775	-11.492	4.255	1.217	0.246	0.304	1.179	0.461**
5	Length of petiole (cm)	X <sub>5</sub>	0.425	2.183	0.323	-1.501	-0.215	-5.826	1.673	1.164	0.177	0.462	1.024	0.553**
6	Length of leaf (cm)	X <sub>6</sub>	-0.192	-1.475	0.828	-2.350	2.941	-5.331	-0.279	0.869	0.189	0.025	0.282	-0.035
7	Number of leaflets (right)	X <sub>7</sub>	-0.062	-0.342	0.614	-1.872	1.189	-2.737	-1.463	1.010	0.288	0.288	0.252	0.016
8	Number of leaflets (left)	X <sub>8</sub>	-0.111	-0.733	0.534	-1.589	1.667	-2.558	-1.538	0.972	0.313	0.232	0.180	-0.110
9	Number of inflorescence per year	X <sub>9</sub>	0.548	3.657	1.356	-4.229	2.095	-11.676	3.098	1.537	0.340	0.669	1.510	1.032**
10	Length of spadix (cm)	X <sub>10</sub>	0.148	2.905	0.877	-4.526	1.306	-4.119	-1.369	1.277	0.327	0.563	0.170	0.271
11	Length of spikelet bearing portion (cm)	X <sub>11</sub>	0.250	2.682	0.456	-2.512	-0.019	-3.891	0.017	1.360	0.552	0.564	-0.091	0.150
12	Length of stalk (cm)	X <sub>12</sub>	-0.109	2.405	0.541	-4.489	-0.592	0.772	-1.130	0.250	0.068	0.202	-0.514	-0.053
13	Number of female flowers/palm/year	X <sub>13</sub>	0.526	1.498	1.001	-0.645	0.153	-9.152	3.401	1.069	0.246	0.549	1.607	1.158**
14	Number of bunches per palm per year	X <sub>14</sub>	0.485	3.028	0.382	-1.228	-0.537	-3.301	0.943	0.737	0.187	0.570	1.207	0.766**
15	Number of nuts per bunch	X <sub>15</sub>	0.711	4.123	0.578	-0.359	-1.296	-7.474	2.110	1.067	0.096	0.629	1.169	0.912**
16	Setting percentage	X <sub>16</sub>	0.516	5.678	0.512	-2.706	-0.637	-3.194	-0.898	0.659	-0.059	0.532	0.500	0.597**
17	Length of nut (cm)	X <sub>17</sub>	0.098	2.410	0.769	-3.004	5.541	-7.763	0.769	0.953	0.429	0.240	0.481	-0.118
18	Equatorial diameter of nut (cm)	X <sub>18</sub>	0.274	1.935	1.503	-3.285	4.332	-11.137	1.896	1.138	0.294	0.393	1.301	0.708**
19	Whole nut weight (g)	X <sub>19</sub>	0.098	2.876	0.924	-5.342	1.760	-3.720	-0.687	0.741	0.119	0.325	0.195	0.272
20	Thickness of husk (cm)	X <sub>20</sub>	-0.111	-0.434	0.782	-1.129	8.328	-7.191	-0.496	0.403	0.207	-0.066	1.009	-0.164
21	Weight of dehusked nut (g)	X <sub>21</sub>	0.376	1.282	1.183	-1.404	4.233	-14.148	4.388	1.376	0.385	0.293	1.327	0.559**
22	Weight of kernel (g)	X <sub>22</sub>	0.210	-0.715	0.400	0.515	-0.579	-8.706	7.131	0.557	0.378	0.023	0.404	0.357*
23	Weight of shell (g)	X <sub>23</sub>	0.419	2.068	0.945	-2.185	1.852	-10.751	2.195	1.811	0.499	0.565	0.900	0.529**
24	Thickness of kernel (cm)	X <sub>24</sub>	0.090	-0.445	0.583	-0.838	2.269	-7.182	3.555	1.189	0.759	0.399	0.310	0.161
25	Thickness of shell (cm)	X <sub>25</sub>	0.630	4.252	0.831	2.445	-0.768	-5.827	0.278	1.441	0.426	0.711	1.034	0.903**
26	Oil content (%)	X <sub>26</sub>	0.431	1.473	1.014	0.542	4.355	-9.739	1.493	0.845	0.122	0.381	1.928	0.827**

\*\* Significant at 1% level  
 \* Significant at 5% level  
 Residual effect = 0.21

#### 4.4.2. Indirect effects

##### 4.4.2.1. Plant height

A strong positive indirect effects of plant height was recorded through length of leaf (4 693), thickness of husk (3 243), setting percentage (2 824), length of spikelet bearing portion (2 587), length of petiole (2 203), weight of shell (1 236) and number of internodes for one meter (1 092) While the indirect effect through number of leaves, length of spadix, oil content, thickness of shell, thickness of kernel, number of nuts per bunch and number of inflorescence per palm were positive and low

The indirect effects of this character through length of nut (-6 619), weight of dehusked nut (-5 736), number of leaflets (left) (-5 344) and other characters showed negative influence

##### 4.4.2.2. Stem girth

The indirect effects of this trait through thickness of husk (5 415), length of leaf (5 606), number of female flowers (3 507) and number of internodes for one meter (2 617) were highly positive while it was low for plant height, length of spadix, equatorial diameter of nut, thickness of kernel, number of leaves and length of spikelet bearing portion

Negative indirect effect of this character were observed via length of nut, number of leaflets (left), setting percentage, whole nut weight, length of petiole, weight of

dehusked nut, number of nuts per bunch, weight of kernel, thickness of shell, oil content, leaflets (right), length of stalk, weight of shell and number of inflorescence

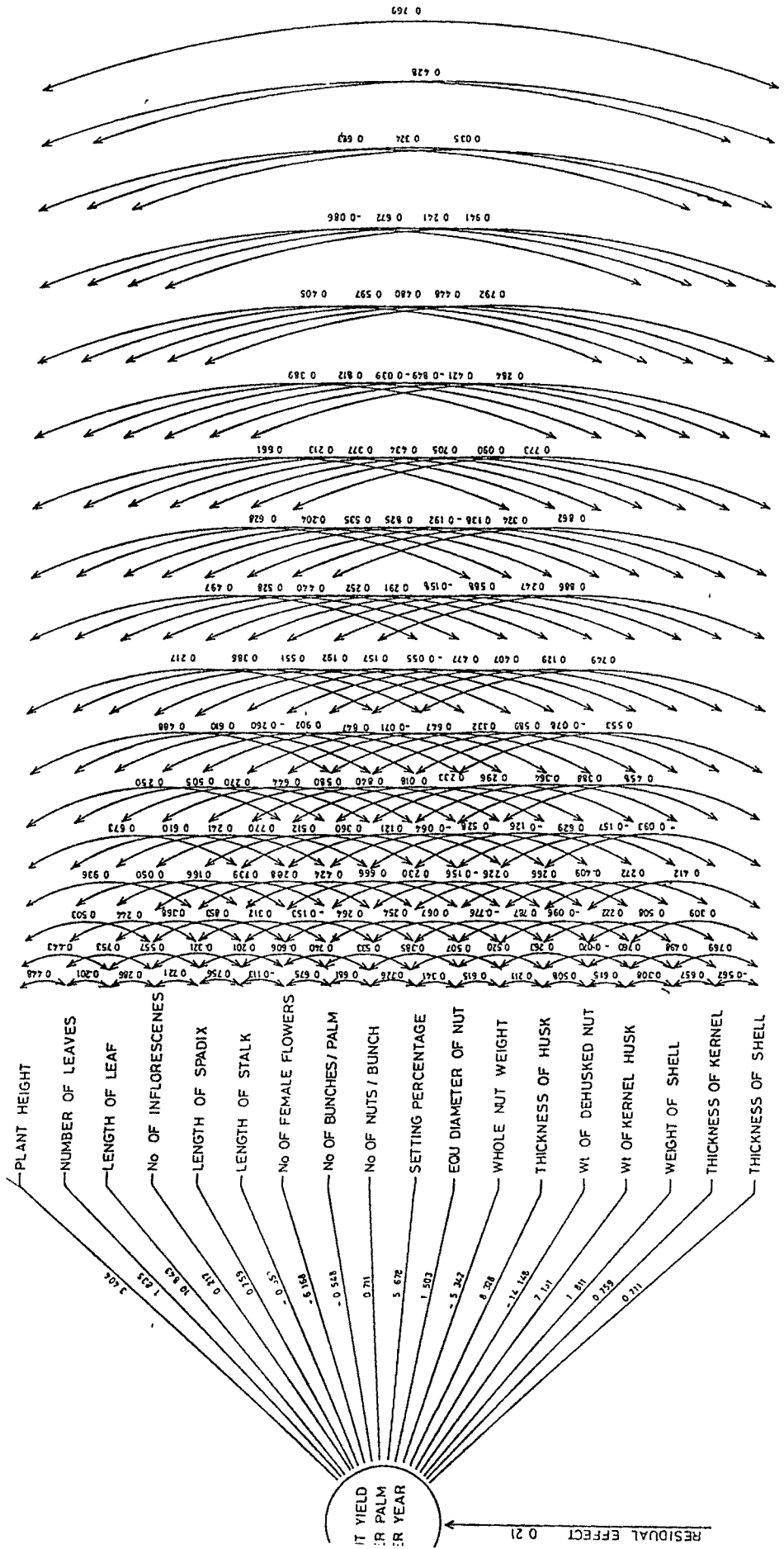
#### 4.4.2.3. Number of internodes for one meter

This parameter exerted positive indirect effect via, length of petiole (3 663), weight of dehusked nut (3 351), length of nut (2 495), stem girth (1 627), whole nut weight (1 583), number of leaflets (left) (1 217), setting percentage (1 002), number of nuts per bunch (0 291), weight of shell (0 202), thickness of shell (0 198), length of spikelet bearing portion (0 181), length of stalk (0 153), number of leaves (0 125), oil content (0 098) and number of inflorescence (0 072) Negative indirect effects were recorded through length of leaf (-4 339), thickness of husk (-3 609), weight of kernel (-1 151), plant height (-0 838), equatorial diameter of nut (-0 771), number of female flowers (-0 517), thickness of kernel (-0 168) and length of spadix (-0 100)

#### 4.4.2.4. Number of leaves

The highest positive indirect effect of number of leaves was through weight of kernel, length of petiole, setting percentage, length of leaf, thickness of husk, plant height, weight of shell and oil content (4 255, 4 089, 2 191, 1 775, 1 525, 1 217 and 1 179) respectively While the characters, equatorial diameter of nut, nuts per bunch, thickness of shell, thickness of kernel, length of spadix, length of spikelet bearing portion, number of inflorescence per year recorded low and positive indirect effect

FIG 6 PATH DIAGRAM



The indirect effects through weight of dehusked nut, length of nut, number of female flowers, number of leaflets (left), whole nut weight, number of internodes, bunches per palm per year, number of leaflets (right) and length of stalk (-11 492, -3 904, -3 760, -1 464, -1 091, -0 301, -0 276, -0 249 and -0 018 respectively) were negative

#### **4.4.2.5. Length of petiole**

Length of petiole exhibited positive indirect effects via setting percentage (2 183), weight of kernel (1 673), number of leaves (1 302), plant height (1 301), weight of shell (1 169), length of spikelet bearing portion, length of leaf, stem girth, nuts per bunch and equatorial diameter and it recorded high negative indirect effect through weight of dehusked nut (-5 826), number of female flowers (-3 455), number of internodes/meter (-2 818), length of nut (-2 112) and number of leaflets on right side of the lamina (-1 635) Other characters showed low negative effects

#### **4.4.2.6. Length of leaf**

Length of leaf registered highest positive indirect effect through thickness of husk (2 941) and number of internodes/meter (1 775) Whereas the traits length of leaflets on left side of lamina (-6 586), weight of dehusked nut (-5 331) and whole nut weight (-2 350) recorded high negative indirect effect The indirect effect of length of leaf through other characters were low either with positive or negative influence

#### 4.4.2.7. Number of leaflets (right)

This trait exhibited the maximum positive indirect effect through length of leaf (9 028) followed by plant height (2 379) and length of spikelet bearing portion (1 574). But its effect was low through number of leaves, oil content, thickness of kernel, thickness of shell and it was least through number of inflorescence per year (0 049). However, the indirect influence through number of leaflets on left side of lamina (-7 873), weight of dehusked nut (-2 737), whole nut weight (-1 872), length of nut (-1 657), weight of kernel (-1 463) and number of female flowers (-1 457) were high and negative. Other characters showed low and negative indirect effect.

#### 4.4.2.8. Number of leaflets (left)

Indirect effect of this trait through length of leaf (9 038), plant height (2 302), thickness of husk (1 667), length of spikelet bearing portion (1 568) and length of petiole (1 193) were high and positive. The traits viz., weight of shell, number of internodes per meter, equatorial diameter of nut, length of spadix, number of leaves, thickness of kernel, thickness of shell, oil content and number of inflorescence per palm per year exhibited low and positive indirect effect. All other characters showed negative indirect effects.

#### 4.4.2.9. Number of inflorescence per palm per year

This parameter showed a very high positive indirect effect through length of petiole (4 679), setting percentage (3 657), length of leaf (3 103) and weight of kernel (3 098). The traits viz., thickness of husk, plant height, weight of shell, oil content, number of inflorescences, length of spikelet bearing portion and equatorial diameter of

nut also recorded positive and indirect effect Negative indirect effect was registered through weight of dehusked nut (-11 676), number of female flowers (-5 261), whole nut weight (-4 229), length of nut (-4 303), number of leaflets on left side of the lamina (-1 051)

#### **4.4.2.10. Length of spadix**

Length of spadix expressed the maximum positive and indirect effect through length of leaf (6 040) followed by plant height (3 198), setting percentage (2 905), length of spikelet bearing portion (2 611), length of petiole (2 128), thickness of husk (1 306) and weight of shell (1 277) while negative indirect effects were registered through the traits *viz*, number of leaflets on left side of the lamina (-5 210), length of nut (-4 793), whole nut weight (-4 526) and weight of dehusked nut (-4 119) The influence of spadix length through other characters was either positive or negative with low indirect effects

#### **4.4.2.11. Length of spikelet bearing portion**

The highest indirect effects of length of spikelet bearing portion through plant height (2 860), setting percentage (2 682), length of leaf (2 438), length of petiole (2 035) was positive However, length of spadix, number of leaves, thickness of shell and kernel, equatorial diameter of nut and number of nuts per bunch also exhibited positive indirect effect but it was low and highest negative effect was exerted via, length of nut (-4 722), length of leaf (-4 024), weight of dehusked nut (-3 891) and whole nut weight (-2 515) but its effect was low through number of female flowers, number of leaflets both on left

and right side of lamina, number of bunches per year, length of stalk, oil content, stem girth and husk thickness

#### 4.4.2.12. Length of stalk

This trait showed positive indirect influence through length of leaf (3 993), setting percentage (2 405), plant height (2 289), number of internodes for one meter (1 927), length of spikelet bearing portion (1 398) While its positive effect through other characters were low However, whole nut weight (-4 489), length of nut (-3 287), number of leaflets on left side of lamina (-2 954), stem girth (-1 368), weight of kernel (-1 130), husk thickness (-0 592), oil content (-0 514) and number of leaflets on right side of lamina (-0 513) influenced negatively

#### 4.4.2.13. Number of female flowers

A positive indirect effect was exhibited by number of female flowers through weight of kernel (3 401), followed by length of petiole (3 210), length of leaf (1 800), oil content (1 607), stem girth (1 562), setting percentage (1 498), number of leaves (1 119), weight of shell (1 069), equatorial diameter of nut (1 001), plant height (0 850), thickness of shell (0 549), nuts per bunch (0 526) and length of spikelet bearing portion (0 431) The indirect effect through weight of dehusked nut (-9 152), number of leaflets on left side of the lamina (-1 236), number of internodes/meter (-0 372) and number of bunches/palm (-0 369) was negative

#### 4.4.2.14. Number of bunches per palm per year

Number of bunches per palm exhibited positive indirect effects via length of petiole (4 754), setting percentage (3 028), plant height (1 662), stem girth (1 219), oil content (1 207), weight of kernel (0 943), length of spikelet bearing portion (0 939) and number of leaves (0 926) and the influence through number of female flowers (-4 161), weight of dehusked nut (-3 301), length of leaf (-2 616), number of internodes per meter (-2 117) and length of nut (-1 749) was negative

#### 4.4.2.15. Number of nuts per bunch

The positive indirect effect of number of nuts per palm through setting percentage (4 123), length of petiole (3 418), stem girth (2 239), weight of kernel (2 110), number of leaflets on left side of lamina (1 235), number of leaves (1 120) and oil content (1 169) accounted for most of the observed significant positive correlation with nut yield per palm and its indirect effect via weight of dehusked nut, number of female flowers, length of leaf, number of internodes, thickness of husk, length of nut, whole nut weight and number of bunches per palm (-7 474, -4 564, -2 931, -1 813, -1 296, -1 110, -0 359 and -0 373 respectively) was negative

#### 4.4.2.16. Setting percentage

The indirect effect of setting percentage through length of petiole (2 216), plant height (1 693), length of spikelet bearing portion (1 454), stem girth (1 039) and number of leaflets on left side of the lamina (1 020) were high and positive While its positive effect via other characters were low The characters viz , length of nut (-2 816), whole nut

weight (-2 706), number of female flowers (-1 627), weight of kernel (-0 898) and number of internodes (-0 783) exerted negative effect

#### **4.4.2.17. Length of nut**

This character exerted positive indirect effect via, thickness of husk (5 541), plant height (2 796), setting percentage (2 410), length of leaf (2 168), length of spikelet bearing portion (1 804), length of petiole (1 511), number of internodes (1 374), weight of shell (0 953), number of leaves (0 889) and weight of kernel (0 769) While negative indirect effect was recorded through weight of dehusked nut (-7 763), whole nut weight (-3 004), number of leaflets on left side of the lamina (-1 889) and stem girth (-1 688)

#### **4.4.2.18. Equatorial diameter of the nut**

The indirect effect of this character via length of leaf (5 975), thickness of husk (4 332), number of internodes per meter (2 274), plant height (2 139), setting percentage (1 935), weight of kernel (1 896) were high The positive effect through other traits were low High negative effect was observed through weight of dehusked nut (-11 137), length of nut (-4 120) and number of female flowers (-4 109) and it was found to be low in case of stem girth (-0 320) and length of stalk (-0 127)

#### **4.4.2.19. Whole nut weight**

The highest positive indirect effect of whole nut weight was exhibited through length of leaf (4 769) The characters namely setting percentage, plant height, thickness of husk, length of petiole, length of spikelet bearing portion and number of internodes per

meter also showed positive effect. The indirect effects through length of nut, weight of dehusked nut, number of leaflets on left side of the lamina, stem girth, number of female flowers and weight of kernel (-4 530, -3 720, -2 350, -1 096, -0 744 and -0 687 respectively) were negative.

#### **4.4.2.20. Thickness of husk**

This trait exhibited maximum positive indirect effect through length of leaf (3 829) followed by number of internodes (1 922), plant height (1 325), oil content (1 009) and equatorial diameter of nut (0 782). While the indirect effects through weight of dehusked nut (-7 191), length of nut (-5 360), stem girth (-1 786), number of leaflets on left side of the lamina (-1 582) and whole nut weight (-1 129) were negative. All other characters showed either positive or negative effect.

#### **4.4.2.21. Weight of dehusked nut**

A very high positive indirect effect of this character was registered through thickness of husk (4 233), weight of kernel (4 388) and length of leaf (4 085) on nut yield per palm. Length of petiole, number of leaves, plant height, weight of shell, oil content, setting percentage, equatorial diameter of the nut, number of internodes per meter, length of spikelet bearing portion, thickness of kernel, number of nuts per bunch, thickness of shell, length of spadix, number of inflorescences per year, and length of stalk also exerted positive effect.

The indirect effect through length of nut and number of female flowers were negative and high (-4 421 and -3 990, respectively) All other characters showed low and negative effect

#### 4.4.2.22. Weight of kernel

The characters viz , number of leaflets on left side of the lamina (1 704), length of petiole (1 352) and number of leaves (1 085) had high positive indirect effect While, weight of dehusked nut (-8 706) and number of female flowers (-2 942) registered maximum negative effects all other characters showed either positive or negative influence on yield

#### 4.4.2.23. Weight of shell

Weight of shell showed a high positive indirect effect through length of leaf, length of petiole, plant height, length of spikelet bearing portion, weight of kernel and setting percentage (5 203, 3 705, 2 325, 2 313, 2 195 and 2 068 respectively) and its negative effect via weight of dehusked nut, number of leaflets on left side of the lamina, length of nut and number of female flowers (-10 751, -4 240, -4 239 and -3 625 respectively) were high The positive and negative indirect effects of other characters were low

#### 4.4.2.24. Thickness of kernel

Thickness of kernel recorded a positive indirect effect via weight of kernel (3 555), length of leaf (2 703), thickness of husk (2 269), length of spikelet bearing

portion (2 237), plant height (2 234), weight of shell (1 189), length of petiole (1 343), number of internodes/meter (0 983) and equatorial diameter of nut (0 583) Other characters showed negative effects on yield

#### **4.4.2.25. Thickness of shell**

The indirect effects showed by this trait via setting percentage (4 252), length of petiole (3 749), plant height (2 602), whole nut weight (2 445) and length of spikelet bearing portion (2 444) were high and positive While the positive effects through characters were low Thickness of shell recorded highest negative indirect effects through weight of dehusked nut (-7 182) While its effect was lowest through length of stalk (-0 100)

#### **4.4.2.26. Oil content**

A positive indirect effect was exerted by this trait on nut yield per palm through husk thickness (4 355), length of petiole (3 061), length of leaf (1 585), weight of kernel (1 493), setting percentage (1 473), number of leaves (1 122) and plant height (1 076)

The indirect effect through weight of dehusked nut (-9 739), number of female flowers (-5 140) and length of nut (-2 011) were high and negative The negative indirect effect of other characters were low

#### 4.5. Stability analysis

##### 4.5.1. Mean performance

The yield performance of ten coconut genotypes over three seasons are presented in Table 8 and Fig. 7.

Studies on the performance of coconut genotypes for nut yield per palm under three seasons revealed that the yield differences among the genotypes are statistically significant over three different seasons. The performance of Tall, Semi Tall, Dwarf and hybrid genotypes over three seasons indicated that the hybrid WCT x MDY ranked first by producing maximum number of nuts during all the three seasons. Among Tall genotypes, Andaman Ordinary ranked first by producing 45.80 nuts during season I, 60.87 nuts during season II and 30.73 nuts during season III. While Philippines Ordinary ranked second in yield with 37.13 nuts during season I and season III 30.53 nuts. The type East Coast Tall produced 36.70 nuts during season I and ranked third, whereas the Semi Tall genotype Strait Settlement Green produced 60.53 nuts during season II and ranked second. The same genotype also produced increased number of nuts of (26.70) during season III and ranked third.

Among the hybrids, the hybrid WCT x MDY produced highest number of nuts over three seasons (42.20 season I, 83.20 – season II and 34.67 - season III) followed by Dwarf and Tall (39.77 during first season, 70.70 nuts – season II and 31.73 nuts – season III) and the hybrid WCT x Gangabondam ranked third over season I and II and second over season III.



