VARIABILITY STUDIES ON CERTAIN T X CDO F_1 HYBRIDS OF COCONUT

(Cocos nucifera L.)

By

P. C. SREELATHA

THESIS

submitted in partial fulfilment of
the requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agricultural Botany
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1987

DECLARATION

I hereby declare that this thesis entitled 'Variability studies on certain T X CDO F1 hybrids of coconut (*Cocos nucifera* L.)' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Vellanikkara,
February, 1987

P C SREELATHA

CERTIFICATE

Certified that this thesis entitled ' Variability Studies on certain T x CDO F1 hybrids of coconut (*Cocos nucifera* L.) ' is a record of research work done independently by Smt. P.C. Sreelatha under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Vellanikkara,
February, 1987

Dr. K.KUMARAN

(Chairman, Advisory Board)
Professor (KAPP),
College of Horticulture,
Vellanikkara.

CERTIFICATE

We, the undersigned members of the advisory committee of Smt. P.C. Sreelatha, a candidate for the degree of Master of Science in Agriculture with major in Agricultural Botany, agree that the thesis entitled 'Variability studies on certain T X CDO F_1 hybrids of coconut (*Cocos nucifera* L.)' may be submitted by Smt. P.C. Sreelatha, in partial fulfilment of the requirements for the degree.

Chairman:

Dr. K. Kumaran

Members:

Dr. K.M. Narayanan Namboodiri

Prof. K.K. Vidyadharan

Smt. P. Soudamini

ACKNOWLEDGEMENT

I hereby place on record my profound sense of gratitude to Dr.K. Kumaran, Professor and Chairman of my advisory Committee for his scholastic guidance and constant encouragement through out the course of the present investigation and preparation of this thesis.

I am greateful to Dr. K.M.N.Namboothiri, Professor and Head of the Department of Agricultural Botany for giving necessary fecility to undertake this study and valuable advice as a member of my advisory Committee.

I greately acknowledge the valuable guidance received from Sri. K.K.Vidyadharan, Professor of Agricultural Botany and member of my advisory Committee in the preparation of the thesis.

My sincere thanks are due to Mrs.P.Soudamini, Assistant Professor of Agricultural Statistics and member of my advisory Committee for the encouragement and guidance rendered.

I express my deep sense of gratitude to Dr.K.Gopakumar, Professor of Agricultural Botany for his valuable suggestions and encouragement during the course of the investigation.

My heart felt ©©©Athanks are also due to Smt.V.K.Mallika, Associate Professor of Agricultural Botany for the encouragement and help rendered at various stages of the preparation of the thesis.

I am extremely thankful to the members of the staff of the Department of Agricultural Botany, College of Horticulture for the cooperation and help rendered.

I am indebted to The Kerala Agricultural University for granting research fellowship for my study.

P.C. SREELATHA

CONTENTS

LIST OF TABLES

INTRODUCTION

INTRODUCTION

Coconut (Cocos nucifera L) of the family Palmae is grown in the humid coastal tracts of tropical countries. This is a crop of vital importance to the national economy of any country wherever it is grown on a commercial scale. It provides food, shelter and employment to millions of the rural folk in the tropics and is rightly called 'the tree of life'. India is the third largest producer of coconut and it earns about two per cent of the agricultural income through this commercial crop (Iyer et al., 1979).

Cocos nucifera consists of two types - tall (var. typica) and dwarf (var. javanica and 'nana'). The former is widely cultivated and constitutes the commercial variety by virtue of better quality attributes particularly oil content, while the latter is early flowering ornamental type. Of the several distinguishing features, the one that has relevance from the genetic point of view is that the talls are mostly cross fertilized and heterozygous, while the dwarfs are generally self fertilised and relatively homozygous (Ohler, 1984).

Improvement of coconut through breeding for yield and other attributes of economic importance has been one of the main objectives of coconut research workers during the last 60 years. Many hold the view that exploitation of hybrid vigour could lead to a green revolution in coconut. Eventhough the earliest coconut hybrid T X D (Tall X Dwarf) with high yield potential was

produced in 1934 by Dr. J.S.Patel (Menon and Pandalai, 1960), there has been no noteworthy improvement in this line of research in subsequent years. Coconut being a perennial crop with out-breeding tendancy, is not easily amenable for improvement which would as well be complicated and time consuming. However, attempts in the last several years have yielded desirable hybrid varieties combining the two diverse types, tall and dwarf. In spite of adequate precautions, the performance of hybrids has been a matter of concern because of considerable variability for yield and other major traits manifested by even the most promising of the hybrids so far produced (Iyer et al., 1979).

In view of the reports that all Tall X Dwarf hybrids do not perform equally well under field conditions, a critical study of such hybrids involving different parental combinations is necessary. Performance of coconut particularly the hybrids, has been found influenced by the prevailing seasonal factors. T X D hybrids are reported to be sensitive to temperature and seasonal rains and hence the effect of seasonal variations are more pronounced in them (Bhaskaran and Leela, 1983). But investigations to unraval the intrinsic influence of different weather elements on coconut, particularly the hybrids has very rarely been carried out. Assesment of variability in hybrids and gathering of information on their response to different seasons should be given utmost consideration in the evaluation and utilisation of coconut hybrid varieties having high yield potential. The present investigation was therefore, undertaken with the following objectives, viz.,

1. To assess the extent of variability of major plant and floral attributes like number of leaves, flowering, pollination, button set etc., in a group of bearing T X D hybrids.

2. To examine the relative contribution by any particular tall parent to the manifestation of the expressed variability.

3. To assess the magnitude of heterozygosity existing in a set of prepotent tall palms.

4. To study the extent of variability in relation to seasonal influences.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Coconut is a cross fertilised crop. Considerable variability in respect of all characteristics exists in natural populations by virtue of a high degree of heterozygosity resulting from open pollination. Hybrid populations of coconut also tend to manifest variability to varying extent. A brief review of the published work relating to variability aspects, seasonal effects and correlations of different characters on yield is attempted here.

A. Vegetative Characters

a) **Trunk.** The coconut palms grow erect. The dwarf variety has a much shorter stem than the tall variety. According to Patel (1938) cultivation, manuring and better soil conditions favour the production of taller stems. Close planting is also reported to favour taller stems. The girth of the stem is also influenced by variety, fertility and moisture conditions of the soil and its management. Observations made on the exotic palms growing at The Central Coconut Research Station, Kasaragode, showed that the forms Philippines, Andaman Giant, etc., possess stems of larger girth. The girth of the stem does not appreciably change with age, once it has reached the maximum size (Menon and Pandalai, 1960). Bhaskaran and Leela (1964) observed the mean girth of stem as 65 cm for 40 T X D hybrids, 67.3 cm for 40 tall and 52.3 cm for 3 dwarf coconut trees. Bavappa *et al.* (1973) on a study of 9 T X D F_1 families observed significant difference in girth and internodal distance between parental combinations. Thampan (1975) reported a mean trunk girth of 65.9 cm for T X D hybrids,

64.6 cm for tall and 55 cm for dwarf green palms at Nileshwar. Ramanathan (1984) tabulated correlation coefficients of yield per plant and eight of its components based on observations from four dwarf and 26 tall cultivars. A number of characters were observed to be significantly and positivey correlated with yield of which stem height was most highly correlated (.62).

b)**Leaf.** Every tree has a crown of leaves which are in the various stages of development. The development of the leaf had been traced by Patel(1938). The primordium of the leaf is first differentiated about 30 months prior to its emergence from the leaf sheath. The number of leaves present on the crown at any time vary according to the age of the palm and the rate of production and shedding of leaves. In one year old seedlings, generally, seven to nine leaves are found. As the tree grows in age, the rate of production first increases, then becomes more or less steady and declines in old age. In a group of grown up trees, the number of leaves was found to vary from 22 to 35. The rate of production of leaves is influenced by age, vigour, fertility of soil, cultural and manurial practices and seasonal conditions (Menon and Pandalai, 1960). Tammes as cited by Ohler (1984) measured lengths of leaves of different ages. A leaf of a mature palm may grow out to a length of six to seven metres weighing 10 to 20 kg and having a total leaf area of about 7 to 8 sq. m. Leaves of senile palms may be shorter than 4 m and have an area of about 5 sq. m. The leaves of dwarf palms are much smaller. They reach a length of about 3 to 4 m. The length of the leaf as reported by Davis (1954) varied with the fertility

of the soil and vigour of trees. Bhaskaran and Leela (1964) observed the mean number of functional leaves on the crown as 27.15 for 40 T X D, 20.02 for 40 tall and 24.0 for 3 dwarf coconut trees. They also reported the mean annual leaf production of 12.91 for T X D, 10 for tall and 14.5 for dwarf palms. Of four dwarf coconut lines used in crosses with tall, Laccadive dwarf gave the best results as male parent producing hybrids with more leaves and leaflets and longer leaves and main leaflets (Krishnan and Nambiar, 1972). Satyabalan et al. (1972) reported 32.2 functional leaves on the average for the high yielders, 29.6 for medium yielders and 25 for poor yielders in west coast tall palms. Significant differences in the number of functional leaves, length of leaves and number of leaflets between parental combinations of T X CDO hybrids belonging to 9 F_1 families were reported by Bavappa et al. (1973). Thampan (1975) reported total leaf production of 395.7 on the average for T X D hybrids, 349.3 for tall and 415 for dwarf at Nileshwar. He also reported a mean annual leaf production of 13.5 for T X D, 12 for tall and 13.6 for dwarf green palms. Exceptionally productive palms in India, the so called elite palms yielding more than 200 nuts per annum, all had high leaf numbers, 35 to 50 per annum (Iyer et al. as cited by Ohler, 1984). Dwarf palms have only 25 to 28 unfolded leaves in the crown and they produce about 21 new leaves per annum. Liyanage et al. as quoted by Ohler (1984) reported that dwarf X tall hybrids in Indonesia produced 19 to 22 percent more leaves than their respective male (tall) parents. Leaf production was more or less equal to the mean of

the respective parents. Louis(1981) observed a phenotypic coefficient of variation of 56.79 in length of leaves based on a study involving 25 varieties and 2 hybrids. Expected genetic advance was high for number of leaves per year (4.56) and leaves on the crown (9.35).

c)Leaflets. The number of leaflets on a leaf in tall palms varies from 200 to 250. Menon and Pandalai (1960) observed that leaves with a low number of leaflets also had narrow leaflets. The first leaflets at the base were short, the following leaflets gradually increasing in length reaching a maximum of 130 cm at about one third of the midrib, gradually becoming smaller again towards the tip where they may not be longer than 80 to 110 cm.

d)Petiole. The petiole length is about one quarter of the total leaf length. According to Menon and Pandalai (1960) palms with short leaf stalks have bunches with short stalks as well, keeping the bunch closer to the stem and putting less strain on the leaf bracket. The shape of the leaf stalk is of importance and there is a certain natural variation in this. The upper surface is nearly flat or just sufficiently grooved to prevent water from runnig to its sides. The lower surface is a round keel which thickens out considerably at the base, thus forming a supporting bracket (Menon and Pandalai, 1960).

B.Floral Characters.

a)Spadix. The coconut produces inflorescences in continuous succession. The development of the inflorescence of the coconut

had been traced by Juliano (1926) and Patel (1938). According to them the inflorescence arises in the axil of every leaf. Patel (1938) traced it in the axil of fourth leaf counted from the tip and observed that the primordium of the rudimentary inflorescence starts almost about the same time as the subtending leaf so that the young rudimentary leaf near the growing point have in their axil the initials of theinflorescence. Initiation of the spadix begins about three years before its opening. The differentiation of the sheaths takes place two years before opening of the spadix and the differentiation of the spike about six months later. The flower primordia are initiated about one year before the opening of spadix (Fremond et al., as cited by Ohler, 1984). When the inflorescence grows with in the spathe, the latter finaly splits open usually starting at the tip. The spathe opens over the whole length and the inflorescence comes out unfolding, with in one day.

The spadix consists of a main axis with 20 to 60 branches orspikes bearingthe flowers.The female flowers are mostly located singly at the base of the spike. The rest of the spike is fully covered with male flowers. The flowers are sessile and are attached directly to the spikes. Each spike may have one or a few female flowers and about 200 to 300 maleflowers. The total number of male flowers per spadix varies with the number of spikes and their length. Normally, the length of the spike variesfrom .75 m to 2 m depending up on the individual palm (Menon and Pandalai, 1960). According to Satyabalan et al. (1969) the production of spadices was greater in regular bearers

than in irregular bearers and the difference was accounted for by the abortion of spadices in irregular bearers. The average number of inflorescences produced per palm per annum of west coast tall was 11.3 as reported by Satyabalan and Pillai (1977). An expected genetic advance of 5.74 and phenotypic coefficient of variation of 50.74 for number of spadices per year was reported by Louis(1981). The number of inflorescences per annum for T X CDO hybrids grown at CPCRI, Kasaragode as reported by Vijayakumar and Satyabalan (1982) ranged from 7.3 to 12.3 with a mean of 9.2.

b)Male Flowers. The development of the male flower had been traced by Juliano and Quisumbing (1931). According to them the male flower is borne either singly or in groups of two or three in the axil of each tertiary bract, on the rachillae of the inflorescence, which is a tiny collar like structure subtending the male or female flowers . Significant difference in male flower production between three varieties of tall and dwarf and three hybrids was reported by Gangolly et al. (1961). Proportion of male flowers at the distal, middle and proximal positions of the inflorescence was constant from tree to tree in the varieties tall, Laccadives and Philippines. But the ratios of male flowers in the three positions were variable from tree to tree in dwarf variety (Nampoothiri, 1970).

c) Female Flowers. The female flowers are comparatively few in number in an inflorescence and vary from zero to 300 in each spadix depending on the condition prevailing namely, nature of the tree, cultivation, manuring, season, age of bearing, etc.

Dwarf palms generally bear female flowers in larger numbers than the tall palms (Menon and Pandalai, 1960). Jack and Sands (1929) observed that the first inflorescence produced only very few female flowers. There was difference in the production of female flowers among the trees as well as among inflorescences of the same tree as reported by Patel (1938). Satyabalan et al. (1969) reported no significant difference in female flower production between regular and irregular bearers. The variation in female flower production appeared to be related to the number of spadices than to the number of female flowers per bunch. Parental combinations of T X CDO hybrids were reported to be significantly different in female flower production by Bavappa et al. (1973). Open pollinated and inbred progenies of 12 varieties of coconut were compared by Nambiar and Ravindran (1974) and reported substantial differences between varieties as well as between inbred and open pollinated progenies of the same variety with respect to the number of female flowers per spike. Satyabalan and Pillai (1977) observed 314.2 female flowers on the average per palm of WCT variety. Louis (1981) reported a genetic advance of 1.67 and phenotypic coefficient of variation of 66.66 in female flowers per palm among 25 varieties and 2 hybrids observed. The number of female flowers per annum for T X CDO hybrids grown at CPCRI, Kasaragode ranged from 103.8 to 344.5 with a mean of 228.8 (Vijayakumar and Satyabalan, 1982).

d)Buttons set. In Malaysia, in an ordinary population of talls, it was observed that the range of variation inyield was from 5 nuts to 115 nuts per palm per annum with a mean 59 nuts and a

coefficient of variation of 34 per cent (Jack, 1932). Liyanage (1961) reported a very high heritability value of 0.81 for setting percentage. Heritability estimated from parent progeny regression for ten characters influencing the final yield of coconut showed that low heritability for number of bunches emerged, total number of spikes and spikes with one female flower and high heritability for the remaining characters appeared to be responsible for inconsistant results. Selection for large number of spikes with one or two female flowers will help in reducing the instability in yield (Nambiar et al., 1970). Variance components analysis, made by Nambiarand Nambiar (1970), of characters influencing productivity in sixyield groups in three sets of crosses has revealed substantial additive genetic variation available for selection for yield and associated characters like number of female flowers and percentage set. High yielding groups showed stability and superiority even in poor environment. A highly significant correlation coefficient of .68 between number of functional leaves and yield in west coast tall palms was reported by Satyabalan et al. (1972). Significant difference in setting percentage of female flowers between parental combinations of T X CDO hybrids was observed by Bavappa et al. (1973). Phenotypic and genotypic correlations with yield were observed by Nampoothiri et al. (1975) for spathe production and number of female flowers. Ramachandran et al. (1975) reported hybrid vigour in VHC-1 (east coast tall X dwarf) for growth characters and that they came to bearing 33 months earlier than tall and recorded 40.8 percent higher mean yield of nuts. Number

of nuts per tree per year was recorded as 131.1 with setting percentage of 27.5. In a study of six tall and two dwarf populations Balingasa and Carpio (1976) observed that percentage of fruit set varied inversely with the number of female flowers. Setting percentage of female flowers in west coast tall palms was 30.4 on the average according to Satyabalan and Pillai (1977).

A wide range of phenotypic variation was observed in 25 varieties and two hybrids. Expected genetic advance observed for nuts produced per year and setting percentage was 5 and .65 respectively. Maximum PCV was recorded for the number of female flowers (66.66) followed by setting percentage (63.06) and number of nuts per year (58.69) (Louis, 1981).

The number of flowers set for T X CDO hybrids grown at CPCRI,Kasaragod as reported by Vijayakumar and Satyabalan (1982) varied from 33.5 to 104.0 per annum with a mean of 61.4 and setting percentage of 26.6. Mathew et al. (1986) observed 10 super yielders of coconut (annual yield of more than 300 nuts) and 6 controls from different sites of Kerala for traits such as number of functional leaves, spadix production and yield along with seedling traits of their progeny. Only one super yielder was found to be superior to the control palms and capable of transmitting its traits to progenies.

e) Anthesis.

Male phase. The male phase which is the interval between the opening of the first male flower and shedding of the last male

flower in a spadix has been observed to vary according to the nature of the tree, locality in which it is cultivated and the season of the year (Menon and Pandalai, 1960). Patel (1938) observed that most of the flowers opened by 15th day of opening of the spathe. The male phase according to him was 18 days for trees at Nileshwar and 18 to 22 days in respect of those at Kasaragod. In Ceylon, Liyanage (1950) estimated the male phase to last for 18 to 22 days.

Female phase. The female phase which is the interval between the receptive stage of the first female flower and the last female flower in a spadix has also been observed to vary according to the condition of the tree. But generally, it is much shorter than the male phase and extends for 4 days to a week depending on the nature of the tree, locality in which it is cultivated, the season of the year and the number of female flowers borne onthe inflorescence (Menon and Pandalai, 1960). Liyanage (1950) observed this to last for 5 to 7 days in tall palms and 10 to 16 days in King coconut and dwarfs of Malayan origin. There is slight variation in the period during which the stigma are receptive in different coconut growing countries. At Kyala and Peradeniya in Ceylon it was 24 hours while in Losbanos in the Philippines it varied between 2 tO 3 days (Patel, 1938). Hybrids between parents with in the same group behave in the same way as parents. Hybrids between parents of different groups closely resemble the parents with the shorter phase. Observations by Jack and Sands (1922) showed that in Malaya, the female phase in dwarf palms not only began, but frequently ended before or at

the same time as the male phase, thus making self pollination the rule instead of a chance. The interval between the end of male phase and beginning of the female phase has an important bearing on the nature of pollination. If there is an interval, cross pollination might be common. The observations made by Patel (1938) for a group of 68 trees for a year showed that when the interval is nil, there may be chances for self pollination. In 34 percent and about 29 percent of the trees the commencement of the female phase was respectively on the 20th and 22nd day after opening of the spathe and the average interval between the end of male phase and the commencement of the female phase was 2.6 days. Only in 1.69 per cent of the trees, the interval was nil.

f)Pollen fertility and viability. When the anthers are fully mature, the pollen sacks burst along two longitudinal slips which coincide with the partitions of the pollen sacks and shed their pollen before the opening of the male flower. Aldaba (1921) estimated that each male flower carried about 272 million pollen grains. From the counts made of the pollen of 6 trees, it was found that on the average about 25 percent of the pollen grains wereinfertile. The variation in the percentage of infertile grains was only between 23 and 28. Pollen yield varies widely. A reasonably reliable figure is that of Varkey and Davis (1960), who reported 111,000 to 221,000 grains per anther. Diurnal and seasonal variations were also recorded by them. Copeland as cited by Child (1974) quoted Mendiola's observations that pollen could remain viable up to 9 days . Nampoothiri

(1970) studied 12 varieties of Cocos nucifera and reported that pollen sterility was significantly and negatively correlated with pollen germination. Studies on variation in pollen characteristics of 8 coconut cultivars indicated some variation in both pollen germination and pollen tube growth which was attributed to different nutritional and environmental requirements of the cultivars. No relationship was observed between the two characteristics (Shamsuddin and Nampoodiri, 1979). Patel as quoted by Menon and Pandalai (1960) recommended 5 per cent sugar and 2 per cent gelatin water solution as the best medium for germination of the pollen grains of coconut, while Aldaba(1921) recommended 25 to 30 per cent cane sugar solution for effecting best germination. Ten per cent cane sugar plus 2 per cent gelatin solution was a satisfactory medium while no germination was observed in 15 and 25 per cent sugar solutions to both of which 2 per cent gelatin was added (Liyanage, 1954). Fairly good germination was obtained when the water from tender nuts was used for germinating the pollen. Patel (1938) observed no significant difference in the viability of the pollen from the flowers opened at different periods on the same inflorescence.

De Beer as reported by Stanley and Linskens (1974) observed that, in pea nuts, Arachis hypogaea, pollen on plants growing at a constant 33o C was only 10 per cent viable compared to 40 per cent viability for pollen developed in green houses under a normal day night temperature cycle. Rice plants grown with a root temperature of 28o C yielded pollen with higher viability than plants grown with roots at 23o C or 33o C (Yamada

and Hasegawa as cited by Stanley and Linskens, 1974). They also reported that moisture stress in the soil affected pollen viability. Stanley and Linsken (1974) quoting Kaurov stated that when pollen was isolated from pea nuts at different periods through out the day, 35 per cent of pollen germinated in the morning and 10 hours later only 3 per cent germinated. Pollen isolated in the early morning germinated better than that collected at other times of the day.

g)Genetic divergence.

Bavappa et al. (1973) grouped 9 F_1 families of WCT X dwarf green coconut hybrids into 4 clusters based on 13 vegetative and yield traits using Mahalanobis D2 and reported that with proper choice among tall and dwarf varieties efficient exploitation of the hybrids could be effected.

Genetic studies with 24 cultivars of coconut maintained in the germplasm collection of Regional Agricultural Research Station, Pilicode was conducted by Balakrishnan (1982). With reference to 17 economic characters, he grouped the 24 cultivars belonging to tall group into 6 clusters. Clusters I and II that were genetically closer comprised of 6 cultivars each, where as clusters IV and VI that were wider apart had 4 and one cultivars respectively.

h)Seasonal effect on floral characters.

Marechal (1928) reported high female flower production in dwarf palms in Fiji during November to March. Patel (1938)

observed the seasonal influences on the floral characters of west coast tall coconut trees and reported the following. Maximum production of spadices during the year (18 percent) occured during March at Nileshwar-1 and it was 10.8 percent during April at Kasaragod. The spadix production was low during October, November, December and January at both places. About 75 per cent of the abortion of spadices during a year occured to those which were to appear during the rainy months of July, August, september and October and attributed due to the dry weather prevailing at the time of formation of branches (15 to 16 months prior to opening of inflorescence). The abortion was practically nil in the months of January, February and March. Male phase was short in the summer months of February and March while it was long during July and November. High female flower production was reported during March, April and May, the highest being in May. Very low production was observed during September to January at Nileshwar and Kasaragod.

Bearing tendency of coconut palms and associated yield components were examined for 48 palms comprising tall, regular and irregular bearers of dwarf green and orange types for a period of 3 years by Nambiaret al. (1970). They concluded that instability in production was due to seasonal differences with in each year.

Bhaskaran and Leela (1983) studied seasonal influence on yield and yield attributes of tall X dwarf and west coast tall coconuts in Kerala and made the following observations. 43 to 50 per cent of the spadices produced in a year are

harvested during hot weather period and the number of bunches harvested during north east monsoon is the lowest (23 to 26 per cent). In west coast tall, 72.6 per cent of the aborted spadices were accounted for in south west monsoon. Spadix abortion was lowest during hot weather period. About 50 per cent of annual female flower production occured during hot weather period in both cultivars. Female flowers per spadix was also high during this season. Button setting was highest during north east monsoon.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation on variability in certain Tall X Dwarf (Chowghat Dwarf Orange) F_1 hybrids of coconut (*Cocos nucifera.* L) was undertaken at the KADP farm of the College of Horticulture, Vellanikkara during 1985-86. A brief description of the materials used and the procedures followed for the purpose are given below.