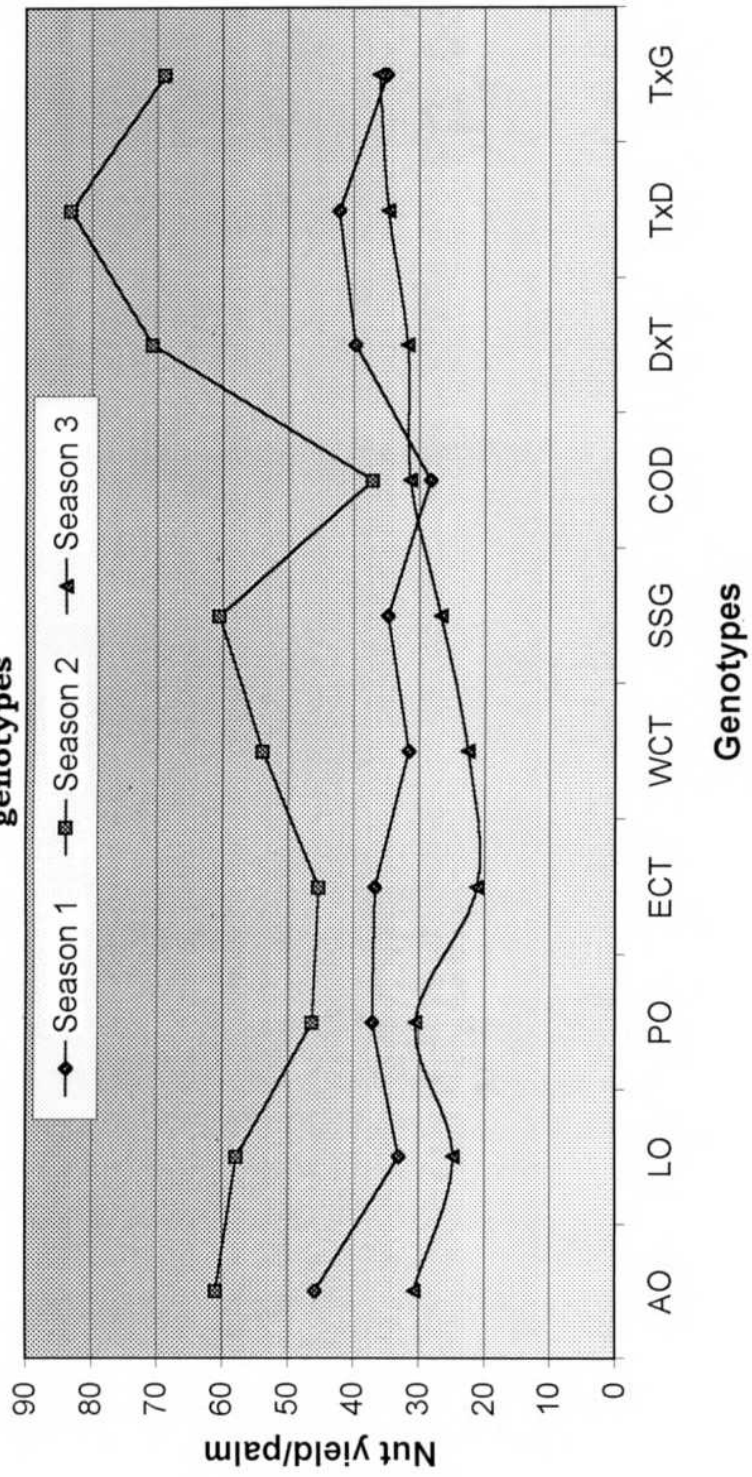
Table 8 Nut yield performance of ten coconut genotypes over three seasons

S No	Characters	Yield in number of nuts/palm		
		Season I	Season II	Season III
1	Andaman Ordinary	45 80	60 87	30 73
2	Laccadive Ordinary	33 00	57 73	24 77
3	Philippines Ordinary	37 13	43 60	30 53
4	East Coast Tall	36 70	45 30	21 17
5	West Coast Tall	31 53	53 83	22 53
6	Strait Settlement Green	34 80	60 53	26 70
7	Chowghat Orange Dwarf	28 20	37 10	31 37
8	MDY x WCT	39 77	70 70	31 73
9	WCT x MDY	42 20	83 20	34 67
10	WCT x Gangabondam	34 87	68 80	36 03

**FIG. 7. SEASONAL INFLUENCE ON THE PERFORMANCE OF TEN COCONUT GENOTYPES**

- AO - Andaman Ordinary
- LO - Laccadive Ordinary
- PO - Philippines Ordinary
- ECT - East Coast Tall
- WCT - West Coast Tall
- SSG - Strait Settlement Green
- COD - Chowghat Orange Dwarf
- DxT - West Coast Tall x Malayan Dwarf Yellow
- TxD - Malayan Dwarf Yellow x West Coast Tall
- TxG - West Coast Tall x Gangabondam

Fig.7 .Seasonal influence on the performance of ten coconut genotypes



#### 4.5.2. Analysis of variance for phenotypic stability

The analysis of variance for phenotypic stability in respect of nut yield per palm per year was worked out as per Eberhart and Russels model (1966) and presented in Table 9

The pooled analysis of variance for nut yield per palm showed highly significant mean squares for genotypes. The mean squares due to environment (Genotype x Environment), environment (linear), pooled deviation are also highly significant at one per cent level. But the mean squares due to genotype x environment (linear) was significant only at five per cent level.

The estimates of three stability parameters namely mean performance of each genotype, regression coefficient ( $b_1$ ) and deviation from regression ( $S^2 d_1$ ) for nut yield of ten coconut genotypes are given in Table 10

#### 4.5.3. Mean performance of coconut genotypes for nut yield

The general mean for this parameter was 41.20. Nut yield per palm varied from 32.22 to 53.36. The hybrid WCT x MDY produced maximum mean number of nuts per palm (53.36) and minimum number was produced by Chowghat Orange Dwarf (32.22). Three genotypes viz, MDY x WCT, WCT x Gangabondam and Andaman Ordinary recorded values greater than general mean.

#### 4.5.4. Regression coefficient ( $b_1$ )

The  $b_1$  values of ten genotypes did not deviate significantly from one.

Table 9 Analysis of variance for nut yield per palm in ten genotypes of coconut tested over three seasons

Source of variation	Degrees of freedom (df)	Mean sum of squares (MS)	'F' values
Genotypes	9	138.34	7.65**
Environment + (Genotype x Environment)	20	278.24	15.39**
Environment (linear)	1	4591.79	254.05**
Genotypes x Environment (linear)	9	88.02	4.87*
Pooled deviation	10	18.07	363.90**
G <sub>1</sub>	1	34.12	687.03
G <sub>2</sub>	1	0.007	0.14
G <sub>3</sub>	1	6.68	134.58
G <sub>4</sub>	1	54.77	1102.67
G <sub>5</sub>	1	0.716	14.41
G <sub>6</sub>	1	0.133	2.68
G <sub>7</sub>	1	13.15	264.71
G <sub>8</sub>	1	2.06	41.54
G <sub>9</sub>	1	13.92	280.24
G <sub>10</sub>	1	55.18	1111.04
Pooled Error	60	0.049	-

\*\* Significant at 1% level

\* Significant at 5% level

Table 10 Mean yield (nuts/palm) and estimates of stability parameter for ten genotypes of coconut tested over three seasons

S No	Genotypes	Mean yield (nuts/palm)	Regression coefficient (b)	Mean squares deviation (MSD)
1	Andaman Ordinary	45 81	0 956	34 07
2	Laccadive Ordinary	38 50	1 132**	-0 04
3	Philippines Ordinary	37 09	0 414**	6 63
4	East Coast Tall	34 39	1 063	0 67
5	West Coast Tall	35 97	1 166**	0 08
6	Strait Settlement Green	40 68	0 245**	13 10
7	Chowghat Orange Dwarf	32 22	1 356**	2 01
8	MDY x WCT	47 40	1 715**	13 87
9	WCT x MDY	53 36	1 223	55 13
10	WCT x Gangabondam	46 57	0 730	54 72

\*\* Significant at 1% level

\* Significant at 5% level

#### 4.5.5. Deviation from regression ( $S^2 di$ )

The ' $S^2 di$ ' values of two genotypes were found to be around zero. All other genotypes were deviating from zero.

Classification and characterization of genotypes are presented in Table 11.

Among the 7 genotypes and 3 hybrids studied, only those which showed high mean values for nut yield were taken into consideration for classification and characterization. The genotypes were classified into four types according to the methodology of Mehra and Ramanujam (1979) and Singh and Singh (1980).

High response with high stability over growth phases can be expected from those falling in group I. Genotype under group II will have above or below average response and they will be suitable for stress or favourable growth phase. Group III and IV are to be ignored in toto.

Classification of ten genotypes based on stability parameters for nut yield per palm (Table 12) revealed that the genotype Laccadive Ordinary, West Coast Tall and East Coast Tall were highly stable over three environments.

#### **Experiment II**

Data on the performance of the four months old seedlings of ten genotypes of three varieties viz., Tall, Semi Tall and Dwarf and the hybrids were statistically analysed. Significant differences were observed among genotypes for all the characters studied.

Table 11 Classification and characterization of genotypes

Group	Mean	$b_1$	$S^2 b_1$
I	High	Around unity	Around zero
II	High	Significantly deviating from unity	Around zero
III	High	Significantly deviating from unity	Significantly deviating from zero
IV	High	Around unity	Significantly deviating from zero

Table 12 Classification of ten genotypes based on stability parameters for nut yield per palm

Group	Yield per palm
I	Laccadive Ordinary, West Coast Tall and East Coast Tall
II	-
III	Chowghat Orange Dwarf
IV	WCT x Gangabondam, Andaman Ordinary and WCT x MDY

#### 4.6. Mean performance of seedling

The mean, range, coefficient of variation and F values for seedling characters are presented in Tables 13 and 14

##### 4.6.1. Per cent germination

Among the varieties and hybrids the per cent germination varied from 53.33 – 94.67 with a general mean of 74.80. Among the varieties, Laccadive Ordinary recorded the maximum germination percentage of 94.67 followed by Strait Settlement Green and Philippines Ordinary with 80.33 and 80.00 respectively. The lowest germination percentage of 53.33 was recorded by East Coast Tall. Among the hybrids, WCT x MDY registered the maximum germination percentage of 84.67. The coefficient of variation was 1.78 per cent.

##### 4.6.2. Days to germination

Days to germination ranged from 83.27 to 112.43 with the general mean of 96.57 days. The genotype Chowghat Orange Dwarf took a minimum of 83.27 days for germination followed by hybrid MDY x WCT (83.57 days). While the tall varieties had taken maximum number of days for germination. The percentage of variability recorded for days to germination was 6.55.

##### 4.6.3. Height of the seedling

The seedling height ranged from 18.10 to 39.90 cm. The height of the seedling was maximum in the hybrid WCT x MDY (39.90 cm). Among Tall, it was maximum in

Table 13 Mean performance of coconut seedlings at fourth month

S No	Variety/ Ecotype	% germination	Days to germination	Seedling height (cm)	Collar girth (cm)	Number embryonic leaves	Length of first embryonic leaf (cm)	Width of first embryonic leaf (cm)	Length of second embryonic leaf (cm)	Width of second embryonic leaf (cm)	Length of petiole in first laminate leaf (cm)	Length of first laminate leaf (cm)	Width of first laminate leaf (cm)	Number of roots	Number of leaves
1	Andaman Ordinary	70.33	96.80	34.17	5.57	2.26	3.37	2.60	6.81	2.33	7.43	9.23	8.03	5.67	3.43
2	Laccadive Ordinary	94.67	107.37	30.86	4.38	2.61	3.07	2.90	6.63	2.18	7.03	8.37	6.30	4.20	2.93
3	Philippines Ordinary	80.00	88.93	29.87	4.97	2.08	2.86	2.43	5.97	2.42	6.87	7.90	6.71	4.93	2.98
4	East Coast Tall	53.33	112.43	20.15	3.93	2.16	4.03	1.77	5.27	2.25	6.23	6.67	5.81	3.87	3.00
5	West Coast Tall	60.00	100.23	18.10	3.90	1.91	2.53	2.33	6.31	2.15	5.97	7.10	6.10	4.58	3.23
6	Strait Settlement Green	78.33	103.10	26.31	4.00	2.15	2.44	2.03	6.11	2.06	6.07	7.33	6.33	4.70	2.93
7	Chowhat Orange Dwarf	70.33	83.27	23.86	3.60	2.05	3.83	2.00	4.65	2.44	5.90	6.63	5.84	4.27	2.37
8	MDY x WCT	85.00	83.57	28.87	4.93	2.03	2.27	1.93	5.21	2.20	6.20	7.23	6.13	4.90	3.03
9	WCT x MDY	84.67	93.90	39.90	5.90	2.34	2.58	2.10	7.26	3.77	7.90	10.43	9.43	5.70	3.73
10	WCT x Gangabondam	71.33	96.13	38.07	5.20	2.24	2.40	1.97	6.52	2.52	7.07	8.30	7.93	5.30	3.08
	Grand Mean	74.80	96.57	29.02	4.67	2.12	2.94	2.21	6.07	2.43	6.64	7.92	6.84	4.81	3.05
	SEd	0.885	5.165	0.81	0.18	0.07	0.15	0.19	0.02	0.06	0.16	0.34	0.37	0.12	0.21
	CD(P=0.05)	1.860	10.851	1.70	0.39	0.15	0.31	0.40	0.04	0.12	0.33	0.72	0.78	0.25	0.45

Table 14 Analysis of variance for the seedling characters at fourth month

S No	Characters	Mean	Range	CV%	Mean squares	'F' value
1	Per cent germination	74.80	53.33-94.67	1.78	220.04	187.14**
2	Days to germination	96.57	83.27-112.43	6.55	278.68	6.96**
3	Seedling height (cm)	29.02	18.10-39.90	3.41	152.44	155.76**
4	Collar girth (cm)	4.67	3.90-5.90	4.80	1.65	32.84**
5	Number of embryonic leaves	2.12	1.91-2.34	4.20	0.05	6.75**
6	Length of first embryonic leaf (cm)	2.94	2.27-4.03	6.13	1.17	36.03**
7	Width of first embryonic leaf (cm)	2.21	1.77-2.90	10.51	0.37	6.90**
8	Length of second embryonic leaf (cm)	6.07	4.70-7.26	0.38	1.98	3795.39**
9	Width of second embryonic leaf (cm)	2.43	2.06-3.77	3.24	0.72	116.00**
10	Length of petiole in the first laminate leaf (cm)	6.64	5.90-7.90	2.86	1.51	41.80**
11	Length of first laminate leaf (cm)	7.92	6.63-10.43	5.28	4.37	24.96**
12	Width of first laminate leaf (cm)	6.84	5.81-9.43	6.68	4.35	20.83**
13	Number of roots	4.81	3.87-5.70	3.03	1.14	53.78**
14	Number of leaves	3.05	2.37-3.73	8.51	0.36	5.39**

\*\* Significant at 1 % level

the genotype Andaman Ordinary (34.17 cm) followed by Laccadive Ordinary with a height of 30.86 cm. The genotype West Coast Tall recorded the minimum seedling height of 18.10 cm. The coefficient of variation per cent observed for this character was 8.41 per cent.

#### 4.6.4. Collar girth

The girth of the seedling ranged from 3.66 cm (COD) to 5.90 cm (WCT x MDY) with the general mean of 4.67 cm. Five genotypes *viz.*, WCT x MDY, Andaman Ordinary, WCT x Gangabondam, Philippines Ordinary and MDY x WCT recorded significantly higher mean than the general mean (5.90 cm, 5.57 cm, 5.20 cm, 4.97 cm and 4.93 cm respectively). The CV was 4.80 per cent.

#### 4.6.5. Number of embryonic leaves

The number of embryonic leaves ranged from 1.91 – 2.61. The general mean for this character was 2.12. The type Laccadive Ordinary produced maximum number of embryonic leaves (2.61) followed by WCT x MDY (2.34) and Andaman Ordinary (2.26) and minimum number of embryonic leaves were produced by West Coast Tall (1.91). This character recorded 4.20 per cent of variation.

#### 4.6.6. Length of first embryonic leaf

It ranged from 2.27 cm to 4.03 cm with a general mean of 2.94 cm. Tall genotype, East Coast Tall exhibited the maximum length of 4.03 cm followed by Dwarf ecotype, Chowghat Orange Dwarf (3.83 cm). Among the hybrids, length of first embryonic leaf was maximum in WCT x MDY (2.58 cm). While minimum length was recorded by

MDY x WCT (2.27 cm) The variability of 6.13 per cent was observed for length of first embryonic leaf

#### **4.6.7. Width of first embryonic leaf**

The width of first embryonic leaf varied from 1.77 cm to 2.90 cm. Significant values higher than the general mean of 2.21 cm were observed in four genotypes *viz*, Laccadive Ordinary, Andaman Ordinary, Philippines Ordinary and West Coast Tall. The Tall genotype, Laccadive Ordinary had the highest mean value of 2.90 cm followed by Andaman Ordinary (2.60 cm) and the lowest value of 1.77 cm was recorded by East Coast Tall. The highest coefficient of variation of 10.51 per cent was exhibited by width of first embryonic leaf.

#### **4.6.8. Length of second embryonic leaf**

It ranged from 4.70 cm to 7.26 cm with a general mean of 6.07 cm. The highest value of 7.26 cm was recorded by the hybrid WCT x MDY followed by a Tall genotype Andaman Ordinary (6.81 cm). While the lowest value of 4.65 cm was recorded by Chowghat Orange Dwarf. The coefficient of variation was low 0.38 per cent for length of second embryonic leaf.

#### **4.6.9. Width of second embryonic leaf**

The width of second embryonic leaf ranged from 2.06 (Strait Settlement Green) to 3.77 cm (WCT x MDY). The general mean was 2.43 cm. The mean values in three genotypes *viz*, WCT x MDY (3.77 cm), WCT x Gangabondam (2.52 cm) and

Chowghat Orange Dwarf (2.44 cm) were significantly higher than the general mean. The per cent of variation was 3.24.

#### 4.6.10. Length of petiole in the first laminate leaf

It ranged from 5.90 cm to 7.90 cm with a general mean of 6.64 cm. Length of petiole in the first laminate leaf was high in the hybrid WCT x MDY (7.90 cm) and low in Chowghat Orange Dwarf (5.90 cm). Among the Tall and Semi Tall genotypes, Andaman Ordinary recorded the highest value of 7.43 cm followed by Laccadive Ordinary (7.03 cm) and Philippines Ordinary (6.87 cm). The variability of 2.86 per cent was recorded by this character.

#### 4.6.11. Length of first laminate leaf

The length of first laminate leaf ranged from 6.63 cm (Chowghat Orange Dwarf) to 10.43 cm (WCT x MDY). Except the genotype Andaman Ordinary (9.23 cm), Laccadive Ordinary (8.37 cm) and WCT x Gangabondam (8.30 cm) all other genotypes recorded significantly lower mean values than the general mean of 7.92 cm. The coefficient of variation registered was 5.28 per cent.

#### 4.6.12. Width of first laminate leaf

It ranged from 5.81 cm to 9.43 cm with a general mean of 6.84 cm. The hybrid WCT x MDY had the maximum mean width of 9.43 cm followed by WCT x Gangabondam and Andaman Ordinary with the same width of 7.93 cm. The

lowest width of 5.81 cm was exhibited by Tall genotype East Coast Tall. The coefficient of variation for width of first laminate leaf was 6.68 per cent.

#### 4.6.13. Number of roots

It ranged from 3.87 to 5.70. The general mean was 4.81. The number of roots were maximum in the hybrid WCT x MDY (5.70) followed by Andaman Ordinary (5.67) and WCT x Gangabondam (5.30). The minimum number of roots were produced by East Coast Tall (3.87). Number of roots showed 3.03 per cent of variation.

#### 4.6.14. Number of leaves

It varied from 2.37 to 3.73 with a general mean of 3.05. The hybrid WCT x MDY recorded maximum number of leaves (3.73). Among the Tall genotypes, Andaman Ordinary (3.43), West Coast Tall (3.23) and East Coast Tall (3.00) produced maximum number of leaves. The lowest number of 2.37 leaves were produced by Chowghat Orange Dwarf. Coefficient of variation for this character was high (8.51 per cent).

#### 4.7. Genetic parameters of seedling

The genotypic and phenotypic variance and genotypic and phenotypic coefficient of variation, heritability, genetic advance and genetic advance as per cent mean among ten genotypes of coconut seedlings for various characters are presented in Table 15 and Fig. 8 and 9.

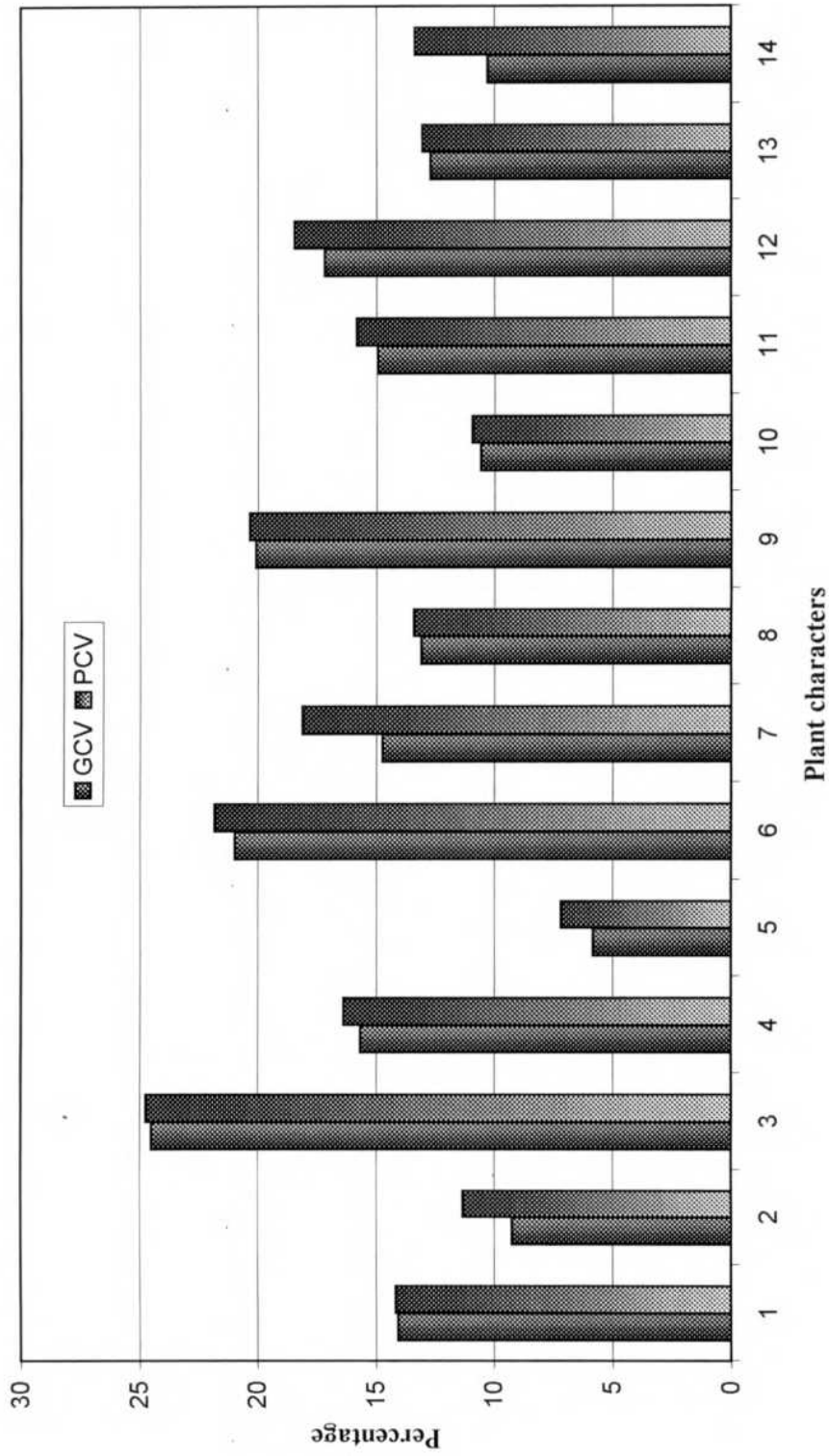
Table 15 Components of variance, heritability, genetic advance and genetic advance as per cent of mean in coconut seedlings at the fourth month

S No	Characters	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability	Genetic advance	Genetic advance as per cent mean
1	Per cent germination	72.96	74.13	14.04	14.15	98.41	17.38	28.68
2	Days to germination	79.56	119.57	9.24	11.32	67.40	15.18	15.52
3	Seedling height (cm)	50.49	51.46	24.49	24.72	98.10	14.49	49.96
4	Collar girth (cm)	0.53	0.58	15.65	16.37	91.37	1.43	30.82
5	Number of embryonic leaves	0.01	0.02	5.82	7.18	65.73	0.20	9.72
6	Length of first embryonic leaf (cm)	0.38	0.41	20.95	21.83	92.11	1.21	41.41
7	Width of first embryonic leaf (cm)	0.12	0.16	14.74	18.10	66.30	0.55	24.72
8	Length of second embryonic leaf (cm)	0.66	0.67	13.39	13.89	97.92	1.62	27.56
9	Width of second embryonic leaf (cm)	0.24	0.25	20.08	20.34	97.46	0.98	40.84
10	Length of petiole in the first laminate leaf (cm)	0.49	0.53	10.56	10.94	93.15	1.40	21.08
11	Length of first laminate leaf (cm)	1.40	1.57	14.93	15.83	88.87	2.26	28.98
12	Width of first laminate leaf (cm)	1.38	1.59	17.17	18.43	86.86	2.26	32.97
13	Number of roots	0.37	0.39	12.69	13.05	94.62	1.23	25.43
14	Number of leaves	0.10	0.17	10.29	13.36	61.40	0.51	16.34

**FIG. 8. PCV AND GCV FOR EMBRYONIC AND GROWTH CHARCTERS OF FOUR MONTHS OLD COCONUT SEEDLINGS**

- 1 Percent germination
- 2 Days to germination
- 3 Seedling height
- 4 Collar girth
- 5 Number of embryonic leaves
- 6 Length of first embryonic leaf
- 7 Width of first embryonic leaf
- 8 Length of second embryonic leaf
- 9 Width of second embryonic leaf
- 10 Length of petiole in the first laminate leaf
- 11 Length of laminate leaf
- 12 Width of laminate leaf
- 13 Number of roots
- 14 Number of leaves

Fig.8.PCV and GCV for embryonic and growth characters of four months old coconut seedlings



#### 4.7.1. Phenotypic and genotypic variance

Phenotypic variance estimated for all the characters were greater in magnitude than the genotypic variances. The phenotypic and genotypic variance were the highest for days to germination (119.57 and 79.56, respectively) followed by per cent germination (74.13 and 72.96, respectively) and plant height (51.46 and 50.49, respectively).

Phenotypic and genotypic variance were lower for width of first laminate leaf (1.59 and 1.38, respectively) and length of first laminate leaf (1.57 and 1.40, respectively). The phenotypic and genotypic variance were the least for number of embryonic leaves (0.02 and 0.01, respectively).

#### 4.7.2. Phenotypic and genotypic coefficient of variation

##### 4.7.2.1. Per cent germination

The per cent germination showed high values both at phenotypic and genotypic levels (14.15 and 14.04, respectively). The heritability and genetic advance as per cent mean were also high (98.41 and 28.68 %, respectively) for this character.

##### 4.7.2.2. Days to germination

Days to germination recorded 11.32 per cent of phenotypic and 9.24 per cent of genotypic coefficient of variation. While the heritability value was moderate (67.40 %) with low genetic advance as per cent of mean (15.52 %).

#### **4.7.2.3. Height of the seedling**

The maximum PCV of 24.72, GCV of 24.49 per cent, heritability of 98.10 per cent and genetic advance as per cent mean of 49.96 per cent was exhibited by height of the seedlings

#### **4.7.2.4. Collar girth**

The girth of the seedling registered a moderate PCV (16.37 per cent) and GCV (15.65 %) The heritability and genetic advance as per cent mean estimated for this character was high (91.37 and 30.82 %, respectively)

#### **4.7.2.5. Number of embryonic leaves**

The PCV and GCV for number of embryonic leaves were 7.81 and 5.82 respectively The values of heritability and genetic advance as per cent mean were moderate (65.73 %) and low (9.72 %)

#### **4.7.2.6. Length of first embryonic leaf**

It recorded high PCV (21.83 %) and GCV (20.95 %) The heritability and genetic advance as per cent mean (92.11 and 41.41 %) were also high for this character

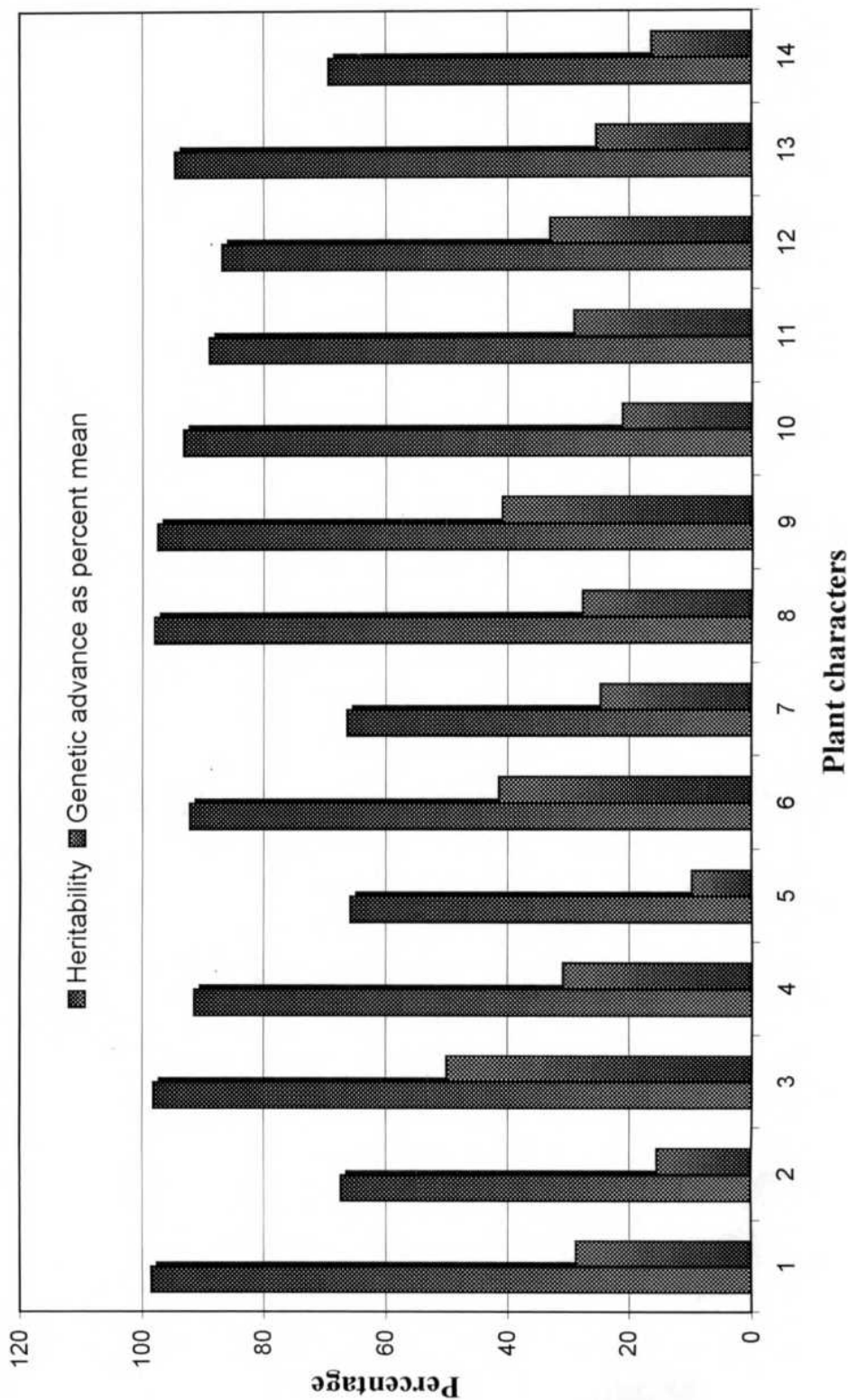
#### **4.7.2.7. Width of first embryonic leaf**

The PCV for width of first embryonic leaf was 18.10 and GCV was (14.74) This character recorded moderate heritability (66.30) and genetic advance as per cent mean (24.72)

**FIG. 9. HERITABILITY AND GENETIC ADVANCE AS PERCENT MEAN FOR EMBRYONIC AND GROWTH CHARACTERS OF FOUR MONTHS OLD COCONUT SEEDLINGS**

- 1 Percent germination
- 2 Days to germination
- 3 Seedling height
- 4 Collar girth
- 5 Number of embryonic leaves
- 6 Length of first embryonic leaf
- 7 Width of first embryonic leaf
- 8 Length of second embryonic leaf
- 9 Width of second embryonic leaf
- 10 Length of petiole in the first laminate leaf
- 11 Length of laminate leaf
- 12 Width of laminate leaf
- 13 Number of roots
- 14 Number of leaves

**Fig.9. Heritability and genetic advance as percent mean for embryonic and growth characters of four months old coconut seedlings**



**4.7.2.8. Length of second embryonic leaf**

The length of second embryonic leaf recorded 13.39 per cent and 13.09 per cent PCV and GCV respectively. The heritability estimate was high (97.92) and moderate for genetic advance as per cent mean (27.56 %) for this character.

**4.7.2.9. Width of second embryonic leaf**

The PCV and GCV were 20.34 and 20.08 per cent respectively, while heritability and genetic advance as per cent mean were high (97.46 and 40.84 %, respectively).

**4.7.2.10. Length of petiole in first laminate leaf**

The length of petiole in the first laminate leaf registered low PCV (10.94 and 10.56). However, it exerted high heritability (93.15 %) and low genetic advance as per cent mean (21.08 %).

**4.7.2.11. Length of first laminate leaf**

The phenotypic and genotypic components of variations were 15.83 and 14.93 per cent respectively. This character exhibited high heritability (88.87 %) and high genetic advance as per cent mean (28.98 %).

**4.7.2.12. Width of first laminate leaf**

High PCV of 18.43 per cent and GCV of 17.17 per cent were recorded for width of first laminate leaf. It also recorded high heritability (86.86 %) and high genetic advance as per cent mean (32.97) values.

#### 4.7.2.13. Number of roots

The PCV and GCV for number of roots were 13.05 and 12.69 per cent respectively. The values of heritability and genetic advance as per cent were high (94.62) and moderate (25.43) respectively.

#### 4.7.2.14. Number of leaves

Number of leaves recorded 13.36 per cent of PCV and 10.29 per cent of GCV. The heritability (69.40 per cent) and genetic advance as per cent mean (16.34 per cent) were low for this character.

### 4.8. Correlation studies for seedling characters

The genotypic, phenotypic and environmental correlation were worked out between various component characters and the results are presented in the Table 16.

In general, the genotypic correlation coefficient was higher than the phenotypic correlation coefficient.

#### 4.8.1. Association between number of leaves and other component characters

At genotypic, phenotypic and environmental levels number of leaves showed significant and positive correlation with number of roots (0.70, 0.594 and 0.364, respectively). While the number of leaves had a significant and positive genotypic and phenotypic association with length of second embryonic leaf (0.883 and 0.676, respectively), length of first laminate leaf (0.874 and 0.623), width of first laminate leaf (0.859 and 0.597), collar girth (0.753 and 0.574, respectively), length of petiole of the first

Table 16. Genotypic, phenotypic and environmental correlation coefficients of coconut seedlings at fourth month

	% germination	Days to germination	Seedling height (cm)	Collar girth (cm)	Number embryonic leaves	Length of first embryonic leaf (cm)	Width of first embryonic leaf (cm)	Length of second embryonic leaf (cm)	Width of second embryonic leaf (cm)	Length of petiole in first laminate leaf (cm)	Length of first laminate leaf (cm)	Width of first laminate leaf (cm)	Number of roots	Number of leaves
1.	G	-0.170	0.520**	0.233	0.006	-0.402**	-0.137	0.342	0.218	0.467**	0.454*	0.232	0.178	0.094
	P	-0.113	0.503**	0.199	0.008	-0.376*	-0.109	0.340	0.206	0.444*	0.435*	0.218	0.173	0.069
	E	0.341	-0.429*	-0.594**	0.046	0.185	0.024	0.216	-0.362*	-0.096	0.242	0.067	0.045	-0.031
2.	G		-0.230	-0.398*	0.066	0.234	-0.637**	0.386*	-0.243	-0.070	-0.045	-0.133	-0.399*	-0.339
	P		-0.189	-0.300	0.096	0.204	-0.436*	0.340	0.206	0.444*	0.435*	0.218	0.173	-0.169
	E		-0.049	0.060	0.136	0.033	-0.040	0.430*	-0.081	-0.175	0.256	-0.102	-0.312	-0.457**
3.	G			0.866**	0.810**	-0.390*	-0.115	0.649**	0.627**	0.905**	0.872**	0.886**	0.804**	0.542**
	P			0.829**	0.638**	-0.372*	-0.099	0.643**	0.620**	0.864**	0.823**	0.838**	0.773**	0.393*
	E			0.211	-0.133	-0.038	-0.087	0.043	0.309	-0.033	0.171	0.390*	-0.066	-0.231
4.	G				0.797**	-0.399*	-0.021	0.600**	0.675**	0.851**	0.870**	0.938**	0.973**	0.753**
	P				0.649**	-0.358*	0.045	0.570**	0.650**	0.790**	0.768**	0.820**	0.895**	0.574**
	E				0.183	0.105	0.363*	-0.400*	0.285	0.057	-0.160	-0.150	-0.133	0.102
5.	G					0.014	-0.183	0.516**	0.711**	0.726**	0.751**	0.879**	0.715**	0.653*
	P					0.026	-0.134	0.415*	0.540**	0.567**	0.602**	0.685**	0.535**	0.363
	E					0.092	-0.039	-0.205	-0.311	-0.008	0.143	0.101	-0.212	-0.147
6.	G						0.352	-0.437*	-0.131	-0.216	-0.297	-0.353	-0.509**	-0.447*
	P						0.301	-0.420*	-0.122	-0.207	-0.272	-0.303	-0.492**	-0.359*
	E						0.162	-0.001	0.060	-0.095	-0.038	0.124	-0.255	-0.160
7.	G						-0.189	0.062	0.062	0.038	-0.010	0.005	0.138	-0.425*
	P						-0.157	0.036	0.036	-0.021	-0.048	-0.033	0.154	-0.210
	E						-0.153	0.377*	-0.104	-0.440*	-0.209	-0.173	0.327	0.153
8.	G							0.468**	0.468**	0.815**	0.878**	0.798**	0.660**	0.883**
	P							0.461*	0.461*	0.783**	0.828**	0.742**	0.642**	0.676**
	E							-0.104	-0.104	-0.374*	0.133	-0.084	0.071	-0.255
9.	G							0.770**	0.770**	0.707**	0.770**	0.845**	0.576**	0.664**
	P							0.670**	0.670**	0.704**	0.704**	0.769**	0.561**	0.501**
	E							-0.104	-0.104	-0.234	-0.234	-0.146	0.223	-0.044
10.	G							1.013**	1.013**	0.824**	0.824**	0.947**	0.784**	0.720**
	P							0.893**	0.893**	0.824**	0.824**	0.742**	0.742**	0.539**
	E							-0.327	-0.327	-0.287	-0.287	-0.287	0.095	0.018
11.	G									0.941**	0.941**	0.840**	0.840**	0.874**
	P									0.728**	0.728**	0.728**	0.728**	0.623**
	E									0.843**	0.843**	0.843**	-0.543**	-0.057
12.	G												0.925**	0.859**
	P												0.804**	0.597**
	E												-0.407*	-0.086
13.	G												0.720**	0.720**
	P												0.594**	0.594**
	E												0.364*	0.364*

\*\* Significant at 1% level

\* Significant at 5% level

lamine leaf (0.720 and 0.539 respectively), width of second embryonic leaf (0.664 and 0.501 respectively), number of embryonic leaves (0.653 and 0.363) and plant height (0.542 and 0.393).

Negative and significant correlation both at genotypic and phenotypic levels was observed for number of leaves with length of first embryonic leaf (-0.447 and -0.359) and days to germination (-0.339 and -0.169).

The number of leaves per seedling recorded positive and non significant correlation at both levels with per cent germination (0.094 and 0.069).

The environmental correlation for number of leaves with length of petiole in first lamine leaf was positive and non significant (0.018). While all other characters exhibited negative and non significant environmental correlation with number of leaves per seedling.

#### **4.8.2. Association of component characters**

##### **4.8.2.1. Per cent germination**

Per cent germination had positive and significant genotypic and phenotypic correlation with plant height (0.520 and 0.503, respectively), length of petiole in first lamine leaf (0.467 and 0.444) and length of first lamine leaf (0.454 and 0.435), whereas per cent germination with length of first embryonic leaf recorded negative and significant correlation at both levels (-0.402 and -0.376) and showed positive and non significant correlation with length and second embryonic leaf (0.342 and 0.340),

collar girth (0.233 and 0.199), width of first laminate leaf (0.232 and 0.218), width of second embryonic leaf (0.218 and 0.206) and number of roots (0.178 and 0.173).

Negative and non significant correlation at genotypic and phenotypic levels was observed for per cent germination with days to germination (-0.170 and -0.173) and width of first embryonic leaf (-0.137 and -0.109).

The environmental correlation for per cent germination with collar girth, plant height and width of second embryonic leaf (-0.594; -0.429 and -0.362 respectively) was negative and significant. While the correlation was negative and non significant with length of petiole in first laminate leaf (-0.096) all other characters showed positive and non significant environmental correlation with per cent germination.

#### **4.8.2.2. Days to germination**

At phenotypic level, the days to germination had a positive and significant association with length of petiole in first laminate leaf (0.444) and length of first laminate leaf (0.435). Whereas at genotypic level, its association with number of roots and collar girth was negative and significant (-0.399 and -0.398).

Both at genotypic and phenotypic levels, days to germination exhibited negative and significant correlation with width of first embryonic leaf (-0.637 and -0.436). Positive and non significant correlation was observed in the case of length of second embryonic leaf (0.386 and 0.340), length of first embryonic leaf (0.066 and 0.096).

Days to germination recorded negative and non significant correlation with seedling height (-0.230 and -0.189) at both levels.

Positive and significant environment correlation was obtained for days to germination with length of second embryonic leaf (0.430). Days to germination with number of roots, length of petiole in first laminate leaf, width of first laminate leaf, seedling height and width of first embryonic leaf showed negative and non significant environmental correlation (-0.312, -0.175, -0.102, -0.040 and -0.040 respectively).

#### **4.8.2.3. Height of the seedling**

Seedling height recorded negative and significant genotypic and phenotypic correlation with length of first embryonic leaf (-0.390 and -0.372). While it recorded positive and non significant correlation with width of first embryonic leaf (-0.115 and -0.099). All other characters registered positive and significant correlation with seedling height.

The environmental correlation between seedling height and width of first laminate leaf was significant and positive (0.390). While height of the seedling recorded positive and non significant environmental correlation with width of second embryonic leaf (0.309), collar girth (0.211) and length of second embryonic leaf (0.043) and negative and non significant correlation with number of embryonic leaf (-0.153), width of first embryonic leaf (-0.087) and number of roots (-0.066).

#### 4.8.2.4. Collar girth

The girth of the seedling recorded significant and positive correlation with number of roots (0.973 and 0.895), width of first laminate leaf (0.938 and 0.820), length of first laminate leaf (0.870 and 0.768), length of petiole in first laminate leaf (0.851 and 0.790), number of embryonic leaf (0.797 and 0.649), width of second embryonic leaf (0.675 and 0.650) and length of second embryonic leaf (0.600 and 0.570). Whereas it showed negative and non significant correlation with length of first embryonic leaf (-0.399 and -0.358) both at genotypic and phenotypic level.

The environmental correlation coefficient was positive and significant for width of first embryonic leaf (0.363) and negative and non significant for length of second embryonic leaf (-0.400). Other characters showed either positive or negative non significant environment correlation with seedling girth.

#### 4.8.2.5. Number of embryonic leaves

Number of embryonic leaves exhibited positive and non significant genotypic and phenotypic correlation with length of first embryonic leaf (0.014 and 0.026) and negative and non significant correlation with width of first embryonic leaf (-0.183 and -0.134). While this character showed positive and significant genotypic and phenotypic correlation for all other characters.

The environmental correlation coefficient was not significant for all the growth characters studied. But it registered positive and non significant correlation for length of

first laminate leaf (0.143), width of first laminate leaf (0.101), length of first embryonic leaf (0.092) and negative and non significant for width of second embryonic leaf (-0.311), number of roots (-0.212) and length of second embryonic leaf (-0.205).

#### 4.8.2.6. Length of first embryonic leaf

Two characters *viz.*, length of second embryonic leaf and number of roots (-0.437 and -0.420) and (-0.509 and -0.492) exhibited negative and significant genotypic and phenotypic correlation with length of first embryonic leaf. Whereas width of first embryonic leaf (0.352 and 0.301) recorded positive and non significant correlation at both levels and other characters recorded negative and non significant correlation.

Positive and non significant environmental correlation was exerted for length of first embryonic leaf with width of first embryonic leaf (0.162), width of first laminate leaf (0.124) and width of second embryonic leaf (0.060). Whereas length of first embryonic leaf showed positive and non significant correlation with number of roots (-0.255), length of first laminate leaf (-0.095) and length of laminate leaf (-0.038).

#### 4.8.2.7. Width of first embryonic leaf

The genotypic and phenotypic correlation coefficient was not significant for width of first embryonic leaf with other growth characters studied. But it recorded negative and non significant correlation with length of second embryonic leaf (-0.189 and -0.157) and length of first laminate leaf (-0.010 and -0.048) and positive and non significant

correlation for number of roots (0.138 and 0.154) and width of second embryonic leaf (0.062 and 0.036) at both levels.

Width of first embryonic leaf exhibited negative significant environmental correlation with length of petiole in first laminate leaf (-0.440) and positive and significant correlation with width of second embryonic leaf (0.377). Except number of roots all other characters showed negative and non significant environment correlation with width of first laminate leaf.

#### **4.8.2.8. Length of second embryonic leaf**

Highly significant positive correlation both at genotypic and phenotypic levels was observed for length of second embryonic leaf with all other characters namely length of laminate leaf (0.878 and 0.828), length of petiole in first laminate leaf (0.815 and 0.783), width of first laminate leaf (0.798 and 0.792), number of roots (0.660 and 0.642) and width of second embryonic leaf (0.468 and 0.461) respectively.

The environmental correlation between length of second embryonic leaf and length of petiole in first laminate leaf was negative and non significant (-0.374). While the characters, length of laminate leaf (0.133), number of roots (0.071) showed positive and non significant correlation and width of second embryonic leaf (-0.109) and width of laminate leaf (-0.084) showed negative and non significant environmental correlation.

#### 4.8.2.9. Width of second embryonic leaf

The genotypic and phenotypic correlation for width of second embryonic leaf with all other growth characters was significant and positive. The width of second embryonic leaf exhibited the highest values for width of first laminate leaf (0.845 and 0.769) and length of first laminate leaf (0.770 and 0.704) respectively.

The environmental correlation was not significant for width of second embryonic leaf with length of petiole in first laminate leaf, length of first laminate leaf, width of laminate leaf or number of roots but it had registered either positive or negative non significant environmental correlation for the above said characters.

#### 4.8.2.10. Length of petiole in first laminate leaf

It also registered highly significant positive correlation with all other growth characters *viz.*, length of laminate leaf, width of laminate leaf and number of roots at both genotypic and phenotypic levels (1.013 and 0.893, 0.947 and 0.824 and 0.784 and 0.742 respectively).

The environmental correlation for length of petiole in first laminate leaf with length of laminate leaf (-0.327) and width of first laminate leaf (-0.287) were negative, non significant and it showed positive and non significant values for number of roots (0.095).

#### **4.8.2.11. Length of first laminate leaf**

Length of first laminate leaf had significant and positive association with width of laminate leaf (0.941 and 0.926) and number of roots (0.840 and 0.728). While the environmental correlation for this character was positive and significant for width of first laminate leaf (0.843) and negative and significant for number of roots (-0.543).

#### **4.8.2.12. Width of first laminate leaf**

At genotypic and phenotypic levels, width of first laminate leaf registered positive and significant correlation with number of roots (0.925 and 0.841). The environmental correlation for this character was negative and significant (-0.407).

#### **4.8.2.13. Number of roots**

It showed positive and significant correlation with number of leaves at all three levels (0.720, 0.594 and 0.364).

The performance, genetic parameters and correlation studied for the fourteen characters during sixth, eighth and tenth months revealed the same magnitude of variability for the characters studied as during the tenth month and the heritability and genetic advance were high and moderate. The data are provided in Appendix 1a to 1c.

The importance of characters associated directly or indirectly with number of leaves was almost the same as observed in the fourth month (Appendix 1c).

The multiple regression function adopted to bring out the importance of the characters influencing the number of leaves as a resultant variable indicated that importance should be given for the characters width of second embryonic leaf and width of first laminate leaf which showed significant positive correlation with number of leaves during tenth month and also for the character length of first laminate leaf which had negative and significant correlation with number of leaves during sixth month seedling (Appendix 1e).

#### **4.9. Correlation studies between nut yield per palm and seedling characters**

The phenotypic, genotypic and environmental correlation between seedling characters and nut yield per palm are presented in Table 17. The significant and positive correlation was observed at both genotypes and phenotypic levels for the characters viz., number of leaves (0.920 and 0.708), collar girth (0.815 and 0.813), length of first laminate leaf (0.837 and 0.789), width of first laminate leaf (0.829 and 0.773), root number (0.810 and 0.787), plant height (0.764 and 0.756), length of petiole in first laminate leaf (0.746 and 0.719), length of second embryonic leaf (0.674 and 0.670), number of embryonic leaf (0.647 and 0.526), width of embryonic leaf (0.623 and 0.615) with nut yield per palm while negative association were observed for three characters viz., length of first embryonic leaf, width of first embryonic leaf and duration taken for germination.