Materials.

The population under study consisted of eight year old T X CDO hybrids grown under rainfed condition, as part of a project of the KADP for fixing up selection criteria for hybrid coconut seedlings at nursery stage. In this experiment altogether 389 F_1 progenies originating from 73 parental combinations of WCT and CDO palms available at the RARS, Pilicode are being studied. Hybrids were obtained through controlled pollination between selected parents in 1977 and seedlings were later planted at the KADP farm, Vellanikkara in 1978. The plants are being maintained under good management in accordance with the recommendations of the package of practices of the Kerala Agricultural University in 1985

For the present study, 69 F_1 progenies from fourteen parental combinations involving 3 males and 14 distinct mother palms were selected from the above said T X CDO population. While selecting, combinations which have started regular flowering since the fifth year of transplanting have been deliberately

chosen. Five trees were selected at random from the progenies of each of the fourteen selected parental combinations except the 13th combination which had four plants only. Thus a total of 69 trees formed the sample. The details of the selected palms are given in table 3.1.

Methods.

Observations on 19 characters of the 69 selected palms were recorded during a period of one year from 15th October, 1985 to 14th October 1986. The different vegetative and floral characters and details of recording of observations were as follows.

1.Girth. Girth of trunk at one metre height from the ground level was measured in cm using a measuring tape in October 1985.

2.Internodal distance. Distance between fifteen nodes (leaf scars) just below the crown was measured in cm using a measuring tape in October 1985. It was then divided by 14 (number of internodes) to get the average internodal distance.

3.Number of functional leaves. Fully opened functional leaves leaving the unopened and senile leaves were counted for each selected palm in October 1985.

4.Annual leaf production. The unopened spindle leaf was marked for each selected palm on 15th October 1985. The number of leaves between the unopened spindle leaf and the one (inclusive) previously marked was counted on 14th October 1986 and the same was recorded as annual leaf production.

5.Leaf Characters.

Table 3.1

Details of T X CDO Combinations and field numbers of F_1 progenies.

Sl.No.for Parental combinations.	Female parent	Male parent	F_1 Progeny numbers.
1	K/8	N8/1	304, 321, 333, 357, 361
2	K/26	N8/1	5, 8, 10, 27, 44
3	I/106	N8/1	117, 155, 175, 178, 240
4	K/25	N8/7	2, 29, 61, 63, 73
5	K/39	N8/7	306, 317, 339, 359, 376
6	K/93	N8/7	21, 158, 173, 184, 190
7	G/50	N8/7	20, 189, 218, 228, 271
8	G/223	N8/7	15, 18, 43, 50, 76
9	H/117	N8/7	167, 204, 210, 222, 260
10	K/10	N8/17	302, 312, 363, 365, 388
11	K/14	N8/17	52, 58, 72, 81, 95
12	G/64	N8/17	180, 244, 251, 258, 281
13	G/115	N8/17	324, 346, 351, 384
14	I/123	N8/17	71, 176, 177, 213, 259

Various characters of the 14th leaf from the top of each palm were observed in October 1985.

a.Rachis length. Length of rachis from tip to bottom was measured in m using a graduated bamboo pole.

b.Peticle length. Length of petiole was measured in metre from the base to the point of emergence of leaflets.

c.Number of leaflets. All leaflets in the fourteenth leaf of every selected palm were counted.

d.Mean length of leaflets. A representative sample of five leaflets from different positions of the forteenth leaf of each selected palm was selected and their lengths measured in cm using a measuring tape. The arithmetic mean of these five values was recorded as the length of leaflets.

e.Mean width of leaflets. Width of each of the five selected leaflets observed for measuring length was also measured in cm and their arithmetic mean was recorded as the width of leaflet.

6.Number of spadices. The spadices produced during the period of one year from 15th October 1985 to 14th October 1986 of every selected palm was counted.

7.Number of branches per spadix (spikes). Total number of branches of all spadices produced during the study period of one year was divided by the number of spadices to get the average number of branches per spadix for each of the selected palms.

8.Flower production.

a.Male flowers. The number of male flowers vary between spadices within a palm and between branches in a spadix. Hence the following systematic procedure was adopted to estimate average number of male flowers per branch for each of the selected palms.

The branches in every spadix were stratified in to three based on their length and the number of branches in each stratum was counted and noted. A representative branch was purposively selected from each stratum and cut retaining the identity of the stratum on the branch. The male flowers on each branch cut was then counted and multiplied by the number of branches in the corresponding stratum. These three values were summed to estimate the total number of male flowers in a spadix. Sum of such estimated number of male flowers of all spadices produed in a palm during the study period was divided by the total number of branches of all spadices to get the average number of male flowers per branch.

b.Female flowers. Female flowers in all inflorescences produced during the study period of one year were counted and recorded for each selected palm.

9.Number of buttons set. Buttons (female flowers) set were counted in all inflorescences produced during the study period, for each selected palm, ninety days after the emergence of each spadix.

10.Percentage set. The percentage set was calculated for every selected palm as $\frac{a}{b} \times 100$, where'a'is the total number of buttons set and 'b' is the total number of female flowers produced during the study period.

11.Male phase. The male phase is characterised by the presence of insects. The date of opening of each inflorescence and that of the first male flower in it was recorded for each selected palm. Similarly, the date of falling apart of the last male flower in every inflorescence was recorded. The number of days between the opening of the first male flower and falling of the last male flower in an inflorescence (inclusive of both days) was taken as the duration of male phase for that inflorescence. The average duration of male phase for a palm was calculated as sum of the durations of male phases of all inflorescences produced in that palm divided by the total number of inflorescences.

12.Female phase. The number of days counted from the day of attaining receptivity of the first female flower to the fading up of the last female flower in an inflorescence was recorded as the female phase for that inflorescence. The condition of receptivity was identified by the presence of a sticky secretion in the swollen trifid stigma. Invariably ants will also be present on the female flower during this period. Arithmetic mean of female phases of all inflorescences produced in the study period was calculated for each of the selected trees.

13.Fertility. One branch was cut from every inflorescence, during active male phase, in the mornig hours (between 8 AM and 9.30

AM). It was colleccted in polythene bag containing little water to provide humid atmosphere to the fresh flowers and brought to the laboratory for studying the pollen fertility and viability.

Pollen fertility was studied by staining 2 per cent acetocarmine. A drop of the stain was taken on a slide using a glass rod and pollen from a fully opened male flower was droped on it. A cover slip was then placed over the stain andthe smear was observed under the low power of a microscope. Pollen grains were examined for stainability. Completely stained and fully round pollen were counted as fertile and the rest as sterile. This was repeated for three to five flowers in one inflorescence to study about 500 pollen per spadix. Percentage of fertility was then calculated for each inflorescence and each tree.

14.Viability. Twentifive g sucrose was dissolved in 100 ml distilled water tc get the medium for testing viability. The solution was smeared on a microscope slide and pollen from one opened male flower was dusted on it. The pollen were completely immersed in the solution and was of uniform spread. These slides were arranged on glass rods in petri dishes which were moistened with filter paper. The petri dishes were arranged one over the other in a dessicator. The slides were observed under microscope the nextmorning. Those pollen grains which were observed germinating with large pollen tubes were counted as viable and the rest as non viable. Percentage of viability was calculated for each inflorescence and the average was obtained for each selected tree.

Statistical Analysis.

The data collected were subjected to statistical analysis as follows.

Analysis of variance.

Analysis of variance was performed for each of the 17 charecters using the model for nested classification (Federer, W.T., 1972). The analysis of variance table for any charecter is presented in Table 3.2

Table 3.2

Analysis of Variance.

Source	DF	Sum of squares	Meansquare	F
Between pollen parents.	s-1	A	MA=A/s-1	MA/MB
Between mother palms within pollen parents	ND	B	MB=B/ND	MB/MSE
Within mother palms within pollen parents	NE	E	MSE=E/NE	
Total	NT	T		

where s is the number of pollen perents,

NT+1 is the total number of palms,

NM is the total number of mother palms,

ND=NM-s

NE=NT+1 - NM ,

$$A = \sum_{i} Y_{i.}^{2} /ni - CF ,$$

$$B1 = \sum_{i} \sum_{j} Y_{ij.}^{2}/nij - CF ,$$

$$B = B1 - A ,$$

$$T = \sum_{i} \sum_{j} \sum_{k} Y_{ijk}^{2} - CF ,$$

$$CF = \left(\sum_{i} \sum_{j} \sum_{k} Y_{ijk} \right)^{2}/(NT+1) ,$$

Y_{ijk} is the observation on the character Y of kth progeny of the ith pollen parent and jth mother palm,

$$Y_{ij} = \sum_{k} Yijk ,$$

$$Yi. = \sum_{j} \sum_{k} Yijk ,$$

n_i is the number of progenies of ith pollen parent,

n_{ij} is the number of progenies for the ith pollen parent and jth mother palm.

Heritability, genotypic coefficient of variation and phenotypic coefficient of variation.

Whenever the differences between pollen parents were insignificant, meansquare between parental combinations §MB1=B1/(NM-1)† was considered for obtaining genotypic and phenotypic variability as suggested in Singh and Choudhary(1978) using the following formule.

Genotypic variance(GV) =(MB1-MSE)/r , where r is the number of replications.

Phenotypic Variance (PV) = GV+MSE

Heritability (H2) = (GV/PV) X 100

Genotypic coefficient of variation(GCV) = $(\sqrt{GV} / Y)$ X 100

Phenotypic coefficient of variation(PCV)= $(\sqrt{PV} / Y)$ X 100

Genotypic and Phenotypic correlations.

Genotypic correlation between X and Y (r_g)

$$= \frac{\text{Genotypic covariance between X and Y}}{\sqrt{GV(X)\ GV(Y)}}$$

Phenotypic correlation between X and Y (r_p)

$$= \frac{\text{Phentypic covariance between X and Y}}{\sqrt{PV(X)\ PV(Y)}}$$

Genetic divergence.

All the characters for which the motherpalms differed significantly were chosen for the analysis of genetic divergence. Wilk's Lamda criterion was first obtained to test the overall differences among the parental combinations with respect to these selected characters. Mahalanobis D2 values between every pair of parental combinations were worked as described in Rao(1952). The procedure is briefly explained below.

Let X_{ij} , j=1,2, ..., n be the means of the n characters under consideration for the ith parental combination, i=1,2, ..., 14.

They were tranformed to n generated variables which were uncorrelated among themselves using the formule

$$Y_{ij} = \sum_{K} b_{kj} X_{ik},\ j=1,2, \ldots\ldots, n,$$

where b_{kj} s are obtained by pivotal condensation of the within scatter matrix.

Once the uncorrelated means were obtained for each parental combination, Mahalanobis D^2 value between ith and jth parental combinations was worked out as

$$D2\ (i,j) = \sum_{k} (Y_{ik} - Y_{jk})2,\ i=j = 1,2, \ldots, 14.$$

The computer oriented iteraive algorithm suggested by Suresh (1986) was made use of to cluster the parental combinations based on the D2 values so obtained. It involved the following steps.

i) Identify the two combinations having the maximum distance between them and they are termed the nuclei of two clusters.

ii) Every parental combination is considered in turn and allocated to the cluster for which its D2 value with the nucleus is least.

iii) To increase the number of clusters by one, the maximum D2 with in the above two clusters is found and the combinations having the maximum value is considered as the nuclei in addition to the nuclei of the remaining clusters. The parental combinations are reassigned as in (ii). In a similar way the number of clusters can be raised to any desired level.

The clusters thus obtained were further optimised using the iterative relocation algorithm. The method of maximum curvature was used to determine the number of clusters.

Seasonal variation in floral characters.

The study period of one year was divided in to 52 standard weeks as provided in the Appendix. Important floral characters were compiled and tabulated for each standard week. Three week moving averages were obtained, to have a better understanding of the trend, for production of spadices, number of

female flowers and number and percentage of buttons set. Three week moving average for any standard week was calculated as the arithmetic mean of the value corresponding to that standard week and those of the preceding and succeeding weeks. Meteorological observations corresponding to the standard weeks were obtained from The Department of Agrometeoroloy of the College of Horticulture and are provided in the Appendix.

RESULTS

RESULTS

Observations on seventeen characters for 69 selected T X CDO F_1 hybrids from 14 parental combinations, hereinafter referred to as combinations, were recorded and were subjected to statistical analysis.