The positive and significant environmental correlation were recorded for width of first laminate leaf (0.430), number of embryonic leaf (0.367) and length of first

Table 17. Genotypic, phenotypic and environmental correlation between seedling characters and nut yield/palm

S.No.	Characters	GCC	PCC	ECC
1.	Per cent germination	0.379*	0.376*	-0.118
2.	Days to germination	-0.157	-0.129	-0.182
3.	Plant height (cm)	0.764**	0.756**	0.099
4.	Collar girth (cm)	0.851**	0.813**	0.060
5.	Number of embryonic leaves	0.647**	0.526**	0.367*
6.	Length of first embryonic leaf (cm)	-0.552**	-0.529**	0.358*
7.	Width of first embryonic leaf (cm)	-0.315	-0.256	0.008
8.	Length of second embryonic leaf (cm)	0.674**	0.670**	-0.397*
9.	Width of second embryonic leaf (cm)	0.623**	0.615**	-0.164
10.	Length of petiole in the first laminate leaf	0.746**	0.719**	-0.203
11.	Length of first laminate leaf (cm)	0.837**	0.789**	0.148
12.	Width of first laminate leaf (cm)	0.829**	0.773**	0.430**
13.	Number of roots	0.810**	0.787**	-0.317
14.	Number of leaves	0.920**	0.708**	-0.128

\*\* Significant at 1 % level

\* Significant at 5 % level

embryonic leaf (0.358), width nut yield per palm. While it was negative and significant for length of second embryonic leaf. All other characters showed either positive or negative non significant environmental correlation with yield.

#### **4.10. Index scoring**

##### **4.10.1. Adult palm**

In the present study, the highest score for adult palm was recorded by the hybrid WCT x MDY (30) followed by Andaman Ordinary (26), MDY x WCT (21), WCT x Gangabondam (20), Philippines Ordinary (20), Laccadive Ordinary (19) and Strait Settlement Green (19). While genotypes Chowghat Dwarf Orange and West Coast Tall recorded the lowest value of 13 and 14 respectively (Table 18 and 19).

##### **4.10.2. Seedling**

The scoring of index for the seedling characters showed that the maximum score of 26 was recorded by both Andaman Ordinary and WCT x MDY followed by Laccadive Ordinary (21), WCT x Gangabondam (21) and Philippines Ordinary (18). While the minimum score of 13 was recorded for West Coast Tall, while 14 for Strait Settlement Green and East Coast Tall (Table 20 and 21).

#### **4.11. Multiple regression function**

Multiple regression function was worked out with five Tall varieties, one Semi Tall, one Dwarf and three hybrids, with number of leaves as dependent variable and

Table 18. Mean data on selected vegetative, reproductive and nut characters in ten coconut genotypes

Genotypes	Plant height (cm)	Number of leaves	Number of inflorescence per palm/year	Number of female flowers	Number of bunches/palm	Number of nuts/Bunch	Setting percentage	Weight of dehusked nut (g)	Weight of kernel (g)	Nuts/palm/year	Total score
Andaman Ordinary	8.17 (3)	34.57 (3)	13.37 (3)	512.60 (2)	13.80 (1)	8.32 (2)	24.70 (3)	525.43 (3)	228.91 (3)	127.00 (3)	26
Laccadive Ordinary	7.92 (3)	32.37 (2)	11.57 (2)	470.81 (2)	14.10 (1)	7.07 (2)	22.50 (2)	424.83 (2)	197.30 (1)	109.67 (2)	19
Philippines Ordinary	7.87 (2)	36.23 (3)	11.80 (2)	488.92 (2)	13.00 (1)	6.78 (2)	20.40 (1)	472.47 (3)	253.40 (3)	98.67 (1)	20
East Coast Tall	9.20 (3)	31.03 (1)	11.08 (1)	472.00 (2)	14.11 (1)	6.80 (2)	25.50 (3)	386.23 (2)	210.77 (2)	94.37 (1)	18
West Coast Tall	8.74 (3)	29.33 (1)	12.20 (2)	428.70 (1)	14.03 (1)	6.68 (1)	22.40 (2)	322.37 (1)	178.40 (1)	103.82 (1)	14
Strait Settlement Green	8.20 (3)	32.93 (2)	12.51 (2)	476.00 (2)	14.08 (1)	6.83 (2)	17.80 (1)	442.63 (2)	237.37 (3)	104.07 (1)	19
Chowghat Orange Dwarf	5.31 (1)	28.23 (1)	10.23 (1)	400.31 (1)	12.90 (1)	5.21 (1)	25.90 (3)	301.87 (1)	214.60 (2)	84.73 (1)	13
Dwarf x Tall	7.25 (2)	31.57 (2)	11.33 (1)	502.70 (2)	14.00 (1)	8.40 (3)	24.80 (3)	377.48 (2)	220.63 (2)	128.77 (3)	21
Tall x Dwarf	8.31 (3)	37.03 (3)	13.70 (3)	596.60 (3)	16.71 (3)	9.90 (3)	26.60 (3)	454.10 (3)	235.87 (3)	147.30 (3)	30
Tall x Gangabondam	8.63 (3)	35.70 (3)	11.62 (2)	407.31 (1)	14.58 (2)	7.67 (2)	19.80 (1)	404.37 (2)	218.37 (2)	118.73 (2)	20

Figures in parenthesis are score values.

Table 19. Index scores for selected traits in ten coconut genotypes

S. No.	Characters	Range of means	Score I value less than	Score II value (ranges)	Score III value more than
1.	Plant height (cm)	5.31 to 9.20	6.61	6.61 to 7.90	7.90
2.	Number of leaves/palm	28.23 to 37.03	31.16	31.16 to 34.10	34.10
3.	Number of inflorescence/palm	10.23 to 13.70	11.39	11.39 to 12.54	12.54
4.	Number of female flowers	400.31 to 596.60	465.74	465.74 to 531.17	531.17
5.	Number of bunches/palm	12.9 to 16.71	14.77	14.17 to 15.44	15.44
6.	Number of nuts/bunch	5.21 to 9.90	6.77	6.77 to 8.34	8.34
7.	Setting percentage	17.80 to 26.60	20.73	20.73 to 23.67	23.67
8.	Weight of dehusked nut (g)	301.90 to 525.40	376.40	376.40 to 450.90	450.90
9.	Weight of kernel (g)	178.41 to 253.40	203.40	203.40 to 228.40	228.40
10.	Number of nuts/palm/year	84.73 to 143.40	104.25	104.25 to 123.78	123.78

Table 20. Mean data on selected embryonic and growth characters in four months old coconut seedlings

Genotypes	Per cent germination	Days to germination	Seedling height (cm)	Collar girth (cm)	Number of embryonic leaves	Length of first embryonic leaf (cm)	Width of first embryonic leaf (cm)	Length of first laminate leaf (cm)	Width of first laminate leaf (cm)	Number of leaves	Total score
Andaman Ordinary	70.33 (2)	96.80 (2)	34.17 (3)	5.57 (3)	2.26 (3)	3.37 (2)	2.60 (3)	9.23 (3)	8.03 (2)	3.43 (3)	26
Laccadive Ordinary	94.67 (3)	107.37 (1)	30.86 (2)	4.38 (2)	2.61 (3)	3.07 (2)	2.90 (3)	8.37 (2)	6.30 (1)	2.93 (2)	21
Philippines Ordinary	80.00 (2)	88.93 (3)	29.87 (2)	4.97 (2)	2.08 (2)	2.86 (1)	2.43 (2)	7.90 (1)	6.71 (1)	2.98 (2)	18
East Coast Tall	53.33 (1)	112.43 (1)	20.15 (1)	3.93 (1)	2.16 (2)	4.03 (3)	1.77 (1)	6.67 (1)	5.81 (1)	3.00 (2)	14
West Coast Tall	60.00 (1)	100.23 (2)	18.10 (1)	3.90 (1)	1.91 (1)	2.53 (1)	2.33 (2)	7.10 (1)	6.10 (1)	3.23 (2)	13
Strait Settlement Green	78.33 (2)	103.10 (1)	26.31 (2)	4.00 (1)	2.15 (2)	2.44 (1)	2.03 (1)	7.33 (1)	6.33 (1)	2.93 (2)	14
Chowghat Orange Dwarf	70.33 (2)	83.27 (3)	23.86 (1)	3.60 (1)	2.05 (1)	3.83 (3)	2.00 (1)	6.63 (1)	5.84 (1)	2.37 (1)	15
Dwarf x Tall	85.00 (3)	83.57 (3)	28.87 (2)	4.93 (2)	2.03 (1)	2.27 (1)	1.93 (1)	7.23 (1)	6.13 (1)	3.03 (2)	17
Tall x Dwarf	84.67 (3)	93.90 (2)	39.90 (3)	5.90 (3)	2.34 (3)	2.58 (1)	2.10 (2)	10.43 (3)	9.43 (3)	3.73 (3)	26
Tall x Gangabondam	71.33 (2)	96.13 (2)	38.07 (3)	5.20 (3)	2.24 (3)	2.40 (1)	1.97 (1)	8.30 (2)	7.93 (2)	3.08 (2)	21

Figures in parenthesis are score values.

Table 21. Index scores for selected embryonic and growth characters in four months old coconut seedlings

S. No.	Characters	Range of means	Score I value less than	Score II value (ranges)	Score III value more than
1.	Per cent germination	53.33 to 94.67	67.11	67.11 to 80.89	80.89
2.	Days to germination	83.27 to 112.43	102.71	92.99 to 102.71	92.99
3.	Plant height (cm)	18.10 to 39.90	25.37	25.37 to 32.61	32.61
4.	Collar girth (cm)	3.60 to 5.90	4.37	4.37 to 5.13	5.13
5.	Number of embryonic leaves	1.91 to 2.34	2.05	2.05 to 2.20	2.20
6.	Length of first embryonic leaf (cm)	2.27 to 4.03	2.86	2.86 to 3.44	3.44
7.	Width of first embryonic leaf (cm)	1.77 to 2.90	2.14	2.14 to 2.52	2.52
8.	Length of first laminate leaf (cm)	6.63 to 10.43	7.90	7.90 to 9.16	9.16
9.	Width of first laminate leaf (cm)	5.81 to 9.43	7.02	7.02 to 8.22	8.22
10.	Number of leaves	2.37 to 3.73	2.82	2.82 to 3.28	3.28

the other growth characters as independent variables and the results are presented in the Table 22.

The results revealed that plant height (0.045) and girth of the seedlings (0.591) exhibited a positive significant influence with number of leaves. While duration taken for germination (-0.023) and width of second embryonic leaf (-0.552) registered a significant negative influence over the number of leaves. The traits number of embryonic leaf, length of first embryonic leaf, length of second embryonic leaf, width of second embryonic leaf, length of first laminate leaf and number of roots had positive influence with number of leaves but non significant. All other characters showed negative influence over number of leaves.

#### **4.12. Metroglyph analysis**

##### **Variation in morphological characters**

Among the Tall, Semi Tall, Dwarf genotypes and hybrids studied. The number of leaves, collar girth and width of first embryonic leaf showed variation among the Tall genotypes. However, Andaman Ordinary recorded high expression for all the three characters followed by Laccadive Ordinary with intermediate values for number of leaves and collar girth and high value for width of first embryonic leaf. While the genotype Philippines Ordinary was intermediate in its morphology for.

The hybrids showed no significant variation for all the characters. Among the three hybrids, WCT x MDY and WCT x Gangabondam had thick collar than

Table 22. Multiple regression function of coconut seedlings at four month

S.No.	Characters	Regression coefficient (B)	SE of B	't' values
1.	Per cent germination	-0.011	0.017	0.676
2.	Days to germination	-0.023*	0.010	2.120
3.	Seedling height (cm)	0.045*	0.017	2.706
4.	Collar girth (cm)	0.591*	0.217	2.730
5.	Number of embryonic leaves	0.151	0.536	0.281
6.	Length of first embryonic leaf (cm)	0.208	0.182	1.141
7.	Width of first embryonic leaf (cm)	-0.552*	0.191	2.886
8.	Length of second embryonic leaf (cm)	0.183	0.199	0.922
9.	Width of second embryonic leaf (cm)	0.321	0.189	1.695
10.	Length of petiole in the first laminate leaf (cm)	-0.446	0.287	1.555
11.	Length of first laminate leaf (cm)	0.362	0.272	1.331
12.	Width of first laminate leaf (cm)	-0.406	0.290	1.396
13.	Number of roots	0.257	0.283	0.907

\* Significant at 5 % level

MDY x WCT which showed intermediate expression for this character. The hybrid WCT x MDY also showed high expression for number of leaves while it was intermediate in MDY x WCT and WCT x Gangabondam. The character width of embryonic leaf showed low value for MDY x WCT and WCT x Gangabondam and intermediate value for WCT x MDY. Thus from the morphology, the Tall and hybrid genotype exhibited high phenotypic expression for all the traits than Dwarf or Semi Tall genotype (Table 23, 24 and Fig. 10).

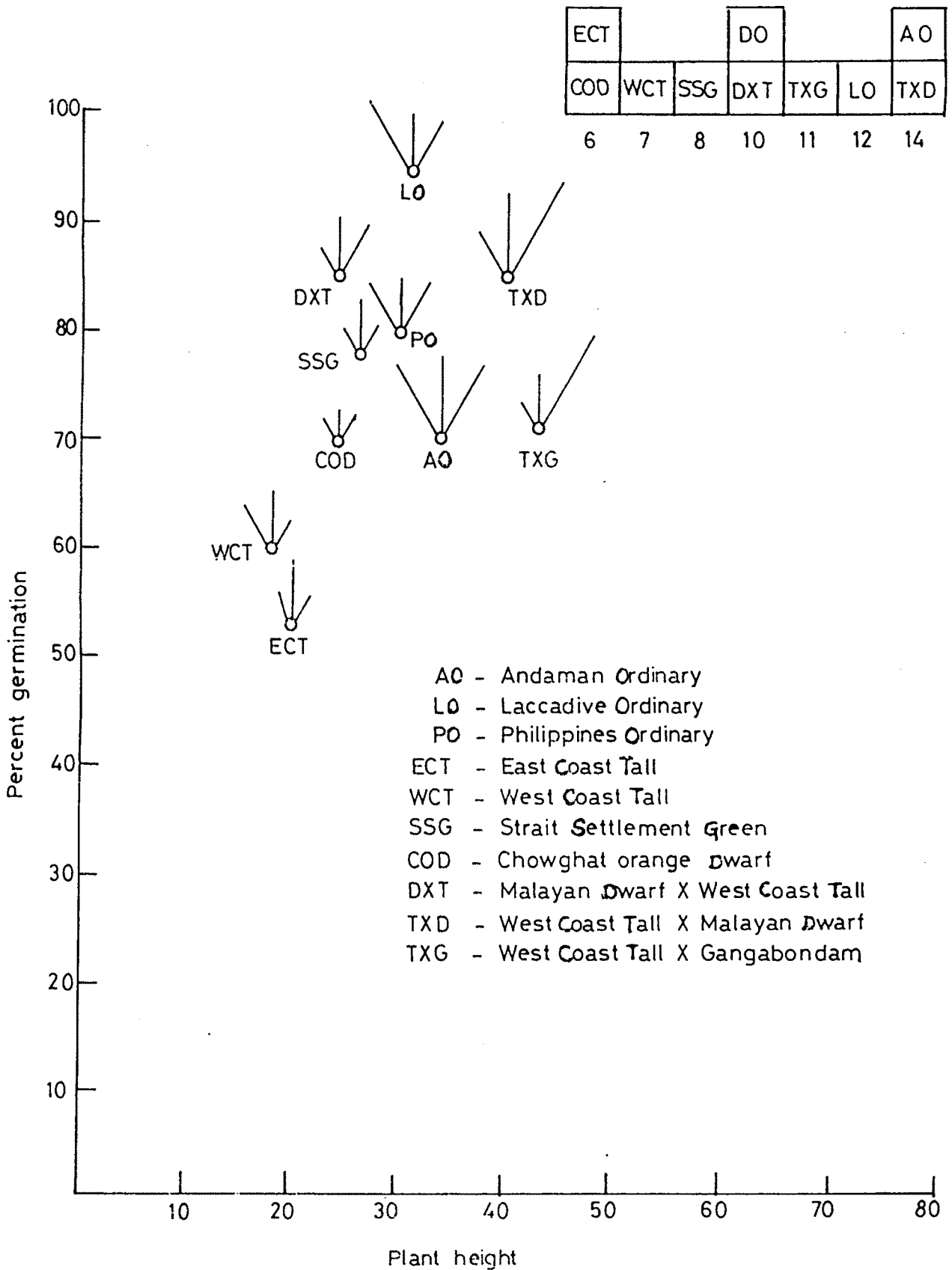
Table 23. Mean data on morphological characters in different coconut genotypes

S.No.	Genotypes	Per cent germination	Seedling height (cm)	Number of leaves	Collar girth (cm)	Width of first embryonic leaf (cm)	Total score
1.	Andaman Ordinary	70.33 (2)	34.17 (3)	3.47 (3)	5.57 (3)	2.60 (3)	14
2.	Laccadive Ordinary	94.67 (3)	30.86 (2)	2.93 (2)	4.38 (2)	2.90 (3)	12
3.	Philippines Ordinary	80.00 (2)	29.87 (2)	2.98 (2)	4.97 (2)	2.43 (2)	10
4.	East Coast Tall	53.33 (1)	20.15 (1)	3.00 (2)	3.93 (1)	1.77 (1)	6
5.	West Coast Tall	60.00 (1)	18.10 (1)	3.23 (2)	3.60 (1)	2.33 (2)	7
6.	Strait Settlement Green	78.33 (2)	26.31 (2)	2.93 (2)	4.00 (1)	2.03 (1)	8
7.	Chowghat Orange Dwarf	70.33 (2)	23.86 (1)	2.37 (1)	3.66 (1)	2.00 (1)	6
8.	MDY x WCT	85.00 (3)	28.87 (2)	3.03 (2)	4.93 (2)	1.93 (1)	10
9.	WCT x MDY	84.67 (3)	39.90 (3)	3.73 (3)	5.90 (3)	2.16 (2)	14
10.	WCT x Gangabondam	71.33 (2)	38.07 (3)	3.08 (2)	5.20 (3)	1.97 (1)	11

Figures in parantheses are score values.

Table 24. Index scores for different traits in coconut seedlings at fourth month

S.No.	Characters	Range of means	Score I value less than	Score II value (ranges)	Score III value more than
1.	Per cent germination	53.33 to 94.67	67.11	67.11 to 80.89	80.89
2.	Seedling height	18.10 to 39.90	25.37	25.37 to 32.61	32.61
3.	Number of leaves	2.37 to 3.73	2.82	2.82 to 3.28	3.28
4.	Collar girth	3.60 to 5.90	4.37	4.37 to 5.13	5.13
5.	Width of first embryonic leaf	1.77 to 2.90	2.14	2.14 to 2.52	2.52



# *Discussion*

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## CHAPTER V

### DISCUSSION

The genetic improvement of the coconut is mainly based on the selection of high yielding mother palms for seed supply (Sampson, 1923; Mendiola, 1926; Copeland, 1931; Dwyer, 1938; Patel, 1938 and Pieries, 1941). An examination of the variability in yield of nuts showed that an improvement upto 20 per cent could be achieved by the mother palm selection alone (Nair and Nampoothiri, 1993). They also reported that an average annual yield of more than 80 nuts/palm/year was considered best for mother palm selection.

Coconut (*Cocos nucifera* L.) is a monotypic genus with a restricted genetic base. Harries (1979 ) reported that in coconut variation can be exploited only among the two varieties namely the Tall and Dwarf forms. Such a selection of mother palm involves identification of potential yielders using some of the easily observable morphological characters like straight stout trunk, spherical or hemispherical crown, number of leaves and inflorescence, short and stout bunch stalks, high and consistent yield of nuts, high copra outturn and pest and disease free trees (Menon and Pandalai, 1958). The seedling raised from selected mother palms were distributed for planting after rigid selection based on early sprouting, vigour of seedlings and resistance to pests and diseases (Harland, 1957 and Liyanage, 1953).

Thus the selected mother palm can be used for crossing to exploit heterosis which is an important feature in breeding programme. So studies on the performance of hybrids

and parents play an important role in selection of future coconut cultivars. In the present study, the selection of mother palms and their seedling were done based on *per se* performance. Duley and Moll (1969) reported that the mean performance is the most important factor in selecting elite types. The present study also aimed to identify the genetic characters that influence the nut yield of the palm and other yield attributing factors, in order to identify the best genotype of coconut which can be further exploited for increased yield. The results obtained in various experiments are discussed with available literature here under.

#### **Mean performance of adult palm**

The main objective of any breeding programme is to evolve a variety with high yield. In the present investigation, among the ten genotypes studied, seven genotypes *viz.*, WCT x MDY, MDY x WCT, Andaman Ordinary, WCT x Gangabondam, Strait Settlement Green, Laccadive Ordinary and West Coast Tall recorded highest value for nut yield per palm per annum. All these genotypes produced more than 100 nuts per palm per annum.

In general hybrids produced maximum number of nuts than the varieties. Similar reports on hybrid vigour in coconut was first documented by Patel (1937) in intervarietal crosses involving the Tall variety as the female and the Dwarf variety as male parent and subsequently by John and Venkatanarayana (1943) who found that these Tall x Dwarf hybrids gave higher yields, combining the nut and copra characters of Tall with early bearing of Dwarf parents.

Bhaskaran and Leela (1963) also found while comparing the 25 years old T x D (WCT x CGD) hybrids that they were early bearing and high yielding than the Tall parents with higher number of functional leaves Liyanage (1955b, 1960 and 1961), Anon (1961), Pieries (1960) and Satyabalan *et al.* (1964) have also confirmed the existence of hybrid vigour in the adult palms of Tall x Tall, Tall x Dwarf and Tall x Gangabondam.

A comparative study by Kannan and Narayanan Nambiar (1974) of the six Tall types of coconut crossed with Semi Tall Gangabondam also revealed that hybrid vigour exists in the progenies of crosses between Laccadive Ordinary x Gangabondam for nut yield per palm per annum. Ramanathan *et al.* (1982) and Ramachandran *et al.* (1990) have also reported that the hybrids East Coast Tall x Malayan Dwarf Green (VHC-1) and East Coast Tall x Malayan Dwarf Yellow (VHC-2) were found to be promising in nut and copra yield and oil content. Such an increased expression of yield and economic attributes observed in hybrid compared to the parents could be utilized for enhancing the production (Ramanathan and Ramachandran, 1993). Nair and Nampoothiri (1993) reported that the report of heterosis in Tall x Dwarf hybrids by Patel (1937) leads to evaluation of various hybrids involving Tall and Dwarf for their increased productivity and due emphasis was given for the production of Tall x Dwarf hybrids, as these hybrids were precocious and high yielding when compared to their parents. The highest yield recorded by the hybrids WCT x MDY and MDY x WCT compared to the varieties in the present study was in agreement with the findings of the above author. Similar results on

increased yield for varieties Strait Settlement Green and Laccadive Ordinary was also reported by Ninan *et al.* (1961) and Joseph *et al.* (1992) respectively.

The genotypes, East Coast Tall, West Coast Tall, WCT x MDY and Tall x Gangabondam showed high expression for plant height. Similar reports on evaluation of coconut cultivars and hybrids for plant height by Ramanathan *et al.* (1992) revealed that the cultivar Laccadive Ordinary and the hybrid WCT x MDY exhibited increased plant height than other types.

Differences in girth of trunk are readily noticeable between palms belonging to different varieties. Classification of Tall and Dwarf varieties by Long (1993) revealed that the Tall varieties showed straight and thick stem base as compared to Dwarf type with thin stem base. In the present study also, the genotypes Philippines Ordinary, Strait Settlement Green, Laccadive Ordinary and West Coast Tall recorded maximum stem girth. The present finding is in confirmation with the reports of (Abeywardena and Mathew, 1980 and Rajamony *et al.*, 1983).

Distance between leaf scars also shows greater differences between Tall and Dwarf varieties. Widely spaced leaf bases are always associated with a long drooping habit of the leaves and closely spaced leaf bases are associated with short, strong and well oriented leaves (Pieries, 1934). In the present study, the Dwarf type Chowghat Orange Dwarf produced maximum number of internodes for one meter than the Tall, Semi Tall

and hybrid genotypes. Iyer and Dhamodaran (1994) also observed increased number of internodes in Dwarf types.

Regarding the leaf characters viz., number of leaves, length of leaf, length of petiole and number of leaflets both on right and left side of the lamina, the hybrid WCT x MDY and variety Philippines Ordinary produced maximum number of leaves. This is in confirmation with the earlier reports of Manthriratna (1973) that the  $F_1$  hybrids from CRIC 65 and hybrids from the reciprocal have exhibited hybrid vigour for number of leaves. Kannan and Narayanan Nambiar (1974) also reported increased rate of leaf production in hybrid, Andaman ordinary x Gangabondam, trees showing greater rate of leaf production in general give better yield than others (Menon and Pandalai, 1958). The present study also indicated that the genotypes producing maximum number of leaves exhibited maximum nut yield. Suggesting that importance should be given for this character in selection programme.

Length of leaf is an important character since it decides the ability of the leaf to support the bunches in its axils. Larger the leaf, weaker it seems to be and unable to provide ample support to its bunches. On the other hand shorter leaf always provide adequate support to its bunches (Pieries, 1934). In the present study also the genotype Philippines Ordinary recorded maximum leaf length and petiole length with decreased number of bunches per palm. Among the hybrid WCT x MDY recorded maximum values for length of leaf and length of petiole. Manthriratna (1973) also observed hybrid vigour for leaf size in his study.