Analysis of variance was performed for each of the seventeen characters and are presented in Table 4.1. No significant difference was observed between progenies of different pollen parents with respect to any of the characters studied. The means and ranges of vegetative characters for different combinations along with critical difference are provided in Table 4.2A and 4.2B and those for floral characters in Table 4.3A and 4.3B. Estimates of heritability, genotypic coefficient of variation and phenotypic coefficient of variation for the seventeen characters studied are presented in Table 4.4. The salient features based on the analysis are given below.

A. Vegetative Characters.

1.Trunk Girth. Differences in trunk girth between progenies of mother palms with common pollen parents were found significant at 1 percent level. Combination 13 had the maximum mean girth of 77.25 cm which was not significantly different from those for combinations 2, 4, 5, 8, 12 and 14. Sixth combination had the minimum mean girth of 65.2 cm which was statistically on par with 1, 3, 7, 9, 10 and 11. The girth ranged from 56 cm in tree No. 167 of combination 9 to 90 cm in tree No. 359 of combination

Table 4.1

Analysis of Variance for 17 Characters

Character	Between pollen parents		Between female parents		Error
	mean square	F	mean square	F	mean square
DF	2		11		126
Girth	65.59	0.71	92.72	3.98**	23.28
Internodal distance	0.93	0.24	3.93	5.96**	0.66
No. of functional leaves	6.24	0.66	9.52	2.45*	3.89
Annual leaf production	5.78	0.51	11.42	3.64**	3.40
Length of leaf	0.63	0.23	0.27	2.75**	0.10
Length of petiole	0.01	0.10	0.06	2.54*	0.02
No. of leaflets	271.63	0.87	313.52	2.99**	271.63
Length of leaflets	125.50	0.63	200.59	4.01**	50.03
Width of leaflets	0.38	0.57	0.67	3.09**	0.22
No. of spadices per annum	8.40	0.49	17.25	3.53**	4.88
No. of branches per spadix	40.44	1.53	26.42	2.53*	10.43
No. of male flowers per branch	132.75	0.07	1905.68	1.58	1209.65
No. of female flowers per annum	11720.63	0.22	53290.14	3.67**	14531.92
No. of buttons set	451.39	0.29	1532.80	2.14*	716.31
Percentage of buttons set	4.69	0.04	122.76	1.73	70.81
Duration of male phase	2.81	1.73	1.62	0.55	2.93
Duration of female phase	0.50	0.72	0.69	2.15*	0.32

* indicates significance at 5 % level
** indicates significance at 1 % level

5. Heritability in the broad sense estimated for this traitwas 35.90 per cent and genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were obtained as 5.10 and 8.50 respectively.

2.Internodal distance. Considerable variation was observed in internodal distance. The mother palms differed in their contribution to the progenies in this trait with in pollen parents at 1 per cent level.The highest mean internodal distance of 6.76 cm was recorded for combination 5 which did not differ significantly from combination 2. The lowest mean of 3.54 cm was for 9th combination which was statistically on par with combinations 3,6,8,10 and 12. Internodal distance was maximum in tree No. 359 of combination 5 and minimum in tree No.167 of combination 9 the corresponding distances being 9.21 cm and 2.43 cm respectively. PCV was 23.11 and GCV 15.67. Heritability was as high as 46 per cent.

3.Number of functional leaves. There was significant difference (at 5 per cent level) in functional leaves between progenies of different mother palms and common pollen parents . The highest number of functional leaves was observed in tree No.259 of 14th combination, while the minimum was found in tree Nos. 20, 21 and 304 of combinations 7,6 and 1 respectively. Fourteenth combination had the highest mean number of functional leaves (21.20) which did not differ significantly from combinations 4,5,6,7and 13. The lowest mean of 16 was for 10th the combination which was statistically on par with 1,2,9 and 12. PCV was 11.97 and GCV 5.47. Heritability for this trait was 20.9 per

Table 4.2A

Mean and Range of Vegetative Characters

Parental combination.	Trunk Girth in cm		Internodal distance in cm		Number of functional leaves		Leaf production.	
	mean	range	mean	range	mean	range	mean	range
1	65.60	62.00- 73.00	4.47	3.86- 5.36	17.00	14.00- 20.00	12.00	10.00- 14.00
2	74.00	71.00- 76.00	6.11	4.93- 7.71	17.60	16.00- 20.00	14.00	13.00- 16.00
3	68.20	64.00- 70.00	4.56	3.64- 5.79	18.60	16.00- 21.00	14.40	12.00- 17.00
4	72.10	66.00- 77.00	5.26	4.71- 5.93	18.80	18.00- 20.00	14.20	10.00- 17.00
5	77.20	69.00- 90.00	6.76	5.50- 9.21	19.60	19.00- 22.00	13.00	12.00- 14.00
6	65.20	59.00- 70.00	3.80	3.21- 4.36	18.80	14.00- 21.00	13.80	12.00- 17.00
7	68.80	66.00- 74.00	5.03	4.43- 5.79	18.80	14.00- 21.00	13.80	13.00- 15.00
8	71.60	63.00- 77.00	4.39	3.71- 5.00	18.60	17.00- 21.00	15.60	14.00- 17.00
9	66.60	56.00- 73.00	3.54	2.43- 4.29	18.40	16.00- 21.00	14.20	13.00- 15.00
10	70.20	63.00- 75.00	4.57	2.93- 6.21	16.00	15.00- 17.00	11.60	10.00- 13.00
11	66.80	64.00- 70.00	4.46	3.79- 5.00	17.40	16.00- 19.00	14.00	12.00- 16.00
12	73.80	71.00- 76.00	4.51	4.14- 4.71	18.20	16.00- 20.00	14.20	12.00- 16.00
13	77.25	71.00- 83.00	4.61	3.64- 5.36	20.75	19.00- 23.00	16.50	15.00- 19.00
14	76.40	72.00- 87.00	4.86	4.00- 6.43	21.20	19.00- 26.00	17.00	14.00- 22.00
CD	6.11		1.03		2.50		2.25	
CD for comparison of cobination 13)	6.49		1.09		2.65		2.38	

cent.

4.Annual leaf production. Annual leaf production differed significantly between combinations with same pollen parent at 1 per cent level. It varied from 10 in tree No.29 of combination 4 , 304 of combination 1 and 388 of combination 10 to 22 in tree No. 259 of combination 14 . Maximum average annual production of leaves of 17 was observed in 14th combination and it did not differ significantly from the combinations 8 and 13. The least mean of 11.6 was recorded for 10th combination and combinations 1,5,6 and 7 were statistically on par with it. GCV was estimated as 8.62 and PCV as 15.22. Heritability for this trait was estimated to be 32.1 per cent.

5.Leaf Characters of 14th leaf.

a.Petiole length. It was observed that progenies of mother palms with common pollen parents differed significantly in petiole length at 5 per cent level. It ranged from 1.05 m in tree No.29 of 4th combination to 1.85 m in tree No. 259 of 14 th combination. The maximum mean petiole length of 1.49 m was recorded in 5th and 14th combinations and it differed significantly only from combinations 1,9,10 and 11. Combination 11 recorded the least petiole length of 1.17 m and was statistically on par with combinations 1, 6, 7, 8, 9, 10 and 12. Heritability for this character was 22.1 per cent with GCV of 5.03 and PCV of 10.66.

b.Leaf length. The mother palms differed significantly (at 1 per cent level) in their contributions to leaf length of their progenies . The shortest leaf was observed in tree No.333 of

Table 4.2B

Mean and range of vegetative characters.

Combination.	Length of leaf in m		Length of petiole in m		Number of leaflets in 14th leaf		Length of leaflets in 14th leaf in cm		Width of leaflets in 14th leaf in cm	
	mean	range	mean	range	mean	range	mean	range	mean	range
1	2.97	2.67 - 3.37	1.26	1.07- 1.50	185.60	174.00-208.00	69.90	61.25- 74.75	2.62	2.43 - 2.83
2	3.46	3.05 - 3.97	1.37	1.26- 1.60	204.00	194.00-220.00	91.40	74.75-101.50	3.77	3.00 - 4.35
3	3.43	2.89 - 3.95	1.39	1.13- 1.56	205.60	182.00-230.00	87.20	71.00- 94.75	3.12	2.50 - 3.63
4	3.73	2.82 - 4.62	1.37	1.05- 1.66	205.20	198.00-214.00	86.15	77.25- 96.50	3.82	3.30 - 4.60
5	3.66	3.20- 4.05	1.49	1.38- 1.67	207.60	190.00-230.00	86.45	78.25- 98.75	3.07	2.85 - 3.73
6	3.17	2.70 - 3.45	1.30	1.25- 1.37	192.00	180.00-200.00	81.20	74.00- 89.25	2.96	2.23 - 4.05
7	3.28	3.12 - 3.48	1.33	1.12- 1.47	203.60	198.00-210.00	83.10	69.50- 92.25	3.32	2.85 - 4.45
8	3.24	2.88 - 3.75	1.34	1.17- 1.60	204.40	192.00-214.00	83.90	74.75- 94.25	3.65	3.38 - 4.03
9	3.16	2.85 - 3.42	1.28	1.11- 1.40	187.60	172.00-200.00	77.25	68.00- 84.25	3.13	2.20 - 3.70
10	3.27	3.05 - 3.50	1.18	1.11- 1.23	212.00	206.00-222.00	73.35	65.25- 79.50	2.87	2.43 - 3.28
11	3.02	2.85 - 3.18	1.17	1.11- 1.21	198.40	192.00-206.00	76.50	66.75- 84.25	3.21	2.78 - 3.65
12	3.32	3.08 - 3.65	1.36	1.12- 1.54	203.20	188.00-208.00	77.00	74.25- 80.25	2.89	2.10 - 3.30
13	3.53	3.36 - 3.73	1.44	1.38- 1.59	204.00	194.00-210.00	88.75	84.75- 94.00	3.03	2.75 - 3.38
14	3.34	3.10 - 3.67	1.49	1.33- 1.85	208.40	196.00-218.00	81.10	78.75- 84.00	3.44	3.25 - 3.83
CD	0.40		0.19		12.97		8.97		0.59	
CD (for comparison of combination 13)	0.42		0.20		13.76		9.51		0.63	

combination 1 and the longest in tree No. 2 of combination 4, the corresponding lengths being 1.05 m and 1.85 m respectively. The mean length of leaf was maximum (3.73 m) in combination 4 which was not significantly different from combinations 2, 3, 5, 13 and 14. The least mean leaf length (2.97 m) was for combination 1 and combinations 6, 7, 8, 9, 10, 11, 12 and 14 were statistically on par with it. This trait had a heritability of 19.2 per cent with PCV and GCV of 12.26 and 5.28 respectively.

c.Number of leaflets. The progenies differed significantly (at 1 per cent level) between mother palms and common pollen parents with respect to the numberof leaflets. The mean number of leaflets was maximum (212) in combination 10 and combinations 2, 3, 4, 5, 7, 8, 12, 13 and 14 were not significantly different. The least mean of 185.6 was for the first combination which did not differ significantly from the 6th, 9th and 11th combinations. The number of leaflets ranged from 172 in tree number 167 of 9th combination to 230 in tree number 359 of 5th combination. Heritability was estimated to be 27.9 per cent , PCV and GCV being 5.98 and 3.16 respectively.

d.Length of leaflets. The combinations having different mother palms and same pollen parent differed significantly at 1 per cent level in this character.Second combination had the highest mean of 91.4 cm which was not significantly different from combinations 3, 4, 5, 7, 8 and 13. The least mean length of 69.9 cm was observed for first combination which was statistically on par with 9, 10, 11 and 12. It ranged from 61.25 cm in tree

number 304 of first combination to 101.5 cm in tree number 27 of combination 2. This trait had relatively high heritability which was 35.7 per cent. The PCV was estimated to be 10.82 and GCV 6.47.

e.Width of leaflets. There was statistically significant difference at 1 per cent level between progenies of different mother palms with same pollen parents with respect to this attribute. The maximum mean width of 3.82 cm was recorded for combination 4 which was statistically on par with combinations 2, 7, 8 and 14. The minimum mean width of 2.62cm in combination 1 did not differ significantly from that in 3, 5, 6, 9, 10, 11, 12 and 13. It ranged from 2.2 cm in tree number 167 of 9th combination to 4.6 cm in tree number 61 of 4th combination. PCV was estimated to be 17.04 and GCV 8.93 for this trait. The character had a heritability of 27.3 per cent.

B.Floral characters.