The mean performance for number of leaflets both on right and left side of the lamina was high for Tall genotypes. The tall types also produced lengthiest leaves. So increase in length of leaf size will result in maximum number of leaflets. Similar trends of result have been documented by Yukio Sugimura *et al.* (1997).

The hybrid WCT x MDY and variety Andaman Ordinary were found to be superior as they produced maximum number of inflorescence per palm per annum. The results are in conformation with Ninan *et al.* (1961) in his coconut improvement studies where the hybrids produced maximum number of inflorescence per palm.

The inflorescence characters *viz.*, length of spadix, length of spikelet bearing portion and length of stalk showed notably wide range of variation. In general, the Tall genotypes recorded maximum length for all these characters. Among the Tall type, West Coast Tall exhibited the highest mean values for length of spadix and length of stalk. The present study thus, indicated that the increase in length of inflorescence or length of stalk did not have any significant influence on yield of coconut. Studies on inflorescence and yield character of coconut by Patil *et al.* (1993a) also showed similar trend with West Coast Tall.

Significant variation was noticed for number of female flowers per palm per annum among the ten genotypes studied. The genotypes WCT x MDY, Andaman Ordinary and MDY x WCT exhibited higher value for this character. Kannan and Narayanan Nambiar (1974) also observed that the hybrid Tall x Gangabondam

produced maximum number of female flowers. According to Patel (1938) the number of nuts harvested to the number of female flowers produced is the most important yard stick for consideration. He also indicated that nut yield in coconut palm can be increased by increasing the number of female flowers per inflorescence.

The present investigation showed that the hybrids WCT x MDY and WCT x Gangabondam produced maximum number of bunches per palm per annum. Similar results in West Coast Tall were reported by Potty *et al.* (1980) on comparative performance of eight coconut varieties for number of bunches per palm.

The genotypes WCT x MDY, MDY x WCT, Andaman Ordinary, WCT x Gangabondam and Laccadive Ordinary recorded maximum number of nuts per bunch. These genotypes also showed maximum value for nut yield. Patil *et al.* (1993b) also recorded maximum number of nuts per bunch with high yield in Laccadive Ordinary. In the selection programme due emphasis should be given for this character as it leads to production of more number of nuts per palm (Abeywardena and Mathew, 1980).

Long (1993) observed marked variation between Tall and Dwarf varieties for the character setting percentage. He also reported that Dwarf varieties recorded higher setting percentage than the Tall varieties. In the present investigation also Chowghat Orange Dwarf exhibited the highest setting percentage next to hybrid WCT x MDY. Patel (1938) observed that trees having a good number of female flowers have the least setting percentage. In the present study also Strait Settlement Green though it ranks sixth in the

production of female flowers it has the lowest setting percentage. The genotypes WCT x Gangabondam, Strait Settlement Green and Andaman Ordinary showed increased length of nut. But the equatorial diameter of the nut was high in case of Andaman Ordinary, Philippines Ordinary, WCT x Gangabondam and Laccadive ordinary. Balakrishnan and Vijayakumar (1988) during their evaluation studies of coconut involving indigenous and exotic cultivars also found that the cultivar Laccadive Ordinary was superior for the character equatorial diameter of nut. They also reported that this character was desirable and directly related to the copra content of nut.

Liyanage (1956) reported that the nuts of the hybrid palms showed an increase in size and weight while Ramanathan *et al.* (1992) during their evaluation study with various cultivar and hybrids of coconut noticed that the cultivars West Coast Tall and Strait Settlement Green recorded the highest weight for whole nut. In the present study also, the genotypes West Coast Tall, Strait Settlement Green and the hybrid WCT x MDY recorded maximum value for this character.

The genotypes West Coast Tall, Andaman Ordinary and Strait Settlement Green exhibited maximum value for thickness of husk. These genotypes also showed increased weight for whole nut. Studies on hybrid vigour for nut characters of coconut hybrids by Satyabalan *et al.* (1970) revealed that decrease in weight of unhusked nut indicated a reduction in husk content. In the present study also hybrids registered low value for husk thickness and weight of whole nut when compared to Tall types.

In a comparative analysis of nut and copra characters of WCT x CGD, WCT x COD and WCT x Gangabondam. Satyabalan *et al.* (1970) found that the latter two hybrids showed hybrid vigour in the weight of dehusked nut and kernel as compared with the female parent West Coast Tall. They also reported that the increase in weight of dehusked nut was mainly due to an increase in weight of nut water and weight of kernel. The present study indicated that the hybrid WCT x MDY and varieties Andaman Ordinary and Philippines Ordinary recorded maximum value for weight of dehusked nut with high kernel weight. These results are also in agreement with the findings of Ramanathan *et al.* (1992) and Patil *et al.* (1993b).

Increase in weight of kernel and weight of shell depend upon the weight of dehusked nut. In the present study those genotypes having maximum value for weight of dehusked nut also showed maximum value for weight of kernel and weight of shell. Similar trend of increase in weight of dehusked nut with increase in kernel weight and shell weight was reported by Ramanathan *et al.* (1992) and Patil *et al.* (1993b) respectively.

The study on classification of coconut varieties based on nut character by Long (1993) showed that the Dwarf varieties registered thin meat than tall varieties. In the present study also the Dwarf type Chowghat Orange Dwarf recorded low value for the thickness of kernel. Oil content was found to be superior in the type MDY x WCT, Laccadive ordinary and Andaman Ordinary. Long (1993) reported that oil content

did not show much variation among Tall and Dwarf types. In the present study also the difference in oil content between Tall and Dwarf genotypes was significant.

From this study it is clear that, it is difficult to postulate a single genotype with all merits combined together. So based on the various economic characters studied, it is clear that among the seven varieties and three hybrids, Andaman Ordinary, Laccadive Ordinary, Philippines Ordinary, WCT x MDY were the most promising for various characters studied.

#### **Variability, heritability and genetic advance in adult palm**

Variability studies provide basic information regarding the genetic properties of the population, based on which, breeding methods are formulated for further improvement of the crop. These studies are also helpful in knowing the nature and extent of variability attributable to different causes, sensitive nature of the crop to the environmental influences, heritability of the character and genetic advance that can be involved in practical breeding. The extent of variability and heritability of characters among the genotypes are the basis for the exploitation of heterotic potentiality of the genotypes. The results observed from variability studies revealed that the estimates of phenotypic variance and phenotypic coefficient of variation were higher in magnitude than genotypic variance or genotypic coefficient of variation, indicating that the apparent variation is not only due to genotype but also due to the influence of environment.

It was observed that phenotypic and genotypic variances were high for whole nut weight, weight of dehusked nut, number of female flowers and nuts per palm and its value was low for number of leaves. This was in accordance with Balakrishnan *et al.* (1991).

In the present study, the traits number of nuts per palm, weight of dehusked nut, whole nut weight, plant height, length of petiole, thickness of shell, number of female flowers and number of nuts per bunch recorded high values for PCV and GCV, and as such there is enough scope for improvement of these traits through selection. The existence of such a high extent of genetic variation for various characters were observed earlier and reported by Louis (1981) for number of nuts per palm and number of female flowers, Muluk (1987) for plant height and Patil *et al.* (1993b) for weight of dehusked nut and number of nuts per palm. Low values for PCV and GCV was observed for the characters length of spadix, thickness of kernel and oil content, suggesting that these characters were less stable and highly susceptible for random environmental effects. This is in consonance with the earlier findings of Patil *et al.* (1993b).

Heritable variation may be effectively used with greater degree of accuracy when studied in conjunction with genetic advance (Burton, 1952; Swarup and Chaugale, 1962). Johnson *et al.* (1955) suggested that heritability and genetic advance when considered together were more useful for predicting the resultant effect of selecting the best individuals than heritability or genetic advance considered alone. It was also stated that genetic gain along with high heritability proves effective in the selection programme.

The selection of mother palm in an existing population is mainly based on the high yield of the palm. Through such selection of mother palm, it was estimated that yield improvement of only upto 15 per cent (Charles, 1961) could be achieved. This is mainly because of the low heritability of about 50 per cent for yield of nuts (Lakshmanachar, 1959; Liyanage and Sakai, 1960; Nambiar and Nambiar, 1970). In the present study also the number of nuts per palm showed low heritability value of 44.62 per cent.

Heritability in general was higher for most of the characters studied except for thickness of shell, stem girth and number of inflorescence per palm per annum which had low heritability values. High heritability recorded for number of leaves per palm is in consonance with the findings of Liyanage (1967); for number of female flowers and setting percentage, Nambiar and Nambiar (1970); number of bunches per palm, Okwuagwo and Tai (1995); nuts per bunch and weight of kernel and shell, Patil *et al.* (1993b); weight of dehusked nut, Liyanage and Sakai (1960) and oil content, Menuier *et al.* (1984) which indicated that these characters possess greater degree of inheritance in further generation.

Genetic advance is a measure of genetic gain that can be expected in the process of selection. Genetic advance expressed on per cent mean basis was high for weight of dehusked nut, whole nut weight, length of petiole, number of nuts per bunch, number of female flowers, number of internodes for one metre and number of nuts per palm. Similar results for number of nuts per palm were obtained by Louis (1981) and Balakrishnan *et al.*

(1991). The high estimates of these characters along with high genetic advance over per cent mean suggested that all these characters except yield per palm are under control of additive gene action. The characters *viz.*, number of leaves, length of leaf, number of leaflets, weight of kernel and weight of shell showed high values for heritability and moderate value for genetic advance over per cent mean and hence could be regarded as under the control of additive as well as non additive gene action. Stem girth, number of inflorescence and thickness of shell exhibited low values of heritability and genetic advance as per cent mean. This indicates that genetic control for these characters are complex. The characters with high additive gene action are expected to show a direct response for selection but those under the control of non additive gene effects should be improved through indirect selection method on the basis of correlated response.

#### **Correlation studies in adult palm**

Growth is a complex entity associated with many characters, which are themselves interrelated. Such interrelationship of various growth components is highly essential to understand the relative importance of each character involved. If genetic correlation is high, attempts to obtain response in one character by selecting for the associated trait may be worth-while. This is especially true for the dependent character like nut yield having low heritability as seen in the present study.

In general, genotypic correlation values were higher than the phenotypic correlation values. Higher genotypic correlation coefficient than the phenotypic

correlation coefficient indicates low environmental effects on the expression of association between the characters.

The traits *viz.*, number of female flowers, number of inflorescence, number of nuts per bunch, thickness of shell, oil content, number of bunch, equatorial diameter of nut, weight of dehusked nut and setting percentage exhibited positive and significant correlation at both genotypic and phenotypic levels with number of nuts per palm. At genotypic level alone, the characters, number of leaves, length of petiole and weight of shell registered significant and positive correlation with yield. The result suggest that these traits could be considered as major yield contributing characters in coconut. Positive and significant correlation for number of nuts per bunch with number of female flowers was reported by Pieries (1934), Thampan (1970), Balingaasa and Carpio (1976) and Louis (1983), number of inflorescence, Abeywardena (1976), number of nuts per bunch and oil content, Patil *et al.* (1993b) number of leaves, Patel (1937), Satyabalan *et al.* (1972), Abeywardena (1976) and Balakrishnan *et al.* (1991). Due emphasis should be given for these character in selection programme.

Plant height, number of internodes for one meter, length of leaf, number of leaflets (left), length of spikelet bearing portion, whole nut weight, weight of kernel and thickness of kernel also showed positive non significant association with nut yield per palm. Similar results have also been reported for plant height by Satyabalan (1972), length of leaf and number of leaflets, Abeywardena (1976) and Sukumaran *et al.* (1981) and thickness of kernel, Louis (1983) and Patil *et al.* (1993b).

Negative and significant correlation was observed for stem girth with nut yield per palm. Indicating selection for stem girth is of minor importance. This results are in line with the findings of Ramanathan (1984).

#### **Inter correlation among various nut yield components in adult palm**

Among the yield components, plant height and stem girth was positively and significantly correlated at both levels through length of nut. The relationship between number of internodes with length of petiole, number of bunches per palm and nuts per bunch was positive and significant.

Positive and significant correlation was observed for number of leaves, length of leaves and number of leaflets through length of spadix, weight of shell and length of stalk with yield. But length of petiole exhibited a positive and significant association with yield through number of bunches, number of female flowers, thickness of shell, weight of shell, nuts per bunch and number of female flowers.

Number of inflorescence was positively and significantly correlated with yield through thickness of shell, equatorial diameter of nut, weight of dehusked nut, number of bunches per palm, nuts per bunch, setting percentage and oil content. Nampoothiri *et al.* (1975) reported positive and significant correlation for number of inflorescence through number of female flowers produced on yield.

Pieries (1941) and Patil *et al.* (1993a) observed a highly significant and positive association between length of spadix with length of stalk. The present study also showed similar results. Inter association involving length of spikelet bearing portion and length of stalk with thickness of shell, weight of shell, length of nut and setting percentage indicated a positive and significant association with yield.

The genotypic and phenotypic correlation for number of bunches per palm with thickness of shell, number of nuts per bunch, oil content, setting percentage and weight of shell was positive and significant. Similar results on association of number of bunches produced with number of nuts per bunch were obtained by Sukumaran *et al.* (1981). Highly significant positive correlation was exhibited for number of nuts per bunch through thickness of shell, setting percentage, oil content weight of shell and weight of dehusked nut with yield. The positive association of nuts per bunch with thickness of kernel in the present study are in accordance with those obtained by Bavappa and Sukumaran (1976) and Louis (1983).

The present study revealed a positive and significant association of setting percentage with nut yield through thickness of shell, length of nut and whole nut weight. Balakrishnan and Vijayakumar (1988) observed a significant and positive correlation between length of nut and equatorial diameter of nut through weight of dehusked nut, whole nut weight and husk thickness. In the present study also similar results were obtained. Inter association of whole nut weight and thickness of husk through thickness of shell and weight of dehusked nut respectively was positive. This is in agreement with

the findings of Balakrishnan and Vijayakumar (1988). The weight of dehusked nut showed significant and positive correlation with nut yield through weight of shell, oil content, weight of kernel, thickness of kernel and thickness of shell. Similar results for weight of shell and copra were observed by Patil *et al.* (1993b). Positive and significant association between weight of kernel and thickness of kernel at both levels was in agreement with Patil *et al.* (1993b). Inter association involving thickness of kernel, weight of shell, thickness of shell and oil content exhibited positive correlation with almost all the parameters studied.

#### **Path coefficient analysis**

The correlation coefficient being the result of cause and effect relationship existing between different characters may not always provide complete information. Hence path coefficient analysis which apportions the correlation coefficient into direct and indirect effect and measures the relative importance of the causal factors (Dewey and Lu, 1959) has proved more useful. The present study indicated a clear description about the contribution made by different yield components upon yield.

Path coefficient analysis in coconut genotypes indicated that the traits *viz.*, length of leaf, husk thickness, weight of kernel, setting percentage, length of petiole and plant height had maximum direct effect on yield of coconut suggesting a better scope for selecting this parameter to increase the yield of coconut. The present findings are in line with the characters like plant height and length of leaf (Bhagavan and Nair, 1989), kernel weight and length of petiole (Louis and Chopra, 1983). While the characters spadix

length, thickness of kernel, thickness of shell and number of nuts per bunch had low positive direct effect on yield. Luke Rathna Kumar *et al.* (1993) also observed that thickness of kernel and thickness of shell had positive direct on yield. However the characters weight of dehusked nut, length of nut, number of leaflets (left), number of female flowers, whole nut weight and number of internodes though exerted direct influence of high magnitude on yield its effect was negative. The results are in accordance with the findings of Luke Rathna Kumar *et al.* (1993).

### **Stability analysis**

The adaptability of genotypes was estimated by the stability parameters (Eberhart and Russel, 1966). A suitable genotype is one which shows high mean, regression coefficient 'bi' around unity and deviation from regression ( $S^2 di$ ) near zero. Eberhart and Russel (1966) model is reliable because of its explicit nature (Jowet, 1972).

The analysis of variance for nut yield per palm and pooled analysis indicated that the genotypes differed among themselves for nut yield per palm over various seasons. The significant mean sum of squares recorded for genotypes and environment (genotype x environment) interaction has not only revealed the existence of genetic variability in the population under study but also proved the interaction of genotypes with environment prevailing during various seasons as suggested earlier by Louis and Chandra Sekharan (1976) and Patil *et al.* (1991).

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The stability analysis revealed that the genotypes Laccadive Ordinary, West Coast Tall and East Coast Tall were highly stable for the trait nut yield per palm. Balakrishnan *et al.* (1988) also reported that the variety West Coast Tall and Laccadive Ordinary were stable for annual yield production. Patil *et al.* (1991) indicated that Tall variety Pratap was the best genotype adopted to fluctuating environmental condition.

### **Mean performance of seedlings**

Selection of seedlings from the nursery is mainly done based on the vigour of the seedlings such as collar girth, height of the seedling and number of leaves (Sampson, 1923; Copeland, 1931; Dwyer, 1938; Patel, 1938; Pieries, 1941; Phillis, 1946; Raghavan, 1948 and Eden, 1952).

Patel (1938) reported differences in the percentage of total germination and early germination in seed nuts according to the month of the year in which they were harvested. He also observed differences in total germination between nuts from the top or bottom, and from middle of the bunch. Umali (1940) also found differences in seedling growth from the top, middle and bottom of the nuts. In the present study also a clear difference was observed in percentage of total germination and early germination.

Among the seven genotypes of coconut studied, Laccadive Ordinary recorded highest germination percentage. The hybrids WCT × MDY, MDY × WCT and the genotypes Strait Settlement Green and Andaman Ordinary also recorded high values for germination percentage. Jack and Sands (1929) found that Dwarf coconut was early in

germination and it leads to early flowering of the palm. In the present study also Dwarf variety Chowghat Orange Dwarf took minimum number of days for germination. The hybrid MDY x WCT showed early germination with increased number of leaves. Similar findings with Malayan Red Dwarf x West African Tall was reported by Fremond and Denuce (1971). Liyanage (1953) reported that the period taken for germination should be considered as an important factor for seedling selection. He also reported that the early germination of seed nut will lead to early bearing and more productive palms.

Hybrid vigour in coconut seedling was noticed by John and Venkatanarayana (1943) in the nursery for the characters such as height, girth at collar and number of leaves. They also reported that transplanting of such hybrids proved to be early and heavy yielders. These findings were supported by Bhavani Shankar Rao and Koyamu (1952), Liyanage (1956) and Bhaskaran and Leela (1963). In the present study, the hybrid WCT x MDY and WCT x Gangabondam, Tall type Andaman Ordinary and Laccadive Ordinary recorded maximum value for plant height. Similar reports on plant height for the hybrid VHC-1 and variety Laccadive Ordinary has been documented by Luke Rathna Kumar (1989). Selection of seedling based on height of the seedlings was reported by Harland (1957) and Luke Rathna Kumar *et al.* (1993). Luke Rathna Kumar (1989) observed in his study high mean value for collar girth in hybrid and Tall genotypes. In the present investigation also WCT x MDY, Andaman Ordinary and Tall x Gangabondam recorded maximum values for collar girth. During seedling selection due emphasis should be given for collar girth (Liyanage, 1953 and Ninan *et al.*, 1964).

The maximum number of embryonic leaves was produced by Laccadive Ordinary and WCT x MDY. Higher estimates for embryonic characters like length of first embryonic leaf, width of second embryonic leaf were registered by East Coast Tall, Laccadive Ordinary, WCT x MDY and WCT x Gangabondam respectively. The results are in confirmity with the findings of Luke Rathna Kumar (1989) that higher the estimates of embryonic characters greater the plant height.

In the present study, the hybrid WCT x MDY was found to record high values for length of petiole in laminate leaf, length of first laminate leaf and width of first laminate leaf. Sundaram (1975) in his crop improvement programme observed that vigour index of Tall seedlings was contributed by a set of characters namely seedling girth, petiole and leaf length of the seedlings.

In the present study, hybrid vigour manifested in the production of maximum number of leaves. The hybrid WCT x MDY and WCT x Gangabondam recorded maximum number of leaves and roots. More the number of leaves higher was the yield recorded at later stages. This study is in confirmation with the reports of Krishnan and Nambiar (1972) and Ramachandaran *et al.* (1974) who have noticed hybrid vigour for number of leaves between Tall x Dwarf.

#### **A comparative study of mean performance between adult palm and seedling characters**

In coconut, selection is normally practised on the mother palms and in seedling. Harland (1957) advocated that identification of high yielding mother palms should be

done on the basis of their progeny performance and suggested that it should be possible to identify prepotent high yielders from a comparative study of sufficiently large number of progenies from open pollinated mothers.

Ninan and Pankajakshan (1961) showed that it is possible to distinguish high yielders which would give superior progenies from those giving inferior progenies on the basis of seedling performance in the nursery. The possibilities of locating prepotent palms on the basis of their progeny performance in the nursery was also reported by Ninan *et al.* (1964) based on significant differences in vigour and growth rate of seedlings between families in comparison with variation within families. In the present study also significant differences were observed between genotypes for various growth and nut characters of adult palm and for vigour of the seedlings in the nursery.

Liyanage and Abeywardena (1957) reported that selection of seed nuts from high yielding adult palms results in production of seedlings with early sprouting and also with increased germination percentage. The present study made between the mother palm and the seedling showed that the high yielding mother palms *viz.*, WCT x MDY, MDY x WCT, Laccadive Ordinary and Strait Settlement Green revealed significant increase in per cent germination and registered minimum number of days to germination.

Similarly the seed nut collected from high yielding mother palm (WCT x MDY, MDY x WCT, Andaman Ordinary, WCT x Gangabondam, Laccadive Ordinary and Strait Settlement Green) for raising nursery also exhibited high value for the characters plant

height, collar girth and number of leaves. John and Venkatanarayana (1943) noticed hybrid vigour in Tall x Dwarf coconut on the vegetative characters such as height, girth at collar and number of leaves. They also reported that transplanting of such seedlings proved to be early and heavy yielders. These findings were supported by Bhavani Shankar Rao and Koyamu (1952), Liyanage (1956) and Bhaskaran and Leela (1963).

The overall performance of the seedlings from high yielding mother palms for seedling height, collar girth and number of leaves were highly significant which indicates that selection can be effectively practised on the seedlings for height, collar girth and number of leaves, instead of waiting for the long generation period of the palm over years.

#### **Variability, heritability and genetic advance in seedlings**

Among the various seedling traits plant height recorded highest phenotypic and genotypic coefficient of variation at the fourth month followed by length of first embryonic leaf, width of second embryonic leaf, width of first laminate leaf and width of first embryonic leaf. Further, the difference between the PCV and GCV is narrow, revealing the low level of environmental influence. Thus, these traits express the true genetic potential in varied environments. The present finding confirms the earlier reports on variability by Luke Rathna Kumar (1989) for plant height and length of first embryonic leaf.

Studies on the heritability in Tall variety by Mathew and Gopimony (1988) revealed medium to high values for all the seedling characters under study. In the present study, related to fourth months of growth, medium to high values for seedling characters were observed. Highest heritability was recorded for the traits, per cent germination, plant height, length of second embryonic leaf and width of second embryonic leaf. While the characters number of roots, length of petiole in the first laminate leaf and collar girth also showed high values for heritability. The results are in agreement with the findings of Louis (1981) for plant height, Luke Rathna Kumar (1989) for length of second embryonic leaf and Louis (1983) for collar girth. Mathew and Gopimony (1988) recorded a moderate heritability for days to germination and number of leaves. In the present study also these two characters showed moderate heritability values.

Heritability estimates when used in conjunction with genetic advance over per cent mean would give a better information than the heritability alone. Panse (1957), reported that high heritability together with high genetic advance was indicative of additive gene effects and high heritability with low genetic advance as an indication of dominance and epistatic effects.

In the present study, high heritability coupled with high genetic advance over per cent mean were noticed for plant height, length of first embryonic leaf, width of second embryonic leaf, width of first laminate leaf and collar girth and moderate heritability with moderate genetic advance over per cent mean for number of leaves and width of first embryonic leaf, suggesting the role of additive gene action in the expression

of these characters and as such could be considered reliable indices for selection. The results confirm the earlier findings on collar girth by Louis (1981) and Anon (1981).

### **Correlation studies in seedlings**

In the present study with four month old seedlings revealed that number of leaves was positively and significantly correlated with length of second embryonic leaf, length and width of first laminate leaf, collar girth, length of petiole of the first laminate leaf, width of second embryonic leaf, number of embryonic leaves and plant height at genotypic and phenotypic levels. Similar observations were made by Satyabalan and Mathew (1976) for number of leaves with plant height and collar girth.

Duration taken for germination had significant and negative effect with number of leaves. Similar results were obtained in one year old seedlings by Jack and Sands (1929), Patel (1938), Liyanage (1955a,b), Nampoothiri *et al.* (1975) and Luke Rathna Kumar (1989).