6.Number of spadices. The number of spadices produced differed significantly at 1 per cent level between combinations having different mother palms and same pollen parents. Mean number of spadices produced was maximum (9.5) in 13th combination which was not significantly different from combinations 3, 4, 5, 8 and 14. It was minimum (3.4) in 10th combination and was on par with combinations 1, 2 and 9. The number of spadices produced ranged from 2 in tree numbers 27, 281, 302, 312 and 321 belonging to combinations 1, 2, 10 and 12 to 11 in tree numbers 43, 72, 117 and 324 belonging to combinations 3, 8, 11 and 13 respectively. The GCV was 22.68 and PCV 40.69. The heritability

for this trait was 31 per cent.

7.Number of branches per spadix. Significant variation at 5 per cent level was observed amongmother palms intheir contribution of this particuler character to the progenies. Maximum mean number of 32.37 branches was observed in 5th combination and followed by combinations 2, 4, 9, 11, 12, 13 and 14 , though the differences were not significant.The lowest mean of 24.13 was observed in the first combination which did not show significant difference from combinations 3, 6, 7, 8 and 10. Number of branches per spadix ranged from 22 in tree number 240 of third combination to 38.33 in tree number 359 of fifth combination. The GCVwas 6.8 and PCV 13.39. The number of branches per spadix showed a heritability of 25.8 per cent.

8.Number of male flowers per branch. There was no significant difference between mother palmsas in the case of pollen parents in their contribution to the progeny in the number of male flowers per branch. The number of male flowers per branch ranged from 64 in tree number 302 of combination 10 to 230.86 in tree number 155 of combination 3, the overall mean being 160.67. As expected the heritability was as low as 6.5 per cent with GCV of 5.73 and PCV of 22.39.

9.Number of female flowers produced. Progenies of different mother palms and common pollen parent differed significantly at 1 per cent level in the number of female flowers produced during the study period. Combination 13 recorded the highest mean number of female flowers of 498.25, while 10th combination

Table 4.3A

Mean and range of floral characters.

Combination	Number of spadices per annum mean	Number of spadices per annum range	Number of branches per spadix mean	Number of branches per spadix range	Number of male flowers/ branch mean	Number of male flowers/ branch range	Number of female flowers per annum mean	Number of female flowers per annum range
1	4.60	2.00 - 7.00	24.13	23.00- 25.82	158.38	126.00-218.00	151.20	42.00-315.00
2	4.00	2.00 - 9.00	28.39	25.50- 36.44	157.60	116.00-198.00	105.80	62.00-216.00
3	8.20	5.00 -11.00	25.51	22.00- 31.09	175.97	110.00-230.86	222.40	38.00-520.00
4	7.40	4.00 -10.00	28.74	22.25- 36.20	168.60	137.00-226.00	215.20	46.00-373.00
5	7.80	7.00 - 9.00	32.37	28.25- 38.33	173.30	150.38-188.80	269.20	178.00-399.00
6	6.40	4.00 - 9.00	25.31	22.20- 29.57	138.65	100.67-187.56	155.80	70.00-278.00
7	6.40	6.00 - 8.00	27.66	25.20- 30.25	155.69	126.00-196.00	152.00	82.00-218.00
8	7.80	4.00 -11.00	27.15	23.75- 29.63	154.96	131.00-201.00	184.60	55.00-355.00
9	5.00	3.00 - 9.00	28.58	24.50- 34.00	161.88	134.10-186.20	127.40	24.00-362.00
10	3.40	2.00 - 7.00	25.19	23.00- 29.29	130.23	64.00-184.00	44.80	0.00-125.00
11	6.40	4.00 -11.00	28.80	24.60- 33.09	140.00	107.81-194.10	163.20	94.00-327.00
12	6.40	2.00 - 9.00	29.09	25.50- 32.00	159.68	121.00-191.00	220.60	39.00-364.00
13	9.50	9.00 -11.00	31.44	30.22- 33.56	204.83	181.90-221.20	498.25	298.00-792.00
14	8.80	7.00 -10.00	30.40	27.50- 32.50	178.45	113.00-216.40	178.20	97.00-257.00
CD	2.80		4.09		NS		152.79	
CD(for comparison of combination 13)	2.97		4.34				162.06	

+

showed the lowest mean value of 44.8 which did not differ significantly from the combinations 1, 2, 6, 7, 8, 9, 11 and 14. This trait ranged from zero in tree number 302 of 10th combination to 792 in tree number 384 of 13th combination. Female flower production had a heritability of 30.8 per cent with GCV and PCV of 42.88 and 77.25 respectively.

10.Number of buttons set. There was significant difference at 5 per cent level among progenies of different mother palms but same pollen parents with regard to the number of buttons set. The highest mean number of buttons set was 71 for 13th combination which did not differ significantly from 3rd, 4th, 5th, 7nth, 8th 12th and 14th combinations. The mean number of buttons set was lowest in combination 10 the value being 10.2 and showed no significant difference from the combinations 1, 2, 6, 7, 8, 9, 11, 12 and 14. It ranged from zero in tree numbers 21, 167 and 302 of combinations 6, 9 and 10 to 118 in tree number 117 of 3rd combination. The PCV was 88.83 and GCV 34.82 , the heritability being 15.4.

11.Setting percentage. There was no significant difference among progenies of different motherpalms as in the case of pollen parents as far as this character was concerned. This trait ranged from zero in tree numbers 21, 167 and 302 of combinations 6, 9 and 10 to 38.46 in tree number 218 of 7nth combination. The overall mean percentage set was 16.2. Heritability was as low as 8.7 per cent with a GCV of 16.05 and a PCV of 54.37.

Table 4.3B

Mean and range of floral characters.

Combination.	Number of buttons set per annum		Setting percentage		Duration of male phase.		Duraion of female phase.	
	mean	range	mean	range	mean	range	mean	range
1	14.60	2.00- 32.00	10.77	1.59- 22.38	18.47	14.50- 20.86	3.41	2.86 - 4.50
2	16.60	6.00- 36.00	15.97	9.68- 32.31	17.54	15.33- 20.22	2.99	2.50 - 3.78
3	48.20	10.00-118.00	21.86	18.25- 26.32	17.89	16.00- 19.38	3.46	2.33 - 4.40
4	47.40	6.00-111.00	18.76	13.04- 29.76	17.99	17.00- 18.50	3.40	3.00 - 3.67
5	44.60	28.00- 66.00	16.57	11.76- 19.27	17.58	16.43- 19.50	3.66	3.33 - 4.00
6	14.00	0.00- 29.00	9.02	0.00- 25.25	17.64	16.50- 19.00	3.29	3.00 - 3.75
7	39.40	20.00- 84.00	25.19	13.85- 38.46	18.50	17.75- 19.38	3.37	3.00 - 3.80
8	34.60	7.00- 62.00	17.76	12.73- 23.29	18.61	17.00- 20.50	3.46	3.00 - 4.00
9	18.20	0.00- 51.00	12.12	0.00- 21.74	18.56	16.50- 20.50	3.27	2.75 - 3.50
10	10.20	0.00- 41.00	12.65	0.00- 32.80	16.37	10.00- 18.67	2.67	0.00 - 4.00
11	31.60	7.00-103.00	15.66	6.54- 31.61	17.64	17.00- 18.20	3.58	3.40 - 3.80
12	34.40	1.00- 59.00	12.66	2.56- 20.70	17.42	13.50- 19.25	3.83	3.50 - 4.50
13	71.00	59.00- 85.00	16.45	8.21- 25.17	18.26	18.11- 18.36	4.20	3.89 - 4.50
14	41.40	15.00- 85.00	21.38	15.46- 33.19	17.99	16.20- 18.75	3.85	3.71 - 4.00
CD	33.92		NS		NS		0.72	
CD(for comparison of combination 13)	35.98						0.76	

12.Duration of male phase. No significant difference was observed in the duration of male phase in progenies either between motherpalms or between pollen parents. It ranged from 10 days in tree number 302 of combination 10 to 20.86 days in tree number 333 of combination 1(Plate-1). The overall mean duration of male phase was 17.88 days. Genotypic variance estimated was negative and hence heritability, GCV and PCV were not calculated for this trait.

13. Duration of female phase. Mother palms showed significant difference at 5 per cent level in the duration of female phase of their progenies. The longest mean duration of 4.2 days was recorded in 13th combination and was statistically on par with combinations 3, 5, 8, 11, 12 and 14. The shortest mean duration of 2.99 days was recordedin 2nd combination which did not differ significantly from combinations except 12, 13 and 14. This trait ranged from 2.33 days in tree number 240 of 3rd combination to 4.5 days in tree numbers 281, 321 and 346 of combinations 12, 1 and 13 respectively (Plate-2). PCV was estimated to be 18.05 and GCV 7.56. Heritability was observed as 17.4 per cent.

14. Pollen fertility and viability. Variation in pollen fertility and viability was not observed between palms at any point of time, while there existed considerable variation in different seasons. The seasonal effects are discussed in section E.

C.Genotypic and Phenotypic Correlations.

Genotypic as well as phenotypic correlations between every pair of seventeen characters observed were worked out as described in Chapter 3 and are provided in Table 4.5 and Table

Table 4.4

Hertability, Genotypic and Phenotypic Coefficients of variation

Character	Heritability	GCV	PCV
Girth	35.9	5.10	8.50
Internodal distance	46.0	15.67	23.11
No. of func. leaves	20.9	5.47	11.97
Leaf production	32.1	8.62	15.22
Leaf length	22.1	5.03	10.66
Petiole length	19.2	5.28	12.26
No.of leaflets	27.9	3.16	5.98
Length of leaflet	35.7	6.46	10.82
Width of leaflet	27.3	8.92	17.04
Spadix production	31.0	22.68	40.69
No. of branches per spadix	25.8	6.80	13.39
No.of male flowers	6.5	5.73	22.39
No.of female flowers	30.8	42.88	77.25
No.of buttons set	15.4	34.82	88.83
Percentage of buttons set	8.7	16.05	54.37
Duration of male phase	-8.4	--	--
Duration of female phase	17.4	7.56	18.05

Table 4.5
Genotypic Correlations among sventeen characters

Character	Girth (1)	Internodal dist. (2)	No.of func. leaves (3)	Annual leaf prdn. (4)	Length of leaf petiole (5)	(6)	Leaflets No.of (7)	Length (8)	Width (9)	No.of spadices (10)	No.of branches (11)	No.of male flrs. (12)	No.of female flrs. (13)	No.of button set (14)	Percentage set (15)	Duration of male phase (16)	female phase (17)
2	.684																
3	.720	.141															
4	.511	-.232	.974														
5	.923	.808	.678	.143													
6	.996	.612	1.212	.660	.756												
7	.893	.620	.251	.230	.675	.346											
8	.637	.597	.678	.494	.960	.836	.503										
9	.429	.401	.408	.625	.684	.404	.507	.761									
10	.611	.083	1.060	.815	.451	.890	.285	.510	.213								
11	1.048	.631	.778	.537	.698	.776	.410	.487	.389	.503							
12	1.371	.452	1.453	1.031	1.293	1.829	.435	1.031	.268	1.215	1.117						
13	.644	.200	.737	.534	.612	.757	.102	.481	-.137	.780	.612	1.460					
14	.911	.419	.968	.693	.889	.914	.602	.714	.262	.971	.728	1.718	.961				
15	.600	.512	.861	.590	.646	.932	1.033	.968	.950	.619	.427	.984	.208	.658			
16	-.032	-.431	.311	.496	-.365	.245	-.705	.050	.130	.254	-.148	-.051	.215	.169	.364		
17	.782	-.134	1.274	1.082	.051	.856	-.116	.255	-.050	1.332	1.065	1.467	1.370	1.466	.308	-.089	

Table 4.6

Phenotypic Correlations among sventeen characters

Character	Girth (1)	Internodal dist. (2)	No.of func. leaves (3)	Annual leaf prdn. (4)	Length of leaf (5)	petiole (6)	Leaflets No.of (7)	Length (8)	Width (9)	No.of spadices (10)	No.of branches (11)	No.of male flrs. (12)	No.of female flrs. (13)	No.of button set (14)	Percentage set (15)	Duration of male phase (16)	female phase (17)
2	.605																
3	.420	.182															
4	.397	.072	.648														
5	.509	.526	.262	.323													
6	.531	.439	.537	.507	.684												
7	.439	.428	.176	.204	.615	.447											
8	.387	.453	.363	.467	.540	.524	.401										
9	.212	.292	.130	.304	.275	.214	.246	.538									
10	.269	.103	.659	.680	.419	.524	.348	.461	.226								
11	.464	.352	.557	.475	.436	.495	.320	.435	.226	.552							
12	.228	.186	.487	.450	.239	.379	.047	.300	.091	.506	.357						
13	.343	.064	.596	.500	.301	.431	.181	.410	.043	.752	.523	.540					
14	.285	.133	.548	.571	.407	.481	.318	.452	.230	.824	.535	.472	.791				
15	.178	.301	.248	.387	.308	.218	.312	.264	.315	.498	.229	.247	.189	.619			
16	-.173	.035	.300	.21@@7	.030	.125	-.147	.140	.175	.298	.174	.421	.230	.238	.153		
17	.141	.207	.358	.284	.287	.376	.144	.146	-.083	.358	.239	.439	.341	.311	.211	.492	

4.6 respectively.