The association of per cent germination with plant height and length of first laminate leaf was positive and negative at both levels, while it was negative for seedling height and collar girth. Pankajakshan and Minnie George (1961) and Balakrishnan *et al.* (1988) however observed positive association between days to germination with height of seedling and collar girth. This is due to a difference in environmental condition and the genetic background of the materials used.

Correlation studies among embryonic and growth characters revealed that duration taken for germination had a negative association with width of first embryonic leaf, length of petiole in first laminate leaf, length and width of first laminate leaf. It is in accordance with the findings of Luke Rathna Kumar (1989) for width of first embryonic leaf and length of petiole.

In the present investigation, the inter association involving plant height with length and width of second embryonic leaf, length and width of laminate leaf and length of petiole in the first laminate leaf exhibited positive and significant association with height of the seedlings. This clearly indicates that longer the embryonic leaf more will be the height of the seedling as reported by Luke Rathna Kumar (1989). Plant height showed positive and significant association for most of the characters studied suggesting the importance of this characters for selection of seedlings with more number of leaves.

Collar girth was significantly and positively correlated with other characters namely, number of embryonic leaves, length of second embryonic leaf and root number at both levels. Similar findings were reported earlier by Balakrishnan<sup>et al</sup> (1988) and Luke Rathna Kumar (1989). Association among the characters, width of embryonic leaf, length and width of first laminate leaf, length of petiole in first laminate leaf and root number was positive and significant and this association establishes a relationship and revealed the influence of these characters on plant height.

The present findings suggest that selection of seedling from the nursery should mainly be based on seedling height, collar girth, number of leaves, length and width of second embryonic leaf, length and width of laminate leaf and length of petiole in the first laminate leaf.

The *per se* performance, genetic parameters and components of variation obtained for all the embryonic and growth characters during sixth, eighth and tenth month of growth showed the same trend. Multiple regression analysis revealed that importance should be given for width of first laminate leaf, width of second embryonic leaf during tenth month other than days to germination, plant height and collar girth during fourth month.

The present study thus brought out that if selection of embryonic characters is to be made, it should be based on the more number of leaves as in the hybrids and through the characters influencing the number of leaves per unit time of growth. This is agreement with the findings of Satyabalan and Mathew (1976) who insisted the importance of the growth characters based on the collar girth and leaf production even at the fifth month of growth.

#### **Correlation studies between nut yield per palm and seedling characters**

In the present study, positive and significant genotypic and phenotypic correlation for number of leaves, collar girth, length and width of first laminate leaf, root number, plant height, length of petiole in the first laminate leaf, number of embryonic leaf and

length and width of second embryonic leaf with nut yield per palm revealed that importance should be given for selection of these characters in increasing the productivity of coconut. These results are in confirmation with the findings of Nampoothiri *et al.* (1975) and Satyabalan *et al.* (1975) who have indicated that seedling characters such as collar girth and number of leaves are genetically correlated with the adult palm yield. The possibilities of identifying palms of superior genetic value based on collar girth and leaf production of high yielding families was indicated by Satyabalan and Jacob Mathew (1983). While Luke Rathna Kumar<sup>etal</sup> (1993) reported that the seedling characters namely number of leaves, height and collar girth recorded significant and positive influence with the copra weight.

#### **Index scoring**

The study on selection indices based on scoring for both adult palm and seedling showed that the genotypes Andaman Ordinary, Laccadive Ordinary and Philippines Ordinary and the hybrids WCT x MDY and WCT x Gangabondam scored the maximum value. Scoring of the seedling and the adult palms revealed significant differences between the two for vegetative, reproductive and nut characters (adult palm) and embryonic and growth characters (seedling). So the selection of the best seedling is well assured if the seed nuts are selected from the superior adult palm.

#### **Multiple regression function**

Multiple regression function adopted with number of leaves as a dependent variable and other characters as independent variables revealed that duration taken for

germination and width of first embryonic leaf had negative influence and the height of seedling and collar girth had positive influence over number of leaves during fourth month of growth indicating the importance of these characters as vigour index. This is in agreement with the findings of Pankajakshan and Minnie George (1961) for plant height and girth and Luke Rathna Kumar (1989) for all the four characters.

### **Metroglyph analysis**

Metroglyph analysis on seedling characters provide a reliable scale for classification of genotypes. Menon and Pandalai (1958) reported that varieties differed each other in their morphological characters. In the present study also the ten genotypes varied among themselves for all the morphological characters studied. A tendency of dominance was evident in Andaman Ordinary and WCT x MDY as they expressed high values for morphological characters and recessiveness in Chowghat Orange Dwarf as the values were low for morphological characters. Thus the results revealed that Andaman Ordinary can be utilized in the hybridization programme to obtain hybrids of superior quality. Hybridization between locally adopted East Coast Tall and exotic genotype Philippines Ordinary may also yield fruitful results. Raveendran *et al.* (1987) also reported that exotic cultivars showed high expression for morphological characters and possibility of obtaining heterotic hybrids from parents of diverse origin.

*Summary*

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## CHAPTER VI

### SUMMARY

when ?  
A study was carried out in ten genotypes of coconut (*Cocos nucifera* L.) with the objective to assess the mean performance of the genotypes, the extent of genetic variability, heritability, association of characters and their direct and indirect contribution towards yield of coconuts. Stability and metroglyph analysis were also carried out for the identification of genotypes. Which is phenotypically stable over environment and classification of genotypes through metroglyph analysis would be helpful to know the genetic divergence of the genotype which can be further utilized in breeding programme. The out come of the investigation are summarized.

#### **Mean performance of the genotypes of adult palm**

The biometrical and quality characters studied in the ten genotypes of coconut, showed a significant variation among the genotypes. The characters *viz.*, nuts per palm per year, plant height, number of inflorescence per palm, thickness of shell, stem girth, number of female flowers and length of petiole exhibited wide variation among the genotypes.

All the three hybrids *viz.*, WCT x MDY, MDY x WCT, WCT x Gangabondam and the genotypes Andaman Ordinary, Strait Settlement Green, Laccadive Ordinary and West Coast Tall were the best with regard to nut yield per palm. The high yielding hybrid WCT x MDY, and the genotypes Andaman Ordinary,

Laccadive Ordinary also recorded high *per se* performance in respect of vegetative, reproductive and nut characters studied.

#### **Variability, heritability and genetic advance in adult palm**

High GCV and PCV estimates was recorded by number of nuts per palm per year followed by weight of dehusked nut, whole nut weight, plant height, length of petiole, thickness of shell, number of female flowers and number of nuts per bunch. This indicated that the variability could be exploited for successful isolation of desirable genotypes for the characters concerned. Low GCV and PCV was recorded by oil content, thickness of kernel, equatorial diameter of nut and thickness of husk.

There was not much of difference between the genotypic and phenotypic coefficients of variation, indicating the less influence of environmental factors on the different biometrical characters studied.

Heritability estimates in general were high for most of the characters studied. But plant height showed moderate heritability value. The characters nut yield per palm, number of inflorescence per palm, stem girth and thickness of shell showed the heritability value.

High heritability coupled with high genetic advance as per cent of mean was observed for weight of dehusked nut, whole nut weight, length of petiole, number of nuts per bunch, number of female flowers and number of internodes for one meter. High

heritability with high genetic advance as per cent mean suggested the additive gene action of these characters and their importance in selection programme.

High heritability with moderate genetic advance as per cent mean was obtained for number of leaves, length of leaf, number of leaflets, weight of kernel and weight of shell. High heritability and low genetic advance was observed for oil content. The characters stem girth, number of inflorescence per palm and thickness of shell showed low heritability with low genetic advance as per cent mean.

#### **Correlation studies in adult palm**

The correlation coefficient worked out were found to be higher at the genotypic level than at the phenotypic level. The characters *viz.*, number of female flowers, number of inflorescence per palm, number of nuts per bunch, thickness of shell, oil content, number of bunches per palm, equatorial diameter of nut, weight of dehusked nut and setting percentage had positive and significant genotypic and phenotypic correlation with yield. Association of component character indicated that yield of nut per palm was positively and significantly correlated with number of leaves, length of petiole and weight of shell at genotypic level alone revealing the true genetic association. The results suggest that these characters could form a good selection index. Stem girth showed negative association with nut yield per palm. The environmental correlation was much pronounced for nut yield with number of female flowers, number of nuts per bunch and thickness of husk.

### **Path analysis**

Path analysis revealed that length of leaf, thickness of husk, weight of kernel, setting percentage, length of petiole and plant height as the primary contribution of yield as they had maximum positive direct effects. The other characters *viz.*, weight of dehusked nut, number of leaflets (left), number of female flowers, whole nut weight and number of internodes for one meter had high and negative direct effect on nut yield per palm.

Hence preference may be given to length of leaf, husk thickness, weight of kernel, setting percentage length of petiole and plant height in coconut genotype in the selection programme to isolate superior genotype.

### **Stability of coconut genotype**

The genotypes with high mean values were resolved into four groups based on the stability parameter like regression and deviation from regression. The trait nut yield per palm over season were used for this classification. Those genotypes falling under group I were identified to be highly stable for the traits nut yield per palm. The genotype Laccadive Ordinary, East Coast Tall and West Coast Tall were found to be highly stable for nut yield per palm.

### **Mean performance for seedling characters**

The mean performance for seedling characters also revealed significant difference for all the embryonic and growth characters. The variability was high for the character

viz., width of first embryonic leaf, number of leaves, plant height, width of first laminate leaf, duration taken for germination, length of first embryonic leaf, length of first laminate leaf and collar girth.

Among the genotypes studied, the Tall types Andaman Ordinary, Laccadive Ordinary, Philippines Ordinary and the hybrids WCT x MDY and WCT x Gangabondam showed high *per se* performance in respect of embryonic and growth characters.

#### **Variability, heritability and genetic advance**

The character *viz.*, plant height, length of first embryonic leaf, width of second embryonic leaf, width of first laminate leaf and width of first embryonic leaf exhibited high values for GCV and PCV. It is evident from comparison of GCV and PCV estimates that almost all the traits were less susceptible to environmental fluctuation indicating the greater role of genetic factors in determining these characters.

Heritability estimates for seedling characters showed moderate to high values. The traits *viz.*, number of leaves, days to germination, width of first embryonic leaf and number of embryonic leaves showed moderate heritability while all other characters showed high values for heritability.

High heritability coupled with high genetic advance was exhibited by plant height, length of first embryonic leaf, width of second embryonic leaf, width of first

lamine leaf and collar girth in seedlings. This suggest that the selection for these characters can be helpful for achieving improvement through selection in seedlings.

#### **Correlation studies for seedling characters**

Studies with four month old seedling showed positive and significant genotypic and phenotypic correlation for length of second embryonic leaf, length and width of lamine leaf, collar girth, length of petiole in the first lamine leaf, number of embryonic leaf and plant height with number of leaves. While duration taken for germination, length and width of first embryonic leaf showed negative and significant correlation with number of leaves at both levels.

Association estimates among embryonic and growth characters revealed that duration taken for germination had negative association with width of first embryonic leaf, length of petiole in first lamine leaf, length and width of first lamine leaf. The height of the seedling has shown a positive and significant correlation through length and width of second embryonic leaf, length and width of first lamine leaf and length of petiole in first lamine leaf. Collar girth exhibited positive and significant correlation with number of leaves, length of second embryonic leaf and root number. Among the characters width of embryonic leaf, length and width of lamine leaf and root number exhibited positive and significant correlation among themselves. This association influence the height of seedling.

Correlation studies in four month old seedling revealed that plant height, collar girth, number of embryonic leaf, length and width of laminate leaf, length of petiole in the first laminate leaf which contributed much towards the increase in number of leaves per seedling should be given equal weightage in the selection process in seedling selection for correlation as well as for breeding programmes.

Studies on *per se* performance, genetic parameters components of variation and correlation for all the embryonic and growth characters during sixth, eighth and tenth month of growth showed the same trend as that of fourth month. This suggests the possibility of seedling selection based on embryonic and growth characters during the early stages of growth itself there by reducing the time and labour.

Highly significant positive genotypic correlation was observed for most of the seedling characters with nut yield per palm. Thus the present study, have relevance in breeding for improved productivity through selection at the early stages.

### **Index scoring**

Studies on index scoring revealed that the genotypes Andaman Ordinary, Laccadive Ordinary and Philippines Ordinary and the hybrids WCT x MDY and WCT x Gangabondam recorded maximum score for both adult palm and seedling characters. Indicating that the selection of the best seedlings is well assured if the seednuts are from the superior adult palm.

**Multiple regression analysis**

Multiple regression brought out the importance of the duration taken for germination, width of first embryonic leaf, collar girth and height of the seedlings which is found to have direct influence with the number of leaves.

**Metroglyph analysis**

Metroglyph analysis studied for seedling characters of ten coconut genotypes revealed that Andaman Ordinary, Laccadive Ordinary and Philippines Ordinary expressed high values for all the characters studied which can be utilized in hybridization programme to obtain hybrids of superior quality.

The present study revealed that the tall genotype Andaman Ordinary, Laccadive Ordinary, Philippines Ordinary and the hybrids WCT x MDY, WCT x Gangabondam could be well recommended for the commercial cultivation as they performed better in terms of all genetic parameters. The potentiality of the promising genotypes and hybrids identified in the present study, if tapped properly is likely to over rule the existing plantations thereby enabling the farming society to prosper in the field of agriculture. Furthermore the best genotypes identified could be exploited as such in the crop improvement programme.

# *References*

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## REFERENCES

- Abeywardena, V. 1976. Relationship between leaf length and yield in coconut. **Ceylon Cocon, Q.** 27: 47.
- Abeywardena, V. and D.T. Mathew. 1980. A biometrical approaches to evolving a selection index for seed parents in coconut (*Cocos nucifera* L.). **Ceylon Cocon. Q.**, 31(3/4): 112-118.
- Akpan, E.E.J. 1994. Evaluation of Tall coconut (*Cocos nucifera* L.) genotypes within the Nigerian coconut germplasm bank. **Oleagineux**, 49(1): 13-19.
- Anderson, E. 1957. A semigraphical method for the analysis of complex problems. **Proc. National Acad. Sci. Washington**, 43: 923-927.
- Anon. 1961. Coconut Administration Report of the Agricultural Department, Kerala for the year, 1959-60.
- Anon. 1976. Annual Report. Central Plantation Crop Research Institute, Kasaragod, Kerala, India. p. 284.
- Anon. 1981. Production year book. Rome. PP. 81-85.
- Anon. 1983. Coconut genetics and plant breeding. All India Co-ordinated Coconut and Arecanut Improvement Project. CPCRI. Kasaragod- 670 123, Kerala, p. 6-29.
- Anon. 1996. Agrostat. Directorate of Agriculture. Chennai, 5.
- AOAC. 1970. Official methods of analysis of the Association of Official Agricultural Chemists. 11<sup>th</sup> edition.
- Ataga, C.D. 1995. Character inter-relationship and path coefficient analysis for oil yield in the oil palm. **Annals of Applied Biol.**, 127(1): 57-162.
- Balakrishnan, P.C. and K.Kannan. 1988. Evaluation of certain coconut (*Cocos nucifera* L.) hybrids under rainfed condition. In National Symposium on Coconut Breeding and Management, KAU, India, 23-26, November.
- Balakrishnan, P.C. and N.K. Vijayakumar. 1988. Performance of indigenous and exotic cultivars of coconut in the Northern Region of Kerala . **Indian Coconut Journal** May issue, p. 3-6.
- Balakrishnan, P.C., S. Sumangala, Nambiar and K.M. Rajan. 1991. Selection indices in coconut. In: Abstracts of papers presented in the International Symposium on Coconut Research and Development, Kasaragod. p: 28.

- Balakrishnan, P.C., V.S. Devadas and V.K.G. Unnithan. 1988. Phenotypic stability of coconut (*Cocos nucifera* L.) cultivars for annual yield of nuts. In: National Symposium on Coconut Breeding and Management. KAU, India, 23-26, November.
- Balingasa, E.N. and C.B. Carpio. 1976. Genetic potential of some coconut populations in the Philippines, International Symposium on Coconut Research and Development. Dec. 28-31, P.62.
- Baskaran, U.P. and K. Leela. 1963. Hybrid coconut Tall x Dwarf. A comparative study with parental types. **Kerala Agric. Res. J.**, 2: 67-83.
- Bavappa, K.V.A. and C.K. Sukumaran. 1976. Coconut improvement by selection and breeding. A review in the light of recent findings. In: Abstract of papers presented in the International Symposium on Coconut Research and Development, Kasaragod.
- Bhagavan, S. and B.P. Nair. 1989. Vigour index as an additional parameter in identifying elite palms in arecanut. **J. Plantation Crops**, 16(Supplement): 389-394.
- Bhavani Shankar Rao, M. and K. Koyamu. 1952. Hybrid vigour in coconut seedlings. **Indian Coconut Journal**, 6: 41-44.
- \*Burton, G.W. 1952. Quantitative inheritance in grasses. **Proc. Sixth, Intl. Grassland Congress**.7: 277-283.
- Chamorro, D.H. and P.A. Sanchez. 1978. Content of copra and oil in some coconut (*Cocos nucifera* L.) cultivars. **Hort Abs.** 49(9): 7125.
- Chan, E. 1983. Progress in coconut breeding in United plantations Berhad, Malaysia. **Oleagineux**. 38(6): 371-379.
- Charles, A.E. 1961. Selection and breeding of coconut palm. **Trop. Agric. (Trin)**., 38: 283-296.
- \*Copeland, E.B. 1931. The coconut third ed. London: Macmillan.
- Dewey, D.R. and K.H. Lu. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. **Agron. J.**, 51: 515-518.
- Duley, J.W. and R.H. Moll. 1969. Interpretation and use of estimates of heritability and genetic advances in plant breeding. **Crop Science**, 9: 257-262.
- \*Dwyer, R.F.P. 1938. Coconut improvement by seed selection and plant breeding Northern Guinea Agric. Gaz. 4(3): 24-102.
- Eberhart, S.A, and R.A. Russel. 1966. Stability parameters for comparing varieties. **Crop Science**, 6: 36-40.

- \*Eden, D.R. 1952. Coconut selection in Western Somoa. **Quart. Bull. S. Pacific Commiss. 2:** 378.
- Fisher, R.A. and W.A. Mackenzie. 1923. Studies in crop variation II. The manurial response of different potato varieties. **J. Agric. Sci. Cambridge. 13:** 311-320.
- Fremont, Y. and M. Denuce. 1971. Characteristics and production of the hybrid palm, Malayan Dwarf x West African Tall. **Proc. Cocoa, Cocon. Conf. Incorp. Soc. Plrs. Kuala Lumpur, Malaysia, p.309.**
- Goulden, C.H. 1959. **Methods of Statistical Analysis.** Asia Publishing House, Calcutta.
- Harland, S.C. 1957. The improvement of the coconut palm by breeding and selection. Circulation paper No. 7/57. **Bull No. 15,** Coconut Research Institute, Sri Lanka.
- \*Harries, H.C. 1979. Targets for coconut breeding programmes. **In:** Papers presented at the fifth session of FAO Technical Party on Coconut Production and Protection and Processing. Manila, Philippines. pp. 85-87.
- Indires, K.M., H. Hanumanthappa, S. Shankar, K. Maharudrappa and V. Palanimuthu. 1997. Evaluation of coconut germplasm in the maiden tracts of Karnataka. **Indian Coconut Journal, 28(8):** 2-4.
- Iyer, R. D. 1980. Central Plantation Crops Research Institute. **Annual Report. pp:** 11-13.
- Iyer, R.D. and S. Dhamodaran. 1994. Improvement of coconut. **In:** Advances in Horticulture Vol. 9 Plantation and Spice Crops Part 1. (Eds. Chadha, K.L. and P. Rethinam) Malhotra Publishing House, New Delhi, India, pp. 218-242.
- Jack, H.W. and W.N. Sands. 1929. Observations on the dwarf coconut palm in Malaya. **Malay. Agric. J., 17:** 140-170.
- \*Johannson, W. 1909. Elementa for exakten erblickkoitalohru, Int. Vol. 515. pp. Jena: Gustav Fisher.

- John, C.M. and G. VenkataNarayana. 1943. Note on improvement of coconut by cross breeding. **Madras Agric. J.**, 31: 75-77.
- Johnson, H.W., H.F. Robinson and R.E. Comstock. 1955. Estimation of genetic and environmental variability in soybean. **Agron. J.**, 47: 314-318.
- Joseph, P.A., P.C. Balakrishnan and N.K. Nayar. 1992. Comparative performance of West Coast Tall and Laccadive Ordinary cultivars of coconut. **Indian Coconut Journal**, 23(7):10-13.
- Jowet, D. 1972. Stability parameters for sorghum in East Africa. **Crop Science**, 12: 314-317.
- Kannan, K. and P.K. <sup>Narayanan</sup> Nambiar. 1974. A comparative study of six tall types (var. Typica) of coconut crossed with semi Tall Gangabondam (var. Javanica). **Agric. Res. J. Kerala**, 12(2): 124-130.
- Kannan, K. and P.K.N. Nambiar. 1979. Mother palm and seedling selection in coconut. **Agric. Res. J. Kerala**, 17(1): 1-6.
- Krishnan, P. and K.P.P. Nambiar. 1972. Effect of different Dwarfs on the performance of TxD hybrids. **Cocon. Bull.**, 2:2-5.
- Kumar, N., J.B.M. Md. Abdul khader, P. Rengaswamy and I. Irulappan. 1993. Coconut. In: Introduction to Spices Plantation crops, Medicinal and Aromatic plants. Rajalakshmi Pub., Nagercoil. pp. 14.01-14.12.
- Kumaran, P.M., M.J. Ratnambal, V. Arunachalam and V. Niral. 1997. Genetical investigations and breeding for high yield in coconut. **Annual Report (1996-1997)**. CPCRI, Kasaragod- 670 124.
- Lakshmanachar, M.S. 1959. A preliminary note on the heritability of yield of coconuts. **Indian Coconut Journal**, 12: 65-68.
- Liyanage, D.V. 1953. Selection of coconut seednuts and seedlings. **Ceylon Cocon. Q.**, 4: 127-129.
- \*Liyanage, D.V. 1955a. Report of Botanist. Annual report of the Coconut Research Board of Coconut Research Institute for 1953, Ceylon Govt., **Segsional Paper**, 5: 29-34.
- Liyanage, D.V. 1955b. Planting materials for coconuts. **Ceylon Cocon. Q.**, 6: 75-80.
- Liyanage, D.V. 1956. Intra specific hybrids in coconut. **Bull. 7, Coconut Res. Inst., Ceylon**, pp. 5-9.

- Liyanage, D.V. 1960. Annual Report of the Botanish for 1960. **Ceylon Cocon. Q.**, 12: 43-51.
- Liyanage, D.V. 1961. Genetic improvement of the coconut palm. **Symposium on tropical crops improvement**. Tenta pacific congress. Neumean, New Caledenia, 39-50.
- Liyanage, D.V. 1967. Identification of genotypes of Coconut palms suitable for breeding. **Expl. Agric.** 3: 205-210.
- Liyanage, D.V. and K.I. Sakai. 1960. Heritabilities of certain yield characters of the coconut palm. **Journal of Genetics**, 57: 245-252.
- ✓ Liyanage, D.V. and V. Abeywardena. 1957. Correlations between seed nut, seedling and adult palm characters in coconut. **Tropical Agriculturist**, 113: 325-340.
- Long, V.V. 1993. Coconut selection and breeding programme in Vietnam. **In: Advances in Coconut Research and Development**. (Eds. Nair *et al.*). Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, pp. 107-114.
- Louis, I.H. 1981. Genetic variability in coconut palm (*Cocos nucifera* L.). **Madras Agric. J.**, 38: 388-393.
- Louis, I.H. 1983. Genetic studies in Coconut (*Cocos nucifera* L.) **Ph.D. Thesis**, submitted to IARI, New Delhi.
- Louis, I.H. and N.R. Chandrasekharan. 1976. Effect of cultural, manurial and irrigation operations on coconut palm. **In: Abstracts of Paper presented in the International Symposium on Coconut Research and Development**, Kasaragod.
- Louis, I.H. and V.L. Chopra. 1993. Path analysis in coconut palm. **In: Advances in Coconut Research and Development**.(Eds. Nair *et al.*) Oxford and IBH publishing Co. Pvt. Ltd.,New Delhi. pp.121-122.
- Luke Rathna Kumar, A. 1989. Selection criteria on coconut palms (*Cocos nucifera* L.) based on juvenile characters. **M.Sc. Thesis**. Agricultural College and Research Institute. TNAU, Coimbatore-3.
- Luke Rathna Kumar, A., S.R. Sree Rangasamy and C.S. Sridharan. 1993. Genetic improvement of copra out turn in coconut palms. **South Indian Horticulture**, 41(1): 33-39.
- \*Luntungan, H.T. and D.V.Liyanage. 1978. Some results of the coconut breeding programme in Indonesia. **Pemberitaan-Lembuga penelitian Tanaman Industry**. 29: 13-22.