The number of buttons set, the most important economic character has highly significant genotypic correlation with trunk girth (.911), number of functional leaves (.968), length of petiole (.914), length of leaf (.889), number of leaflets (.602), length of leaflets (.714), spadix production (.971), number of branches per spadix (.728), and female flower production (.961). Its genotypic correlation with number of male flowers was greater than unity and has to be considered as high. The corresponding phenotypic correlations were .285, .548, .481, .407, .452, .318, .824, .535 and .791 respectively. It was highest for number of spadices while genotypic correlation was highest for number of functional leaves. In general, phenotypic correlations were not so high as the genotypic correlations, though they were not very low. The percentage of buttons set also had high genotypic correlation with trunk girth (.6), number of functional leaves (.861), length of petiole (.932), length of leaf (.646), number of leaflets (1.033), length of leaflets (.968), width of leaflets (.95) and male flower production (.984). Trunk girth had very high genotypic correlation with all leaf characters, female flower production, number of buttons set and percentage set and so was the case of number of functional leaves.

D.Genetic divergence.

Fourteen characters for which the combinations were significantly different were selected for D2 analysis. The Lamda criterion for testing the overall difference among the combina-

Table 4.7

Mahalanobis' D2 values between fourteen Combinations

	Combinations												
	1	2	3	4	5	6	7	8	9	10	11	12	13
2	30.48												
3	33.21	12.52											
4	41.65	11.67	2.86										
5	54.44	20.63	10.99	4.44									
6	20.04	18.86	5.60	11.82	19.59								
7	23.05	14.29	4.74	9.57	17.76	3.51							
8	40.91	16.23	2.84	5.32	15.44	10.97	7.24						
9	18.77	14.43	5.86	9.69	18.81	2.28	5.59	8.94					
10	19.79	30.25	50.9**2	53.73	69.98	50.09	40.05	56.38	45.51				
11	13.35	15.98	11.94	17.40	33.27	11.70	7.64	12.62	9.18	22.36			
12	37.74	13.30	7.83	3.87	9.69	17.78	15.51	7.86	10.94	47.10	16.40		
13	165.53	92.37	64.64	50.14	42.75	89.15	91.97	63.14	81.68	195.43	115.79	53.79	
14	128.96	77.48	40.96	37.55	35.75	55.93	53.06	32.20	55.00	161.65	80.04	44.43	30.37

tions with respect to the selected fourteen characters was found significant. Consequently, Mahalanobis'D^2 value was calculated for every pair of combinations and are furnished in Table 4.7. Maximum D^2 value (195.43) was obtained between combinations 13 and 10 followed by 13 and 1 (165.43). combinations 9 and 6 had the minimum D^2 value of 2.28 followed by 8 and 3 , the value being 2.84. The combinations were grouped by the computer oriented iterative algorithm based on the D^2 values. The number of clusters was determined as 3 by the method of maximum curvature. The cluster configuration is provided in Table 4.8 . The inter and intra cluster D^2 values and the inter and intra cluster distances ($\sqrt{D^2}$ values) are given in Tables 4.9 and 4.10 respectively. Clusters I and II were the most divergent (12.76) ones. 10th and 1st combinations, the most distant from 13th combination constituted Cluster I (Plate-3) and 13th and 14th combinations formed Cluster II (Plate-4). Cluster III consisted of the remaining ten combinations (Plate-5) and was more close to Cluster I than to Cluster II, the corresponding distances being 6.24 and 7.93.

The clustering pattern is represented in Fig.1. The mean and range of different characters of each cluster are provided in Tables 4.11 and 4.12 respectively. Cluster II consisted of parental combinations with most desirable properties such as maximum number of female flowers set, female flower production, girth, number of spadices produced, number of functional leaves and annual leaf production. Cluster I had the least of all these desirable characters.

Table 4.8

Cluster Configuration

Cluster	Numbers of parental combinations
I	1, 10
II	13, 14
III	2, 3, 4, 5, 6, 7, 8, 9, 11, 12

Table 4.9

Inter and intra cluster D2 values

Cluster	I	II	III
I	19.79		
II	162.89	30.37	
III	39.00	62.89	11.49

Table 4.10

Inter and intra cluster distances ($\sqrt{D2}$ values)

Cluster	I	II	III
I	4.45		
II	12.76	5.51	
III	6.24	7.93	3.38

Fig-1. CLUSTER DIAGRAM

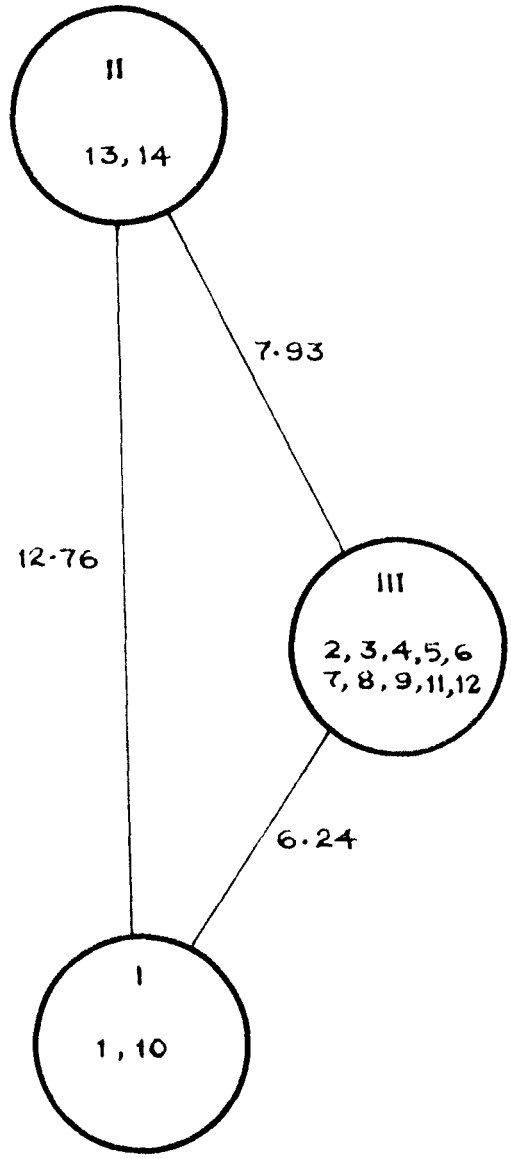


Table 4.11

Cluster means for the 17 characters

Characters	Clusters I	II	III
Girth	67.90	76.78	70.43
Internodal distance	4.52	4.75	4.84
No. of fun. leaves	16.50	21.00	18.48
Leaf production	11.80	16.78	14.12
Leaf length	3.12	3.43	3.35
Petiole length	1.22	1.47	1.34
Number of leaflets	198.80	206.44	200.16
length of leaflets	71.62	84.50	83.01
Width of leaflets	2.75	3.26	3.29
No. of spadices/annum	4.00	9.11	6.58
No. of branches/spadix	24.66	30.86	28.16
No.of male flowers/branch	144.31	190.17	158.63
No.of female flowers/annum	98.00	320.44	181.62
Number of buttons set	12.40	54.56	32.90
Percentage of buttons set	11.71	19.19	16.56
Duration of male phase	17.42	18.11	17.94
Duration of female phase	3.04	4.01	3.43

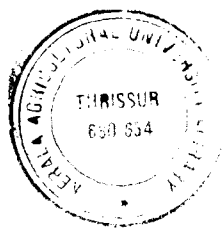


Table 4.12

Range in 17 Characters for the three Clusters.

Character	CLusters I	II	III
Trunk girth	62.00 - 75.00	691.00 - 87.00	569.00 - 90.00
Internodal distance in cm	2.93 - 6.21	3.64 - 6.43	2.43 - 9.21
No.of functional leaves	14.00 - 20.00	19.00 - 26.00	14.00 - 22.00
Annual leaf production	10.00 - 14.00	14.00 - 22.00	10.00 - 17.00
Length of leaf in m	2.67 - 3.50	3.10 - 3.73	2.70 - 4.62
Length of petiole in m	1.07 - 1.50	1.13 - 1.85	1.05 - 1.67
Number of leaflets	174.00 - 222.00	194.00 - 218.00	172.00 - 213.00
Length of leaf-lets in cm	61.25 - 79.50	78.75 - 94.00	66.75 - 101.50
Width of leaf-lets in cm	2.43 - 3.28	2.75 - 3.83	2.10 - 4.60
No. spadices	2.00 - 7.00	7.00 - 11.00	2.00 - 11.00
Number of branches/spadix	23.00 - 29.29	24.88 - 33.56	22.00 - 38.33
Number of male flowers/branch	64.00 - 218.00	113.00 - 221.20	100.67 - 230.86
Number of female flowers produced	00.00 - 315.00	97.00 - 792.00	24.00 - 520.00
Number of buttons set	0.00 - 41.00	15.10 - 85.00	0.00 - 118.00
Percentage of buttons set	0.00 - 32.80	8.21 - 33.19	0.00 - 38.46
Duration of male phase	10.00 - 20.86	16.20 - 19.38	13.50 - 20.50
Duration of female phase	0.00 - 4.50	3.63 - 4.50	2.33 - 4.50

E.Seasonal effect on Floral Characters.

The number of spadices, number of female flowers produced, active female phase and the corressonding number and percentage of buttons set, pollen fertility and viability during the different standard weeks of the study period of one year are furnished in Table 4.13. The trend obtained in these traits by taking three week moving averages are provided in Table 4.14. Trends in production of spadices and female flowers are graphically represented in Fig. 2 and that in number and percentage of buttons set are represented in Fig. 3.

It was observed that no spathe opened during the study period till the end of December 1985. Spadix production initiated in early January and gradually increased reaching its peak in the middle of March with 29 spadices in the standard week from 11th march. Thereafter the production decreased slowly and attained zero by october,1986.

Female flower production also showed a similar trend as that of spadix production. Maximum number of female flowers have been recorded to be 978 during the period of 11th to 17th of March and minimum production of 18 female flowers was recorded during January 8th to 14th. No spadix was produced in any of the selected palms from 15th October (beginning of the study) to 31st December 1985. More female flowers were produced during February, March, April and May having the maximum in March. Occurance of female phase was first observed during the last

Table 4.13

Distribution of floral characters by standard week

Week	No.of spadices opened	No. of female flowers	No.of spadices having female phase	No. of receptive female flowers	No. of buttons set	Percentage of buttons set	Fertility	Viability
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Oct.15 to Dec. 31	-	-	-	-	-	-	-	-
Jan. 1- 7	1	63	-	-	-	-	-	-
8-14	1	18	-	-	-	-	98.76	85.26
15-21	2	74	-	-	-	-	99.64	91.88
22-28	2	155	2	81	0	0.00	95.34	87.06
Feb.29- 4	11	398	0	0	0	0.00	97.07	87.21
5-11	13	530	2	74	4	5.41	96.49	89.62
12-18	17	703	2	155	12	7.74	97.50	92.07
19-25	18	548	12	447	46	10.29	97.23	88.87
Mar.26- 4	18	729	9	420	49	11.67	98.34	87.49
5-11	10	341	17	779	86	11.04	97.74	79.35
12-18	29	978	19	616	77	12.50	97.77	94.66
19-25	19	485	13	644	60	9.32	96.54	84.07
26- 1	19	622	8	279	29	10.39	94.60	72.48
Aprl.2- 8	21	642	28	1042	125	12.00	60.50	0.00
9-15	20	645	17	545	78	14.31	66.00	0.00
16-22	16	437	18	559	70	12.52	66.10	0.00
23-29	23	741	15	563	69	12.26	65.00	0.00
May 30- 6	13	265	23	777	166	21.36	64.80	0.00
7-13	12	225	9	305	45	14.75	64.50	0.00
14-20	15	493	21	762	181	23.75	63.80	0.00

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
21-27	20	507	8	198	74	37.37	80.90	0.00
Jun.28- 3	15	331	12	273	68	24.91	92.00	31.00
4-10	7	168	14	499	107	21.44	97.90	80.00
11-17	8	211	15	449	91	20.27		
18-24	7	165	14	341	34	9.97		
Jul.25- 1	14	314	5	111	2	1.80		
2- 8	4	95	8	221	35	15.84	98.14	89.00
9-15	7	182	6	140	18	12.86	98.10	88.50
16-22	14	273	12	271	36	13.28	97.80	87.80
23-29	10	216	3	80	14	17.50	98.20	90.50
Aug.30- 5	7	173	7	182	38	20.88	98.40	89.90
6-12	13	285	12	260	49	18.85	97.30	85.90
13-19	6	124	9	187	85	45.45	96.79	83.83
20-26	7	177	7	173	52	30.06	97.10	85.50
Sep.27- 2	15	310	8	175	63	36.00	95.70	87.60
3- 9	9	199	12	260	98	37.69	97.40	88.00
10-16	3	52	9	214	79	36.92	98.00	87.90
17-23	9	196	14	291	114	39.18	98.20	88.60
24-31	6	116	7	155	61	39.35	97.50	85.50
Oct. 1- 7	-	-	4	78	37	47.44	97.9	84.10
8-14	-	-	8	17			98.00	87.20

Fertility and viability of pollen could not be determined from 11 nth June to 1st Jully due to heavy rain.

week of January, though the corresponding number of buttons set was nil. The number of buttons set increased and reached its peak when the female phase occured in May and a sudden decline was noted by the middle of June. But the number of buttons set showed an increasing trend from July to the end of the study period, though this rise was never anywhere near the peak observed in May.

The setting percentage was zero during January and was less than eight till the middle of February. From then on it fluctuated between 1 and 15 till the end of April. By the end of April the setting percentage rose to 20 and above and remained so up to the middle of June when there was a sudden drop to 1.8 in the last week of June. Thereafter it increased and reached 45 percent by the middle of August and fluctuated between 30 and 45 till the end of the study period. The maximum percentage set was recorded when the inflorescence had its female phase in the week starting on 2nd October.

The pollen fertility was fluctuating between 95 percent and 100 percent from the second week of January when the first male phase was observed to the end of March. There was a steep decline in pollen fertility by the beginning of April and fluctuated between 60 percent and 67 percent till the third week of May. Thereafter it increased and reached above 90 percent by the end of May and remained so till the end of the study period.

The pollen viability was observed to be fluctuating between 80 percent and 95 percent from the second week of

Table 4.14

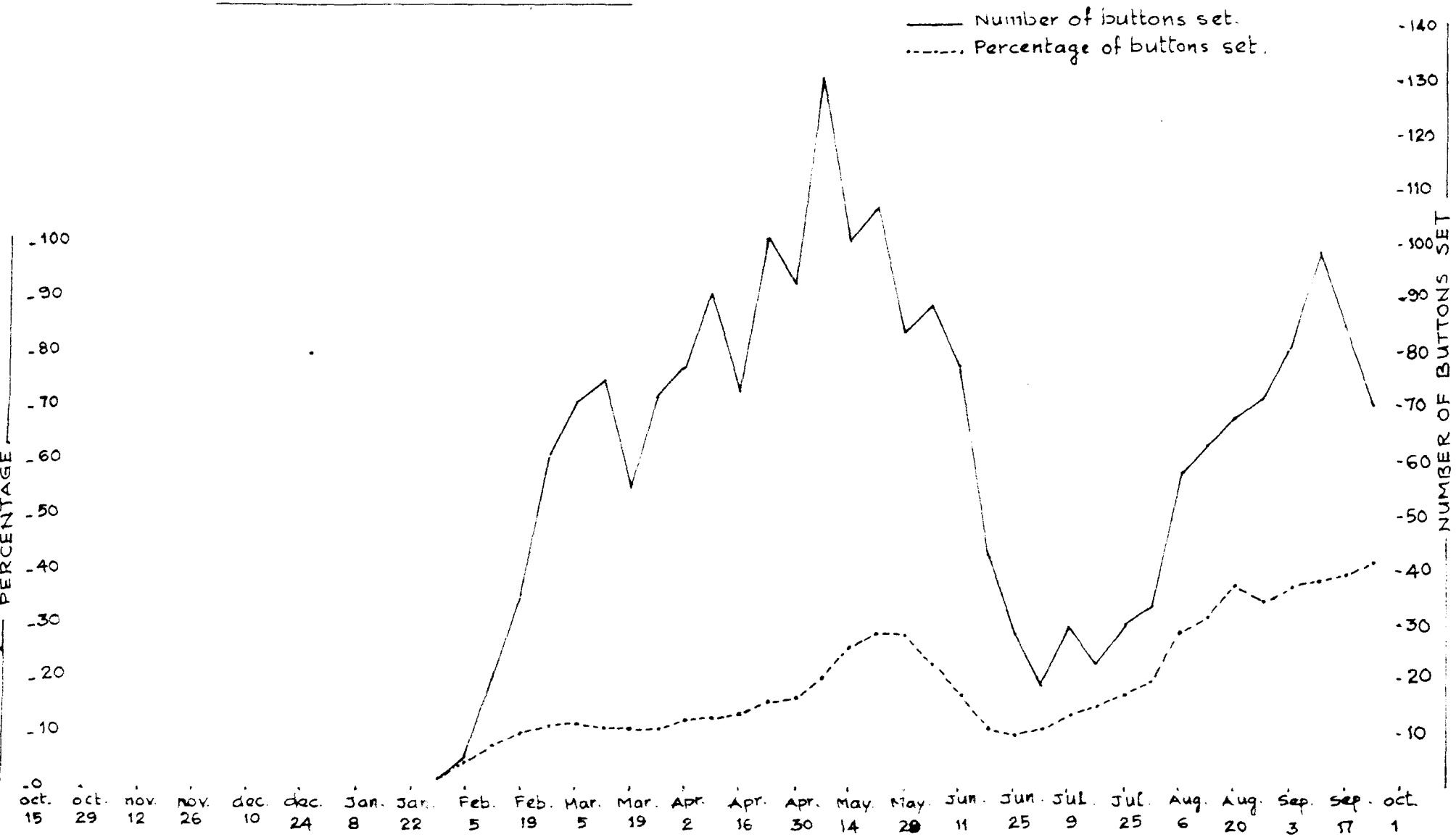
Three week moving averages of floral characters

Week	No.of spadices opened	No. of female flowers	No.of spadices having female phase	No. of receptive female flowers	No. of buttons set	Percentage of buttons set	Pollen fertility	Pollen viability
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Oct.15 to Dec.31	-	-	-	-	-	-	-	-
Jan. 1- 7	-	-	-	-	-	-	-	-
8-14	1.33	51.67	-	-	-	-	-	-
15-21	1.67	82.33	0.67	27.00	-	-	97.91	88.07
22-28	5.00	209.00	0.67	27.00	-	-	97.35	88.72
Feb.29- 4	8.67	361.00	1.33	51.67	1.33	1.80	96.30	87.96
5-11	13.67	543.67	1.33	76.33	5.33	4.38	97.02	89.63
12-18	16.00	593.67	5.33	225.33	20.67	7.81	97.07	90.18
19-25	17.67	660.00	7.67	340.67	35.67	9.90	97.69	89.48
Mar.26- 4	15.33	539.33	12.67	548.67	60.33	11.00	97.77	85.24
5-11	19.00	682.67	15.00	605.00	70.67	11.74	97.95	87.17
12-18	19.33	601.33	16.33	679.67	74.33	10.95	97.35	86.03
19-25	22.33	695.00	13.33	513.00	55.33	10.74	96.30	83.74
26- 1	19.67	583.00	16.33	655.00	71.33	10.57	83.88	52.18
Aprl.2- 8	20.00	636.33	17.67	622.00	77.13	12.23	73.70	24.16
9-15	19.00	574.67	21.00	715.33	91.00	12.94	64.20	0.00
16-22	19.67	607.67	16.67	555.67	72.33	13.03	65.70	0.00
23-29	17.33	481.00	18.67	633.00	101.67	15.38	65.30	0.00
May 30- 6	16.00	410.67	15.67	614.67	93.33	16.12	64.77	0.00
7-13	13.33	327.67	17.67	614.67	130.67	19.95	64.37	0.00
14-20	15.67	408.33	12.67	421.67	100.00	25.29	69.73	0.00

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
21–27	16.67	443.67	13.67	411.00	107.67	26.62	78.90	10.33
Jun.28– 3	14.00	355.33	11.33	323.33	83.00	27.91	90.27	33.67
4–10	10.00	236.67	13.67	407.00	88.67	22.21		
11–17	7.33	181.33	14.33	429.67	77.33	17.23		
18–24	9.67	230.00	11.33	300.33	42.33	10.60		
Jul.25– 1	8.33	191.33	9.00	224.33	28.67	9.20		
2– 8	8.33	197.00	6.33	157.33	18.33	10.17		
9–15	8.33	183.33	5.33	210.67	29.67	13.99	93.01	86.45
16–22	10.33	223.67	3.67	163.67	22.67	14.55	93.03	88.03
23–29	10.33	220.67	4.00	177.67	29.33	17.22	93.13	89.40
Aug.30– 5	10.00	224.67	7.33	174.00	33.67	19.08	97.97	86.77
6–12	8.67	194.00	9.33	209.67	57.33	28.39	97.50	86.54
13–19	8.67	195.33	9.33	206.67	62.00	31.45	97.06	85.08
20–26	9.33	203.67	8.00	178.33	66.67	37.17	96.53	85.64
Sep.27– 2	10.33	228.67	9.00	202.67	71.00	34.58	96.73	87.03
3– 9	9.00	187.00	9.67	216.33	80.00	36.87	97.03	87.83
10–16	7.00	149.00	11.67	255.00	97.00	37.93	97.87	88.17
17–23	6.00	121.33	10.00	220.00	84.67	38.48	97.90	87.33
24–31	–	–	8.33	174.67	70.67	41.99	97.87	86.07
Oct. 1– 7	–	–	6.33	83.33	–	–	–	–
8–14	–	–	6.00	70.33	–	–	–	–

Fig.2. TREND IN PRODUCTION OF SPADICES AND FEMALE FLOWERS

FIG-3. TREND IN NUMBER OF BUTTONS SET AND SETTING PERCENTAGE.



January to the third week of March. Then there was a drop to 72.5 percent in the last week of March and became zero till the end of May. It was 30 percent in early June and recovered to 80 percent in the succeeding week and continued to oscillate between 80 percent and 90 percent till the end of the study period.

DISCUSSION

DISCUSSION

Development of superior and high yielding coconut strains has received attention only recently. The importance of utilising the prococious bearing character of dwarfs in breeding was first realised by Patel (1938), who observed maximum hybrid vigour when the tall variety was used as female parent with dwarf as male. The success of the crop improvement programme lies on the effective identification of superior genotypes utilising the available source of existing genetic variability in the population, that make selection more effective.

The information gathered in the present investigations on variabiity in F_1 coconut hybrids would permit identification of superior mother palms. The analysis performed helped to identify superior genotypes capable of transmitting their traits to progenies and the extent of genetic variability can be utilised to identify superior types through appropriate breeding procedures. Important results are discussed in this chapter as follows.

General variability.

The extent of variability for the different vegetative and floral attributes in the progenies of the three pollen parents was only moderate, while that contributed by the different female parents was relatively conspicuous. The analysis of variance of the 17 characters viz., girth, internodal distance, length of 14th leaf and its petiole, number, length and width of leaflets of 14th leaf, number of spadices, number of branches

per spadix, number of female flowers, number of buttons set, percentage of buttons set and duration of male and female phases is given in Table 4.1. The extent of variability was assessed from range, GCV and PCV which are given in Tables 4.2A, 4.2B, 4.3A, 4.3B and 4.4. The pollen parents used in different crosses were N8/1, N8/7 and N8/17 and no significant difference was observed between their progenies in any of the characters studied. On the other hand, progenies from different mother palms differed significantly with respect to all characters except number of female flowers, percentage of buttons set and duration of male phase. In other words, the mother palms had greater share in the contribution of most of the traits to their progenies than the pollen parents.