- Lush, J.H. 1940. Intra-Sire correlation and Regression of offspring on dams as a method of estimating heritability of characters. **Proc. Amer. Soc. Animal Prodn.**, **33**: 293-301.
- Manthriratna, W.A.P.B. 1973. Some results on field experimentation with Typica x Nana (F<sub>1</sub>) hybrids, copra and oil content. **Ceylon Cocon. Q.**, **24(3&4)**: 96-101.
- Mathew, T. and G. Gopimony. 1988. Influence of seed nut characters on seedling vigor in coconut. **In: Abstracts of papers presented in the National Symposium on Coconut Breeding and Management**, Nov. 23-26, Kerala p.13.
- Mathew, T., R. Gopimony and D. Gangadharan. 1984. Evaluation of superior mother palms of coconut by progeny analysis. **Agric. Res. J. Kerala**, **12(2)**: 186-190.
- \*Mendiola, N.B. 1926. A manual of Plant Breeding for the tropics. Manila: Bureau of Printing. 365 pp.
- Menon, K.P.V. and K.M. Pandalai. 1958. The Coconut Palm: A monograph, Indian Central Coconut Committee, Ernakulam, S. India.
- Meunier, J., A. Sangare, J. Saint and F.Bannot. 1984. Genetic analysis of yield characters in some hybrids of coconut (*Cocos nucifera* L.). **Oleagineux**. **39(12)**: 581-586.
- \*Muluk, C. 1987. Variation and heritability of vegetative characters, yield components and growth parameters in oil palm. **Buletin Perkebunan**, **18(3)**: 97,101-112.
- Nair, M.K. and K.V.K. Nampoothiri. 1993. Breeding for high yield in coconut. **In: Advances in Coconut Research and Development** (Eds. Nair *et al.*, Oxford and IBH Co. Pvt. Ltd. pp.61-70.
- Nambiar, M.C. and K.P.P. Nambiar. 1970. Genetic analysis of yield attributes in *Cocos nucifera* var. West Coast Tall. **Euphytica**, **19**: 543-51.
- Nambiar, M.C., J.Mathew and Sumangalakutty. 1970. Inheritance of nut production in coconut. **Indian J.Genet.**,**30**:599-603.
- Nampoothiri, K.U.K., K. Satyabalan and J.Mathew. 1975. Phenotypic and genotypic correlations of certain characters with yield in coconut. **FAO. Tech. Wkg. Pty. Cocon. Prod. Prot. and Processing**, Kingstom, Jamaika.
- Ngsiewkee and Edward Chan. 1976. Potential of Hybrid coconuts in Malaysia. Early results of progeny trials. **Proc. East Malaysian Plrs. Assn. Cocoa – Cocon Sem.**, Taiwan, Sabah, Malaysia.

- Ninan, C., A.S. Pankajakshan, K. Satyabalan and P. Gopinath. 1961. A comparison of the performance of some cultivars of coconuts in the Central Coconut Research station, Kasaragod and Agricultural Research Station, Neelestiwar (Pilicode). **Indian Coconut Journal**, 15(1): 12-19.
- Ninan, C.A. and A.S. Pankajakshan. 1961. Progeny studies in coconuts. 1. Relationship between parent yield and seedling characters of progeny with special reference to open pollinated and hybrid progenies of West Coast Tall and its bearing on the concept of prepotent in coconuts. **Indian Coconut Journal**, 14: 100-109.
- Ninan, C.A., A.S. Pankajakshan and K.M. Abdu. 1964. Some observations on growth rate and vigour of coconut seedlings. **Indian Coconut Journal**, 18: 12-17.
- Okwuagwo, C.O. and G.C.C. Tai. 1995. Estimation of variance components and heritability of bunch yield and yield components in the oil palm. **Plant Breeding**, 114(5): 464-465.
- \*Pamin, K. and D. Asmono. 1993. Path analysis of oil production and its components in coconut. **Bulletin Pusat Penelitian and its Components in Coconut**. 1(2): 189-187.
- Pankajakshan, A.S. and Minnie George. 1961. Character association studies in coconut seedlings. **Indian Coconut Journal**, 14: 67-70.
- Panse, V.G. 1957. Genetics of quantitative characters in relation to plant breeding. **Indian J. Genet. and Pl. Breed.**, 19: 318-328.
- Panse, V.G. and P.V. Sukhatme. 1961. Statistical methods for agricultural workers. ICAR. New Delhi. p: 381.
- Patel, J.S. 1937. Coconut Breeding. **Proc. Assoc. Econ. Bio.**, 5: 1-6.
- Patel, J.S. 1938. The coconut: A monograph. Madras Government Press, 313 p.
- Patil, J.L., P.M.Haldankar, B.M. Jamadagni and P. Rethinam. 1991. Stability in nut yield in coconut (*Cocos nucifera* L.). **J. Plantation crops**, 19(1): 37-40.
- Patil, J.L., P.M. Haldankar, B.M. Jamadagni and M.J. Salvi. 1993a. Inflorescence characters and yield in coconut. **Journal of Maharashtra Agricultural University**, 18(2): 303-304.

- Patil, J.L., P.M. Haldankar, B.M. Jamadagni and M.J. Salvi. 1993b. Variability and correlation studies for nut characters in Coconut. **Journal of Maharashtra Agricultural University, 18(3):** 361-364.
- Phillis, E. 1946. An out line for a coconut selection scheme. **Proc. Agric. Soc. Trin. Tab. 46:** 155-159.
- Pieries, W.V.D. 1934. Studies on coconut palm. **Tropical Agriculturist, 82:** 75-97.
- \*Pieries, W.V.D. 1941. Yield recording and the issue of planting material by the coconut research scheme. **Ceylon Coconut Res. Sch. Leaflet. No :11,** 6 pp.
- Pieries, W.V.D. 1960. Coconut Production, Research and Extension in India. (F.A.O. Report).
- Pillai, R.V., E.V.V.B. Rao and P.M. Kumaran, 1991. Characterisation of coconut cultivars. **In: Coconut Breeding and Management. KAU. Vellanikkara, Trichur, India.**pp.78-82.
- Potty, N.N., B.J. Nair, L.Rajamony and P.R. Nambiar.1980 Comparative performance of eight coconut varieties in red loam soil. **Indian Coconut Journal, 11(15):** 1-2.
- Raghavan, T.S. 1948. Further notes on seedling selection. **Ceylon Coconut Res. Sch. Leaflet. NO. 14:** 3 pp.
- Rajamony, L., K. Kannan and P.C. Balakrishnan. 1983. Comparative performance of coconut hybrids in the laterite soil under rainfed conditions- A preliminary study. **Indian Coconut Journal , December :** 7-11.
- Ramachandran, M., A.N. Venkateswaran, C.S. Sridharan and K. Balasubramanian. 1974. Performance of different hybrids- A preliminary study. **Cocon. Bull. 4:** 2-7.
- Ramachandran, T.K., T.S. Raveendran, T. Ramanathan and I.H.Louis. 1990. VHC-2. A new TxD hybrid Coconut, for Tamil Nadu. **Madras Agric. J., 77(5&6):** 211-216.
- Ramanathan, T. 1984. Character association in coconut. **Madras Agric. J., 71(3):** 191-192.
- Ramanathan, T. and I.H. Louis. 1983. Heterosis in coconut. **In: Pre-congress Scientific Meeting on Genetics and Improvement of Heterotic systems. TNAU, Coimbatore – 641 003.**

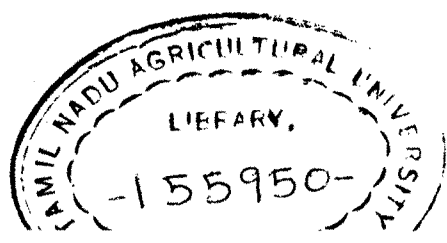
- Ramanathan, T. and T.K. Ramachandran. 1993. Evaluation of VHC -1 coconut hybrid in farmers field. **Indian Coconut Journal**, September : 10-14.
- Ramanathan, T., I. H. Louis and A.N. Venkateswaran. 1982. Genetic diversity and exploitation of heterosis in coconut. **In: Abstracts of paper presented in the 5<sup>th</sup> Ann. Symp. on Plant. Crops.** 15-18. December. pp: 20-21.
- Ramanathan, T., S. Thangavelu, C.S. Sridharan and S. Alarmelu. 1992. Performance of coconut cultivars and hybrids under semi dry conditions. **Indian Coconut Journal**, October : 9-11.
- Raveendra, T.S., T. Ramanathan, G. Nallathambi and H. Vijayaraghavan. 1987. Metroglyph analysis in coconut (*Cocos nucifera* L.). **Cocos.**, 5: 32-38.
- Sampson, H.C. 1923. The coconut palm. London. John Bale. Sons and Danieleson. pp. 262.
- Sangare, A., M. De. Lamothe, D.E. Nuce, and J.P . Saint. 1983. Promising hybrid coconuts. **Oleagineux**, 38 (8/9): 481-491.
- Santos, C.A., S.B. Cano, and M.C. Ilagan. 1981. Variability of nut components and copra recovery in various coconut population. **Philippines J. Coconut Studies**, 6(1): 34-39.
- Satyabalan, K. 1972. Fiji contributors report on coconut breeding. Effects of some breeding procedures. **Indian Coconut Journal**, 17: 155-164.
- Satyabalan, K. 1993. Yield variation in West Coast Tall coconut palms. **Indian Coconut Journal**, December : 5-8.
- Satyabalan, K. and J. Mathew. 1976. Identification of prepotent palms in West Coast Tall variety of coconuts based on growth of progeny in the nursery. **In: Paper presented at International Symposium on Coconut Research and Development**, Dec. 28-31. Kasaragod, Kerala.
- Satyabalan, K. and K. Rajagopal. 1983. The Malayan Dwarf coconut, **Indian Coconut Journal**, 13(2): 11-12.
- Satyabalan, K. and K. Rajagopal. 1985. Genetic improvement of the coconut palms prepotency studies. **J. Plantation Crops**. 13(2): 125-131.

- Satyabalan, K., Nampoothiri, K.V.K. and J. Mathew. 1975. Identification of prepotent West Coast Tall Palms based on progeny performance. **In: Abstracts of Paper presented in the IV Session. FAO Technical Working Party on Coconut Production and Processing, Kingstom, Jamaica, 14-25. September. Rome.**
- Satyabalan, K., T.C. Ratnam and P.V. Kunjan. 1970. Hybrid vigour in nut and copra characters of coconut hybrids. **Indian J. Agric. Sci., 40(12): 1088-1093.**
- Satyabalan, S., M.V. George and V. Radhakrishnan. 1964. Coconut breeding. A comparative study of Tall x Dwarf, Tall x Gangabondam and Tall x Tall seedlings in the nursery for maximum expression of vigour. **Indian Coconut Journal, 17: 155-164.**
- Shanthamallaiiah, N.R., T.N.V. Gowda, R.K. Manohar, and P. Balakrishnan. 1981. Growth and yield performance of coconut germplasm collection at Agricultural Research Station. Assikera (Karnataka). **In: Genetics, Plant breeding and Horticulture proceedings of the 4<sup>th</sup> annual symposium on plantation crops. Mysore. 3-5, Dec.**
- Snedecor, G.W. and W.G. Cochran. 1967. The Statistical Methods, Sixth Edn. The IOWA State College Press. Amer. IOWA, Oxford and IBH. Pub. Co., New Delhi.
- Sukumaran, C.K., G. Narasimhaya and G. Vijayakumar. 1981. Path coefficient analysis in coconut. **In: Genetics, Plant Breeding and Horticulture proceedings of the fourth annual symposium on plantation crops, Mysore, 3-5 Dec.**
- Sundaram, S. 1975. Coconut varietal improvement: Selection and breeding, Part 1, World Review, Fiji, **Agricultural Journal, 37: 41-46.**
- Swarup, V. and D.S. Chaugale. 1962. Studies on genetic variability in sorghum. Phenotypic variation and its heritable components in some plant quantitative characters contributing towards yield. **Indian J. Genet., 22: 31-36.**
- Thampan, P.K. 1970. Hybrid palm. **Cocon. Bull., 1: 3-5.**
- Umali, D.L. 1940. A seed of coconut seed selection for germination. **Philipp. Agric., 29: 296-312.**
- Vijayaraghavan, H., T.S. Raveendran and T.K. Ramachandran. 1993. Season variation in the production of spathes in certain coconut hybrids and their parents. **Indian Coconut Journal, April: 9-11.**
- Wright, S. 1921. Correlation and causation. **J. Agric. Res., 20: 557-585.**

Wuidart, W. 1979. Production of coconut planting materials, selection in the seed bed. **Oleagineux**, 34: 8-9.

Yukio Sugimura, H.I., D.S. Christine and H. Yamaguchi. 1997. Biometric analysis on diversity of coconut palm: cultivar classification by botanical and agronomical traits. **Euphytica**, 98: 29-35.

\* Originals not seen.



# *Appendices*

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Appendix 1(a) Mean performance of coconut seedlings at sixth month

S.No.	Variety/ Ecotype	% germination	Days to germination	Plant height (cm)	Collar girth (cm)	Number embryonic leaves	Length of first embryonic leaf (cm)	Width of first embryonic leaf (cm)	Length of second embryonic leaf (cm)	Width of second embryonic leaf (cm)	Length of petiole in first laminate leaf (cm)	Length of first laminate leaf (cm)	Width of first laminate leaf (cm)	Number of roots	Number of leaves
1.	Andaman Ordinary	85.97	102.03	65.83	7.33	2.22	5.63	2.50	8.13	2.35	8.87	9.97	8.27	10.33	4.07
2.	Laccadive Ordinary	96.90	108.20	53.77	6.00	2.09	5.27	2.67	6.94	2.60	8.40	9.87	7.33	8.20	3.77
3.	Philippines Ordinary	89.77	91.20	59.77	6.80	2.22	4.70	2.70	7.36	2.49	7.03	9.23	6.60	8.70	4.00
4.	East Coast Tall	87.47	113.13	43.87	5.81	2.30	4.93	2.43	7.62	2.37	8.20	9.37	6.87	7.47	3.13
5.	West Coast Tall	82.83	118.73	42.00	5.87	1.73	4.50	2.46	6.42	2.28	6.33	8.63	6.07	7.33	3.60
6.	Strait Settlement Green	88.10	110.43	49.47	6.90	2.09	4.63	2.58	7.06	2.32	7.43	7.27	6.23	8.77	3.92
7.	Chowghat Orange Dwarf	86.90	92.60	45.73	5.01	2.05	5.27	2.48	5.14	2.91	7.20	6.37	5.13	9.33	3.90
8.	MDY x WCT	89.97	98.37	52.03	6.83	2.26	5.23	2.77	5.03	2.30	7.13	6.47	4.90	9.17	4.20
9.	WCT x MDY	91.90	102.07	55.70	7.80	2.31	6.33	2.50	6.93	2.70	7.97	7.37	7.50	10.13	4.47
10.	WCT x Gangabondam	85.00	111.90	49.07	7.67	2.12	5.70	2.97	6.09	2.42	7.03	6.77	5.03	9.80	4.10
	Grand Mean	88.47	104.87	51.72	6.60	2.14	5.22	2.59	6.67	2.47	7.56	8.13	6.39	8.92	3.91
	SEd	0.610	6.15	0.69	0.27	0.101	0.197	0.131	0.169	0.03	0.28	0.377	0.219	0.345	0.144
	CD(P=0.05)	1.282	12.91	1.45	0.56	0.211	0.413	0.276	0.355	0.059	0.58	0.792	0.460	0.725	0.303

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Appendix I(a) (Contd....) Mean performance of coconut seedlings at eighth month

S.No.	Variety/ Ecotype	% germination	Days to germination	Plant height (cm)	Collar girth (cm)	Number embryonic leaves	Length of first embryonic leaf (cm)	Width of first embryonic leaf (cm)	Length of second embryonic leaf (cm)	Width of second embryonic leaf (cm)	Length of petiole in first laminate leaf (cm)	Length of first laminate leaf (cm)	Width of first laminate leaf (cm)	Number of roots	Number of leaves
1.	Andaman Ordinary	98.07	112.80	103.13	8.53	2.38	7.50	3.23	8.94	2.23	10.67	9.93	9.10	12.30	5.33
2.	Laccadive Ordinary	96.90	108.20	92.27	9.43	2.22	6.07	2.53	7.87	2.18	9.17	10.37	8.70	10.73	4.97
3.	Philippines Ordinary	94.87	98.93	95.80	10.23	2.10	5.33	2.13	7.60	2.42	10.30	9.90	7.80	11.53	4.90
4.	East Coast Tall	89.73	117.43	80.20	6.37	2.18	6.13	2.37	7.40	2.25	10.13	9.70	8.51	10.00	5.03
5.	West Coast Tall	86.40	119.23	74.73	8.97	2.11	5.13	2.33	7.03	2.06	9.67	10.10	8.03	9.60	4.23
6.	Strait Settlement Green	91.93	118.43	94.73	9.40	2.08	5.83	2.58	7.23	2.00	8.77	10.33	9.77	10.37	4.93
7.	Chowghat Orange Dwarf	85.93	93.27	60.10	6.90	2.23	5.20	2.63	6.53	2.43	6.20	6.83	7.07	10.67	5.00
8.	MDY x WCT	93.10	101.57	73.67	9.23	2.02	6.07	2.57	6.08	2.37	6.43	8.43	7.47	10.83	5.03
9.	WCT x MDY	96.93	105.90	92.83	10.13	2.07	7.40	2.87	6.37	2.77	7.33	9.43	8.23	13.03	5.73
10.	WCT x Gangabondam	86.93	113.13	95.20	10.50	2.09	6.63	2.50	6.22	2.53	6.70	8.30	7.50	11.67	5.08
	Grand Mean	92.11	108.89	86.25	8.97	2.17	6.13	2.57	7.13	2.32	8.54	9.33	8.22	11.07	5.02
	SEd	1.184	5.145	3.855	0.513	0.045	0.213	0.203	0.087	0.068	0.295	0.352	0.293	0.360	0.207
	CD(P=0.05)	2.487	10.809	8.099	1.079	0.094	0.447	0.427	0.184	0.143	0.620	0.739	0.616	0.756	0.435

Appendix 1(a) (Contd...) Mean performance of coconut seedlings at tenth month

S.No.	Variety/ Ecotype	% germination	Days to germination	Plant height (cm)	Collar girth (cm)	Number embry- onic leaves	Length of first embry- onic leaf (cm)	Width of first embry- onic leaf (cm)	Length of second embry- onic leaf (cm)	Width of second embry- onic leaf (cm)	Length of petiole in first laminated leaf (cm)	Length of first laminated leaf (cm)	Width of first laminated leaf (cm)	Number of roots	Number of leaves
1.	Andaman Ordinary	99.80	115.80	127.73	11.27	2.22	9.03	2.93	9.00	2.70	11.47	10.90	10.47	14.07	6.57
2.	Laccadive Ordinary	96.90	108.20	119.70	10.37	2.07	8.00	2.60	8.23	2.52	10.93	11.23	9.08	12.80	5.47
3.	Philippines Ordinary	98.50	98.93	124.83	12.20	2.05	7.30	2.20	7.73	2.60	10.50	10.67	9.67	13.20	6.07
4.	East Coast Tall	94.60	119.87	103.37	10.07	2.08	7.13	2.13	7.63	2.37	10.07	11.93	9.37	11.47	5.97
5.	West Coast Tall	96.70	118.53	99.70	9.63	2.19	6.08	2.43	7.43	2.30	9.28	6.87	8.31	11.73	5.33
6.	Strait Settlement Green	97.50	118.60	121.17	10.80	2.17	6.47	3.00	7.22	2.48	9.90	10.23	8.63	11.53	5.80
7.	Chowghat Orange Dwarf	96.20	99.47	83.33	9.40	2.22	5.87	2.70	6.50	2.30	6.77	8.17	7.10	12.73	5.57
8.	MDY x WCT	95.23	97.57	106.27	10.60	2.08	6.43	2.40	6.47	2.65	9.47	8.50	8.00	13.07	5.90
9.	WCT x MDY	99.66	106.07	114.87	12.53	2.20	8.87	2.77	8.10	2.46	11.27	12.07	9.90	14.97	6.20
10.	WCT x Gangabondam	93.80	118.93	119.33	12.73	2.08	7.40	2.23	7.58	2.30	9.70	10.30	8.93	14.03	6.11
	Grand Mean	96.79	110.20	112.03	10.96	2.11	7.26	2.54	7.59	2.47	9.93	10.09	8.94	12.96	5.90
	SEd	0.967	4.814	0.221	0.434	0.046	0.335	0.212	0.139	0.041	0.380	0.301	0.271	0.386	0.188
	CD(P=0.05)	2.032	10.113	0.464	0.911	0.133	0.703	0.444	0.291	0.087	0.797	0.631	0.570	0.810	0.394

Appendix 1(b). Analysis of variance for the seedling characters at sixth month

S. No.	Characters	Mean	Range	CV%	Mean squares	'F' value
1.	Per cent germination	88.47	82.83-96.90	1.06	47.15	84.45**
2.	Days to germination	104.87	91.20-118.73	7.18	249.19	4.40**
3.	Seedling height (cm)	51.72	42.00-65.83	1.63	162.72	228.49**
4.	Collar girth (cm)	6.60	5.80-7.80	4.93	2.47	23.30**
5.	Number of embryonic leaves	2.14	1.73-2.31	5.76	0.087	5.71**
6.	Length of first embryonic leaf (cm)	5.22	4.50-6.33	4.62	0.953	16.43**
7.	Width of first embryonic leaf (cm)	2.59	2.43-2.99	6.20	0.095	3.67**
8.	Length of second embryonic leaf (cm)	6.67	5.03-8.13	3.10	3.074	71.81**
9.	Width of second embryonic leaf (cm)	2.47	2.28-2.91	1.38	0.126	108.81**
10.	Length of petiole in the first laminate leaf (cm)	7.56	6.33-8.87	4.48	1.791	15.65**
11.	Length of first laminate leaf (cm)	8.13	6.37-9.97	5.68	6.151	28.87**
12.	Width of first laminate leaf (cm)	6.39	4.90-8.27	4.19	3.89	54.18**
13.	Number of roots	8.92	7.33-10.33	4.74	3.232	18.08**
14.	Number of leaves	3.91	3.13-4.47	4.52	0.394	12.63**

\*\* Significant at 1 % level

Appendix 1(b) (Contd...) Analysis of variance for the seedling characters at eighth month

S. No.	Characters	Mean	Range	CV%	Mean squares	'F' value
1.	Per cent germination	92.11	85.93-98.07	1.96	93.99	44.72**
2.	Days to germination	108.89	93.27-119.23	5.79	236.87	5.97**
3.	Seedling height (cm)	86.25	60.13-103.13	5.47	538.82	24.17**
4.	Collar girth (cm)	8.97	6.37-10.50	7.01	5.67	14.35**
5.	Number of embryonic leaves	2.17	2.01-2.38	2.52	0.03	11.17**
6.	Length of first embryonic leaf (cm)	6.13	5.13-7.50	4.26	2.11	31.02**
7.	Width of first embryonic leaf (cm)	2.57	2.13-3.23	9.69	0.28	4.45**
8.	Length of second embryonic leaf (cm)	7.13	6.08-8.94	1.50	2.34	204.16**
9.	Width of second embryonic leaf (cm)	2.32	2.00-2.77	3.59	0.17	23.87**
10.	Length of petiole in the first laminate leaf (cm)	8.54	6.20-10.67	4.23	8.88	67.93**
11.	Length of first laminate leaf (cm)	9.33	6.83-10.37	4.61	3.87	20.87**
12.	Width of first laminate leaf (cm)	8.22	7.06-9.77	4.37	2.03	15.78**
13.	Number of roots	11.07	9.60-13.03	3.98	3.36	17.29**
14.	Number of leaves	5.02	4.23-5.73	5.06	0.42	6.49**

\*\* Significant at 1 % level

Appendix 1(b) (Contd...) Analysis of variance for the seedling characters at tenth month

S. No.	Characters	Mean	Range	CV%	Mean squares	'F' value
1.	Per cent germination	96.79	93.80-99.80	1.47	51.28	36.53**
2.	Days to germination	110.20	97.57-119.87	5.35	254.64	7.33**
3.	Seedling height (cm)	112.03	83.33-127.73	0.24	566.00	7722.13**
4.	Collar girth (cm)	10.96	9.40-12.73	04.85	4.25	15.07**
5.	Number of embryonic leaves	2.11	1.99-2.22	2.68	0.02	7.05**
6.	Length of first embryonic leaf (cm)	7.26	5.87-9.03	5.65	3.66	21.79**
7.	Width of first embryonic leaf (cm)	2.54	2.13-3.00	10.20	0.28	4.24**
8.	Length of second embryonic leaf (cm)	7.59	6.47-9.00	2.24	1.76	61.10**
9.	Width of second embryonic leaf (cm)	2.47	2.30-2.70	2.05	0.07	26.47**
10.	Length of petiole in the first laminate leaf (cm)	9.93	6.77-11.47	9.68	5.44	25.16**
11.	Length of first laminate leaf (cm)	10.09	6.87-12.07	3.65	8.76	64.68**
12.	Width of first laminate leaf (cm)	8.94	7.10-10.47	3.72	2.91	26.42**
13.	Number of roots	12.96	11.47-14.96	3.64	4.11	18.41**
14.	Number of leaves	5.90	5.33-6.57	3.90	0.41	7.80**

\*\* Significant at 1 % level

Appendix 1(c). Components of variance, heritability, genetic advance and genetic advance as per cent of mean in coconut seedlings at the sixth month

S.No.	Characters	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability	Genetic advance	Genetic advance as per cent mean
1.	Per cent germination	15.55	16.12	5.59	5.69	96.51	7.99	11.31
2.	Days to germination	64.17	120.84	7.64	10.48	58.10	12.02	11.47
3.	Seedling height (cm)	54.00	54.72	14.21	14.30	98.01	14.94	20.08
4.	Collar girth (cm)	0.79	0.89	13.44	14.31	88.14	1.71	25.99
5.	Number of embryonic leaves	0.02	0.04	7.21	9.23	61.07	0.25	11.61
6.	Length of first embryonic leaf (cm)	0.30	0.36	10.47	11.44	83.72	1.03	19.73
7.	Width of first embryonic leaf (cm)	0.02	0.05	5.83	8.52	46.97	0.21	8.24
8.	Length of second embryonic leaf (cm)	1.01	1.05	15.07	15.38	95.94	2.03	30.38
9.	Width of second embryonic leaf (cm)	0.04	0.05	8.26	8.37	97.29	0.43	16.78
10.	Length of petiole in the first laminate leaf (cm)	0.56	0.67	9.89	10.86	83.00	1.40	18.56
11.	Length of first laminate leaf (cm)	1.98	2.19	17.30	18.21	90.28	2.75	33.87
12.	Width of first laminate leaf (cm)	1.27	1.35	17.65	18.15	94.66	2.26	35.89
13.	Number of roots	1.02	1.20	11.31	12.26	85.06	1.93	21.47
14.	Number of leaves	0.12	0.15	8.89	9.97	79.49	0.64	16.32

Appendix 1(c) (Contd...). Components of variance, heritability, genetic advance and genetic advance as per cent of mean in coconut seedlings at the eighth month

S.No.	Characters	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability	Genetic advance	Genetic advance as per cent mean
1.	Per cent germination	30.63	32.73	7.47	7.72	93.58	11.03	14.89
2.	Days to germination	65.72	105.42	7.45	9.43	62.34	13.18	12.11
3.	Seedling height (cm)	172.18	194.47	15.21	16.17	88.54	25.43	29.49
4.	Collar girth (cm)	1.76	2.15	14.78	13.36	81.65	2.47	27.52
5.	Number of embryonic leaves	0.01	0.05	4.65	5.29	77.23	0.35	8.42
6.	Length of first embryonic leaf (cm)	0.68	0.75	13.46	14.12	90.91	1.63	26.44
7.	Width of first embryonic leaf (cm)	0.07	0.13	10.39	14.21	58.49	0.40	15.65
8.	Length of second embryonic leaf (cm)	0.78	0.79	12.35	12.44	96.54	1.77	25.25
9.	Width of second embryonic leaf (cm)	0.05	0.06	9.90	10.53	88.41	0.46	19.17
10.	Length of petiole in the first laminate leaf (cm)	2.92	3.05	20.00	20.44	95.71	3.45	40.31
11.	Length of first laminate leaf (cm)	1.23	1.41	11.87	12.74	86.88	2.13	22.80
12.	Width of first laminate leaf (cm)	0.64	0.76	9.70	10.64	83.13	1.49	18.22
13.	Number of roots	1.05	1.25	9.27	10.09	84.46	1.95	17.55
14.	Number of leaves	0.12	0.18	6.84	8.50	64.65	0.56	11.32

Appendix 1(c) (Contd...). Components of variance, heritability, genetic advance and genetic advance as per cent of mean in coconut seedlings at the tenth month

S.No.	Characters	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation	Phenotypic coefficient of variation	Heritability	Genetic advance	Genetic advance as per cent mean
1.	Per cent germination	16.63	18.03	5.05	5.26	92.22	8.07	10.10
2.	Days to germination	73.29	108.05	7.77	9.43	67.83	14.51	13.18
3.	Seedling height (cm)	188.64	188.72	12.26	12.26	97.60	27.63	25.25
4.	Collar girth (cm)	1.32	1.61	10.49	11.55	82.43	2.16	19.63
5.	Number of embryonic leaves	0.006	0.010	3.81	4.65	66.86	0.14	6.41
6.	Length of first embryonic leaf (cm)	1.17	1.33	14.87	15.91	87.39	2.07	28.64
7.	Width of first embryonic leaf (cm)	0.07	0.14	10.59	14.70	59.91	0.40	15.72
8.	Length of second embryonic leaf (cm)	0.58	0.61	10.01	10.26	92.25	1.48	20.13
9.	Width of second embryonic leaf (cm)	0.02	0.03	5.96	6.30	89.46	0.32	11.61
10.	Length of petiole in the first laminate leaf (cm)	1.74	1.96	13.29	14.09	88.85	2.56	25.82
11.	Length of first laminate leaf (cm)	2.88	3.01	16.81	17.20	95.50	3.42	33.84
12.	Width of first laminate leaf (cm)	0.93	1.04	10.82	11.44	89.44	1.88	21.07
13.	Number of roots	1.29	1.58	8.78	9.51	85.30	2.21	16.70
14.	Number of leaves	0.12	0.17	5.87	7.05	69.39	0.59	10.07

Appendix 1(d). Genotypic, phenotypic and environmental correlation coefficients of coconut seedlings at sixth month

	% germination	Days to germination	Seedling height (cm)	Collar girth (cm)	Number embryonic leaves	Length of first embryonic leaf (cm)	Width of first embryonic leaf (cm)	Length of second embryonic leaf (cm)	Width of second embryonic leaf (cm)	Length of petiole in first laminated leaf (cm)	Length of first laminated leaf (cm)	Width of first laminated leaf (cm)	Number of roots	Number of leaves
1.	G	-0.277	0.321	0.017	0.381*	0.252	0.166	0.094	0.346	0.476**	0.263	0.361*	-0.010	0.182
	P	-0.138	0.305	-0.010	0.315	0.235	0.123	0.081	0.348	0.447*	0.257	0.337	-0.011	0.137
	E	0.474**	-0.400*	-0.390*	0.189	0.119	0.082	-0.260	0.389*	0.270	0.189	-0.191	-0.027	-0.270
2.	G		-0.582**	0.050	-0.627**	-0.277	-0.054	0.258	-0.607**	-0.100	0.237	0.110	-0.579**	-0.581**
	P		-0.443*	-0.057	-0.263	-0.135	-0.097	0.182	-0.449*	0.007	0.140	0.001	-0.390*	-0.404*
	E		-0.282	-0.387*	0.220	0.179	-0.141	-0.019	-0.113	0.211	-0.112	-0.492**	-0.003	-0.088
3.	G			0.594**	0.545**	0.430*	0.226	0.478**	0.002	0.572**	0.396*	0.599**	0.658**	0.592**
	P			0.565**	0.397*	0.366*	0.159	0.470**	-0.004	0.511**	0.358	0.587**	0.606**	0.527**
	E			0.292	-0.360*	-0.528**	0.056	0.192	-0.291	-0.142	-0.420*	0.322	0.069	0.050
4.	G				0.540**	0.592**	0.592**	0.288	-0.309	0.194	-0.092	0.239	0.669**	0.739**
	P				0.273	0.478**	0.386*	0.276	-0.286	0.142	-0.082	0.235	0.613**	0.589**
	E				-0.576**	-0.222	0.019	0.158	0.004	-0.169	0.001	0.217	0.255	-0.187
5.	G					0.529**	0.208	0.254	0.145	0.670**	0.003	0.298	0.522**	0.264
	P					0.475**	0.197	0.184	0.082	0.400*	-0.012	0.183	0.329	0.293
	E					0.383*	0.188	-0.086	-0.294	-0.298	-0.074	-0.298	-0.197	0.386**
6.	G						0.252	-0.024	0.453*	0.492**	-0.229	0.268	0.842**	0.633**
	P						0.128	-0.042	0.411*	0.408*	-0.187	0.198	0.676**	0.620**
	E						-0.104	-0.256	0.029	-0.015	0.101	-0.440*	-0.219	0.479**
7.	G							-0.337	-0.230	-0.249	-0.279	-0.494**	0.350	0.466**
	P							-0.222	-0.127	-0.178	-0.245	-0.338	0.218	0.320
	E							0.030	0.234	-0.073	-0.276	-0.053	-0.012	0.107
8.	G								-0.298	0.630**	0.848**	0.884**	-0.060	-0.271
	P								-0.301	0.572**	0.754**	0.845**	-0.062	-0.228
	E								-0.407*	0.123	-0.558*	0.044	-0.104	0.104
9.	G									0.101	-0.270	-0.028	0.308	0.272
	P									0.120	-0.238	-0.019	0.294	0.228
	E									0.429*	0.292	0.220	0.215	-0.155
10.	G										0.571**	0.799**	0.300	-0.033
	P										0.469**	0.722**	0.301	-0.022
	E										-0.193	0.139	0.310	0.026
11.	G											0.814**	-0.361*	-0.454*
	P											0.742**	-0.319	-0.454**
	E											-0.143	-0.020	-0.490**
12.	G												0.086	-0.031
	P												0.118	-0.056
	E												0.280	-0.280
13.	G												0.453*	0.932**
	P													0.683**
	E													-0.476

\*\* Significant at 1% level

\* Significant at 5% level

Appendix I(d) (Contd...) Genotypic, phenotypic and environmental correlation coefficients of coconut seedlings at eighth month

	% germination	Days to germination	Seedling height (cm)	Collar girth (cm)	Number embryonic leaves	Length of first embryonic leaf (cm)	Width of first embryonic leaf (cm)	Length of second embryonic leaf (cm)	Width of second embryonic leaf (cm)	Length of petiole in first laminate leaf (cm)	Length of first laminate leaf (cm)	Width of first laminate leaf (cm)	Number of roots	Number of leaves
1.	G	-0.143	0.602**	0.253	0.344	0.555**	0.621**	0.582**	0.119	0.413	0.537**	0.530**	0.583**	0.628**
	P	-0.055	0.557**	0.253	0.250	0.545**	0.342	0.562**	0.090	0.393*	0.509**	0.428*	0.527**	0.477**
	E	-0.108	0.586**	0.253	0.309	0.552**	0.501**	0.575**	0.108	0.406*	0.527**	0.493**	0.563**	0.566**
2.	G		0.395**	0.045	0.027	0.241	0.128	0.298	-0.627**	0.406*	0.717**	0.751**	-0.372*	-0.276
	P		0.330	-0.050	-0.066	0.145	-0.122	0.251	-0.470**	0.411*	0.516**	0.515**	-0.213	-0.299
	E		0.368*	0.006	-0.012	0.202	0.012	0.278	-0.562**	0.477**	0.634**	0.652**	-0.307	-0.286
3.	G			0.617**	0.172	0.655**	0.307	0.538**	0.047	0.496**	0.676**	0.617**	0.616**	0.416*
	P			0.564**	0.183	0.541**	0.244	0.493**	0.053	0.443*	0.567**	0.591**	0.486**	0.348
	E			0.597**	0.176	0.614**	0.278	0.522**	0.049	0.477**	0.636**	0.607**	0.568**	0.388*
4.	G				-0.422*	0.247	-0.047	-0.169	0.275	-0.107	0.285	0.022	0.514**	0.120
	P				-0.310	0.201	-0.086	-0.169	0.245	-0.124	0.261	0.054	0.438*	0.145
	E				-0.378*	0.230	-0.063	-0.169	0.264	-0.113	0.276	0.034	0.485**	0.130
5.	G					0.084	0.361*	0.892**	-0.306	0.663**	0.204	0.205	0.054	-0.044
	P					0.044	0.323	0.760**	-0.195	0.557**	0.139	0.205	0.071	-0.062
	E					0.069	0.343	0.842**	-0.264	0.623**	0.179	0.205	0.061	-0.051
6.	G						0.915**	0.199	0.462*	0.009	0.135	0.360	0.812**	0.910**
	P						0.610**	0.250	0.407*	0.014	0.159	0.262	0.712**	0.654**
	E						0.781**	0.201	0.442*	0.011	0.144	0.324	0.775**	0.806**
7.	G							0.352	0.237	-0.089	-0.056	0.294	0.756**	0.707**
	P							0.251	0.150	-0.055	-0.103	0.301	0.400*	0.592**
	E							0.308	0.199	-0.075	-0.075	0.295	0.600**	0.653**
8.	G								-0.476**	0.863**	0.630**	0.656**	0.050	-0.004
	P								-0.453*	0.840**	0.587**	0.590**	0.056	-0.008
	E								-0.467**	0.855**	0.615**	0.632**	0.052	-0.006
9.	G									-0.532**	-0.523**	-0.581**	0.786**	0.779**
	P									-0.499**	-0.457*	-0.473**	0.701**	0.617**
	E									-0.520**	-0.495**	-0.541**	0.754**	0.713**
10.	G									0.831**	0.831**	0.636**	-0.149	-0.262
	P									0.754**	0.754**	0.528**	-0.130	-0.208
	E									0.803**	0.803**	0.597**	-0.142	-0.240
11.	G											0.845**	-0.061	-0.153
	P											0.681**	-0.089	-0.124
	E											0.784**	-0.071	-0.141
12.	G												-0.024	0.095
	P												-0.010	0.147
	E												-0.016	0.116
13.	G													0.957**
	P													0.684**
	E													0.845**

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

Appendix 1(d) (Contd....) Genotypic, phenotypic and environmental correlation coefficients of coconut seedlings at tenth month

	% germination	Days to germination	Plant height (cm)	Collar girth (cm)	Number embryonic leaves	Length of first embryonic leaf (cm)	Width of first embryonic leaf (cm)	Length of second embryonic leaf (cm)	Width of second embryonic leaf (cm)	Length of petiole in first laminate leaf (cm)	Length of first laminate leaf (cm)	Width of first laminate leaf (cm)	Number of roots	Number of leaves
1.		-0.134	0.484**	0.356	0.657**	0.721**	0.714**	0.683**	0.581**	0.594**	0.359	0.676**	0.542**	0.596**
	G	-0.078	0.466**	0.309	0.513**	0.651**	0.484	0.653**	0.497**	0.540**	0.344	0.630**	0.470**	0.451
	P	0.172	0.189	-0.012	-0.019	0.040	-0.054	0.214	-0.343	0.022	0.124	0.181	-0.105	-0.139
2.			0.238	0.016	-0.212	0.104	0.170	0.409*	-0.378**	0.273	0.161	0.342	-0.329	0.093
	G		0.196	-0.070	-0.121	0.121	-0.082	0.359	-0.324	0.205	0.154	0.222	-0.297	0.018
	P		0.013	-0.342	0.067	0.203	-0.467**	0.250	-0.157	-0.038	0.201	-0.238	-0.213	-0.146
3.				0.725**	-0.048	0.697**	0.179	0.706**	0.620**	0.872**	0.599**	0.804**	0.382*	0.622**
	G			0.658**	-0.038	0.651**	0.128	0.686**	0.589**	0.823**	0.584**	0.759**	0.352*	0.521**
	P			0.025	0.090	-0.079	-0.091	-0.468**	0.292	0.168	-0.182	-0.287	-0.094	0.258
4.					-0.072	0.674	-0.141	0.433*	0.252	0.587**	0.582**	0.651**	0.793**	0.739**
	G				0.032	0.502**	-0.021	0.354	0.223	0.543**	0.475**	0.571**	0.656**	0.606**
	P				0.355	-0.473**	0.245	-0.331	0.049	0.293	-0.471**	0.085	-0.057	0.203
5.						0.359	1.013**	0.165	0.252	-0.045	0.274	0.124	0.345	0.396*
	G					0.232	0.531**	0.122	0.194	0.013	0.231	0.081	0.214	0.350
	P					-0.209	-0.165	-0.074	-0.007	0.253	0.096	-0.082	-0.210	0.253
6.							0.283	0.905**	0.484**	0.874**	0.724**	0.918**	0.749**	0.769**
	G						0.203	0.836**	0.416*	0.786**	0.788**	0.810**	0.638**	0.603**
	P						0.052	0.137	-0.107	0.136	0.058	-0.011	-0.062	0.021
7.								0.288	0.302	0.148	0.065	0.058	0.098	0.151
	G							0.152	0.223	0.061	-0.014	0.067	0.232	0.077
	P							-0.335	0.078	-0.173	-0.408*	0.120	0.626**	-0.037
8.									0.374*	0.852**	0.627**	0.912**	0.429*	0.561**
	G								0.321	0.781**	0.625**	0.860**	0.356	0.452*
	P								-0.333	-0.048	0.576**	0.257	-0.368*	-0.038
9.										0.607**	0.292	0.512**	0.289	0.534**
	G									0.528**	0.250	0.415*	0.292	0.497**
	P									-0.122	-0.286	-0.409*	0.317	0.427*
10.											0.726**	0.951**	0.421*	0.618**
	G										0.687**	0.844**	0.333	0.474**
	P										0.257	-0.039	-0.266	-0.061
11.												0.775**	0.374*	0.647**
	G											0.722**	0.309	0.496**
	P											0.085	-0.355	-0.257
12.													0.474**	0.796**
	G												0.410	0.658**
	P												-0.026	0.172
13.													0.729	0.492**
	G													-0.324
	P													
	E													

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

Appendix 1(e). Multiple regression function of coconut seedlings at sixth month

S.No.	Characters	Regression coefficient (B)	SE of B	't' values
1.	Per cent germination	-0.011	0.018	0.627
2.	Days to germination	-0.007	0.005	1.345
3.	Seedling height (cm)	0.060**	0.014	4.410
4.	Collar girth (cm)	0.208	0.099	2.124
5.	Number of embryonic leaves	-0.108	0.281	0.383
6.	Length of first embryonic leaf (cm)	0.165	0.117	1.410
7.	Width of first embryonic leaf (cm)	0.024	0.212	0.114
8.	Length of second embryonic leaf (cm)	-0.148	0.117	1.265
9.	Width of second embryonic leaf (cm)	0.435	0.402	1.082
10.	Length of petiole in the first laminate leaf (cm)	-0.055	0.086	0.637
11.	Length of first laminate leaf (cm)	-0.206**	0.055	3.718
12.	Width of first laminate leaf (cm)	0.096	0.093	1.027
13.	Number of roots	-0.115	0.098	1.176

\*\* Significant at 1 % level

Appendix 1(e) (Contd...). Multiple regression function of coconut seedlings at eighth month

S.No.	Characters	Regression coefficient (B)	SE of B	't' values
1.	Per cent germination	0.003	0.017	0.193
2.	Days to germination	-0.015	0.007	1.959
3.	Seedling height (cm)	0.204**	0.073	2.779
4.	Collar girth (cm)	-0.084	0.089	0.949
5.	Number of embryonic leaves	-1.824	0.914	1.995
6.	Length of first embryonic leaf (cm)	0.009	0.133	0.070
7.	Width of first embryonic leaf (cm)	0.328	0.224	1.463
8.	Length of second embryonic leaf (cm)	0.124	0.231	0.535
9.	Width of second embryonic leaf (cm)	0.852	0.550	1.550
10.	Length of petiole in the first laminate leaf (cm)	-0.006	0.084	0.067
11.	Length of first laminate leaf (cm)	-0.013	0.132	0.098
12.	Width of first laminate leaf (cm)	0.160	0.123	1.298
13.	Number of roots	0.065	0.115	0.569

\*\* Significant at 1 % level

Appendix 1(e) (Contd...). Multiple regression function of coconut seedlings at tenth month

S.No.	Characters	Regression coefficient (B)	SE of B	't' values
1.	Per cent germination	-0.035	0.023	1.494
2.	Days to germination	-0.002	0.009	0.178
3.	Seedling height (cm)	2.059**	0.768	2.682
4.	Collar girth (cm)	0.113	0.069	1.640
5.	Number of embryonic leaves	0.006	0.007	1.040
6.	Length of first embryonic leaf (cm)	0.161	0.126	1.273
7.	Width of first embryonic leaf (cm)	-0.169	0.169	1.002
8.	Length of second embryonic leaf (cm)	-0.151	0.168	0.898
9.	Width of second embryonic leaf (cm)	1.198**	0.554	2.163
10.	Length of petiole in the first laminate leaf (cm)	-0.134	0.079	1.701
11.	Length of first laminate leaf (cm)	-0.058	0.056	1.019
12.	Width of first laminate leaf (cm)	0.366**	0.133	2.745
13.	Number of roots	-0.013	0.073	0.173

\*\* Significant at 1 % level

## Weather data for the experimental period

Month	Maximum Average Temperature	Minimum Average Temperature	Average RH		Total Rainfall (mm)	No. of rainy days
			Maximum	Minimum		
1997						
January	29.3	18.9	85	45	2.0	-
February	32.4	18.3	79	32	-	-
March	34.9	21.2	82	30	10.5	2
April	34.4	22.2	80	38	29.5	3
May	34.7	23.5	81	44	54.0	3
June	33.8	23.4	77	44	17	2
July	29.4	22.8	80	61	121.5	11
August	30.7	22.6	78	54	24.5	5
September	32.9	22.5	80	45	16.5	3
October	31.3	22.4	85	54	259	15
November	29.4	22.1	91	67	299.1	19
December	28.9	21.8	90	62	37.3	8
1998						
January	30.1	20.2	87	47	-	-
February	32.8	20.5	85	40	-	-
March	35.5	22.0	82	80	-	-
April	36.6	24.8	80	39	96.0	4
May	35.5	24.8	81	46	52.5	3
June	32.7	24.2	71	56	57.8	6
July	30.8	23.3	80	56	51.5	6
August	31.4	22.9	85	60	254	5
September	30.8	22.6	83	58	170.5	4
October	31.2	22.3	84	56	30.0	3
November	29.9	20.9	89	51	303.7	4
December	27.9	20.0	90	61	161.6	6

*Plates*

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**PLATE 1. LANDAMAN ORDINARY**



**PLATE 2. PHILIPPINES ORDINARY**



**PLATE 3.**

**WEST COAST TALL X MALAYAN DWARF YELLOW**



**PLATE 4.**

**WEST COAST TALL X GANGABONDAM**



**PROMISING GENOTYPES AND HYBRIDS FOR YIELD**

**PLATE 5.**



**PLATE 6.LACCADIVE ORDINARY**



**PLATE 7.PHILIPPINES ORDINARY**



**PLATE 8.**

**WEST COAST TALL X MALAYAN DWARF YELLOW**



**PLATE 9.**

**MALAYAN DWARF YELLOW X WEST COAST TALL**



**PLATE 10.**

**WEST COAST TALL X GANGABONDAM**



PLATE 11.

VARIATIONS IN THE NUT SIZE AMONG THE  
GENOTYPES AND HYBRIDS



# NURSERY VIEW DURING DIFFERENT STAGES OF SEEDLING GROWTH

PLATE 12.

FOUR MONTHS AFTER GERMINATION



PLATE 13.

SIX MONTHS AFTER GERMINATION



**PLATE 14.**

**EIGHT MONTHS AFTER GERMINATION**



**PLATE 15.**

**TEN MONTHS AFTER GERMINATION**



**BEST SEEDLINGS IDENTIFIED AT THE NURSERY STAGE FOR  
INCREASED PRODUCTION AND PRODUCTIVITY**

**PLATE 16.**



**PLATE 17**



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**PLATE 18**



**PLATE 19.**

**WEST COAST TALL X MALAYAN DWARF YELLOW**



**PLATE 20.**

**WEST COAST TALL X GANGABONDAM**



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## VARIATIONS IN THE ROOT DENSITY

### AMONG THE GENOTYPES AND HYBRIDS

#### GENOTYPES (PLATE 21)



1. ANDAMAN ORDINARY
2. PHILIPPINES ORDINARY
3. LACCADIVE ORDINARY
4. CHOWGHAT ORANGE DWAR

#### HYBRIDS (PLATE 22)



1. WEST COAST TALL X MALAYAN DWARF YELLOW
2. WEST COAST TALL X GANGABONDAM
3. MALAYAN DWARF YELLOW X WEST COAST TALL