Cytoplasm had been established as a vehicle of inheritance in plants. Majority of the cytoplasm of the progenies is contributed by the female parent rather than by the male parent. Hence the inheritance of most characters will be more through the mother palm than through pollen parent. Similarity of the pollen parents could also be the reason for nonsignificance of differences among their progenies. The differences observed between progenies of different mother palms and the same pollen parent could be either because of the varying contribution from mother palms or due to the interaction of male and female parents or due to genotype environment interaction. The specific reason for this could not be assertained from the data gathered in this investigation. Bavappa et al. (1973) observed significant difference in girth, internodal distance, number of functional

leaves, length of leaf, number of leaflets, female flower production and setting percentage between parental combinations in nine F_1 families of T X D hybrid coconuts. Nonsignificant differences among progenies of different crosses with respect to number of male flowers, percentage of buttons set and duration of male phase was mainly due to the large variation in these characters between progenies with in the same cross. The relatively high values of PCV and low values of GCV for these attributes indicate greater extent of environmental effect on them. No previous reports have indicated this situation in coconut hybrids.

Correlation and Heritability.

Correlation coefficients worked out at genotypic level revealed existance of strong positive association of button set with most of the characters. Button set was highly correlated with number of spadices (0.971) followed by the number of functional leaves (0.968), number of female flowers (0.961), petiole length (0.914) and girth (0.911). The corresponding phenotypic correlations were 0.824, 0.548, 0.791, 0.481 and 0.285 respectively. This is in general agreement with the results of earlier workers. Satyabalan *et al.* (1972) observed high positive correlation of yield with stem height and number of functional leaves (0.686 and 0.680), while high genotypic correlation of female flowers with yield (0.933) was reported by Nampoothiri *et al.* (1975) in different open pollinated tall palms. Similarly significant and positive correlation of stem height with yield (0.622) was observed by Ramanathan (1984).

Heritability was observed to be 30.8 per cent for number of female flowers produced and 15.4 per cent for the number of buttons set. Corresponding GCV was 42.9 per cent and 34.8 per cent respectively. In other words, heritability of female flower production is much higher than that of number of buttons set. More over female flower production has very high genotypic correlation (0.961) with number of buttons set. Hence, selection of mother palms based on female flower production will be much more effective than that based on button set. Previous attempts in this line are scarce. But Liyanage (1961) reported a very high heritability of 0.81 for the ratio of nuts to female flowers per bunch, which indicated a predominant role of the genotype on the manifestation of this economic attribute.

Heritability estimates for the characters having high genotypic correlation with the number of buttons set were also fairly high (Table 4.4). Medium to moderately high estimates were obtained for the characters internodal distance, trunk girth, length of leaflets, spadix production and number of female flowers, while it was lowest for number of male flowers and percentage of buttons set. Hence, selection of female parent based on number of spadices, number of functional leaves, female flower production, length of leaf and trunk girth will be effective to achieve high yield of progenies. Very low heritability was observed for number of male flowers (6.5 per cent) followed by percentage of buttons set (8.7 per cent) which indicated that more than 90 per cent of the variation in these characters were contributed by environment rather than genetic. This sugge-

sts that these characters were less stable and highly susceptable to environmental effects. Environmental components were found to far exceed the genetic components, there by indicating the predominating influence of environment in the manifestation of such characters. Such high environmental variation in these characters resulted in nonsignificant difference among combinations with regard to these characters. Due to the low heritability, selection of mother palms should not be based on these characters.

Louis (1981) observed a wide range in phenotypic variation in 25 varieties and two hybrids. Maximum phenotypic coefficient of variation was observed for the number of female flowers (66.66) followed by setting percentage (63.06), number of nuts per annum (58.69), length of leaf (56.79) and number of spathes per annum (50.74). A very high genotypic correlation of female flower production with yield (0.961) in the present study suggests that selection of mother palms based on female flower production will be much more effective than that based on yield.

Genetic Divergence.

There exists considerable amount of genetic variation even with in one group of coconut, say tall, which offers great scope for selection (Kavappa, 1973). It is desirable to investigate the degree of variability in a population of tall and dwarf palms which can be utilised for selection of parents to achieve the breeding objectives.

In the present investigations, grouping of the 14 parental

combinations in to clusters using the computer oriented iterative algorithm based on Mahalanobis' D^2 values was performed. Three clusters were identified (Table 4.7). Cluster I cosisted of combinations 1 and 10 , the progenies of which were poor in performance with respect to all the characters studied. Similarly cluster II contained combinations 13 and 14 and they were found to possess superiority in respect of the desirable traits such as spadix production, number of branches per spadix, female flower production, trunk girth, number of functional leaves, annual leaf production, number of leaflets, length of leaf, petiole and leaflets (Table 4.2A, 4.2B, 4.3A and 4.3B). Naturally, these two clusters were the most distant ones (12.76). The third cluster was constituted by the remaining 10 combinations, which were moderate in these characters as evidenced by analysis of variance.

The observations made from the analysis of variance of individual characters could be substantiated by clustering based on the simultaneous consideration of all the characters. Hence, it could be inferred that the female parents used for the production of the 13th and 14th combinations namely G/115 and 1/123 were the most desirable ones and those used for combinations 1 and 10 were inferior for hybridisation. Bavappa et al. (1973) also grouped 9 F_1 families of WCT X Dwarf green coconut hybrids into four clusters based on 13 vegetative and yield traits using Mahalanobis D^2 and identified superior mother palms. They suggested that, with proper choice among tall and dwarf varieties, efficient exploitation of the hybrids could be effected. Bala-

krishnan (1982) also used D2 analysis to asses genetic divergence in 24 cultivars of west coast tall coconut palms and grouped them in to six clusters on the basis of 17 economic characters constituting vegetative, floral and nut characters. Clusters I and II were found to be genetically closer, the distance being 3.06 and clusters IV and VI were wider having a distance of 8.72.

Investigations made on variability in T X CDO coconut hybrids showed that the traits such as spadix production, number of branches per spadix, female flower production, trunk girth, number of functional leaves, annual leaf production, number of leaflets, length of leaf, petiole and leaflets have direct and marked influence on the number of buttons set and that these characters can be relied up on in the selection of potential mother palms capable of producing high yielding progenies.

Effect of season on floral characters.

There appeared to have definite effect©© of the season on the behaviour of the palms in respect of the manifestation of major economic traits in coconut. Spathe opening was almost nil from October to December during the course of the investigation. Spadix emergence was observed to commence by early January and it gradually increased reaching a peak in the middle of March with a total of 29 spadices in the population studied in the standard week from 11th March. There after the production decreased slowly and attained zero by the next October. This is in general agreement with the findings of Patel (1938) who

observed that the maximum number of bunches opened during the month of March at Nileshwar-1 and in the month of April at Kasaragod. The number of bunches was very low from October to January at both the places. They reported relatively high rate of abortion of spadices that were to open during the rainy months and attributed to the drought at the time of formation of branches. Bhaskaran and Leela (1983) also obtained similar results in tall and dwarf varieties and expressed the view that abortion of spadix occured mostly during the south west monsoon. Spadix abortion was lowest during hot weather period (October and November).

Female flower production also showed a similar trend as spadix production. More female flowers were produced during the months of February, March, April and May and a maximum of 978 was recorded in the experimental trees during the period from 11th to 17th of March. Where as the minimum production of 18 was recorded during January 8th to 14th (Table 4.13). No spadix was produced in any of the selected palms from 15th October (beginning of the study period) to 31st of December 1985. This is in agreement with the observation made by Patel (1938) and Bhaskaran and Leela (1983). According to the former, the production of female flowers in WCT variety was low from September to January and high during March to May at Kasaragod. The low production in September to January is probably due to the adverse effect of the seasons at the time of differentiation of the ovary and the perianth from the primordium of the female flower whichtakes place about six to seven months prior to the opening of the

spathe. In other words, the first differentiation of the ovary in the spadices which open during February to June takes place in the rainy months. On the contrary, differentiation of the ovaries of the spadices that open during August to December when production of female flowers is generally low, takes place during the dry months of February to June (Menon and Pandalai, 1960). Bhaskaran and Leela (1983) also observed similar pattern for female flower production. They reported that 50 per cent of annual female flower production was accounted for in hot weather period.

Setting of buttons in the inflorescences having active female phase during the course of the investigations exhibited a uniform trend - the values ranging from 30 to 47 per cent except in the last week of June, when it was only 1.8 per cent which possibly could be the undesirable consequences of heavy rains (328 ml) experienced during this period which in turn affected adequate pollination. High setting percentage observedduring August, September and October must be due to the favourable climatic conditions especially the absence of moisture stress in the soil and a temperature range of 22oCto 30oC. Relative humidity in the FN was 90 and between 60 and 80 in the AN. Pollen fertility appeared to be the least influenced by seasonal variations. It was above 90 per cent in all standard weeks except in the summer months of April and May during which the fertility was between 60 and 70 per cent. The decrease in fertility could be due to the effect of relatively high temperature that prevailed and /or dueto increased moisture stress in the soil as

reported by Stanley and Linskens (1974). Pollen Viability also had the same trend keeping a level above 80 per cent for most of the study periodd, but was totally inviable in summer months. A moderately high level of button setting notwithstanding low pollen fertility and complete pollen inviability is difficult to explain and needs further study. However the possibility of pollination and fertilisation during early hours of the day, when the temperature is not too high to be detrimental to pollen germination cannot be ruled out.

SUMMARY

SUMMARY

Investigations were carried out to examine the nature and extent of variability in 17 vegetative and floral characteristics of 14 parental combinations between Tall and Chowghat Dwarf Orange (T X CDO) hybrids maintained at the KADP farm of the College of Horticulture, Kerala Agricultural University for a continuous period of 12 months from 15th October 1985. Saliant results obtained from the study are summarised below.

1. The pollen parents did not differ significantly in their contribution to the progenies in the magnitude of variability expressed by any of the 17 characters studied while female parents differed in their contribution in most of the traits.

2. A very high genotypic correlation of 0.971 was observed between the number of flowers set and the number of spadices followed by the number of functional leaves (0.968) and the number of female flowers (0.961). So, emphasis should be given to these attributes in exercising selection.

3. Phenotypic coefficient of variation was found to be highest for the number of buttons set (88.83) followed by number of female flowers (77.25) and percentage of buttons set (54.37). The genotypic coefficient of vaiation was maximum for number of female flowers (42.88) followed by number of buttons set (34.82) and the number of spadices (22.68) indicating a greater influence of environment in the expression of these attributes.

4. A very high heritability was observed for internodal distance (46.0) followed by girth (35.9), length of leaflets (35.7) and annual leaf production (32.1). Very low heritability was observed in the case of duration of male phase, number of male flowers and percentage of buttons set and hence there is not much scope for the selection of promising genotypes based on these characters.

5. All the 14 parental combinations could be grouped into three clusters using Mahalanobis' D^2 analysis based on 14 characters for which combinations differed significantly. Cluster I consisted of two combinations which were inferior with respect to all the desirable traits, while Cluster II consisted of two combinations which were superior with respect to the desirable traits. Expectedly, these two clusters were most divergent. The third cluster consisted of the remaining 10 combinations which were moderate with respect to the desirable traits.

6. Spadix production did not occur during October, November and December. It was found to commence in early January and gradually incresed reaching the peak by the middle of March (29 spadices in the standard week from 11th March). Thereafter production decresed slowly and attained zero by October 1986. Female flower production also showed a similar trend as that of spadix production.

7. Percentage setting of buttons was low during the months of January anf February and medium to moderately high from March to October (27 to 47 per cent) with a drastic drop to 1.8 per cent

in the last week of June when heavy rains prevailed.

8. Pollen fertility was very high (above 90 per cent) during the study period except in April and May, when it ranged from 60 to 67 per cent. Pollen viability also had a similar trend. Generally it was above 80 per cent, but the pollen was completely inviable during the summer months of April and May cosequent on the high ambient temperature.

REFERENCES

REFERENCES

*Abeyavardena,V. (1971). Yield variations in coconut. Ceylon cocon. Q.22(3) : 97-103.

*Aldaba,V.C. (1921). The pollination of Coconut. Philipp. Agriculturist. 10 : 195-210.

Balakrishnan, P.C. (1982) Genetic Divergence in Coconut. M.Sc. thesis sumbimitted to the Kerala Agricultural University.

*Balingasa,E.N. and Carpio, C.B. (1977). Genetic potential of some coconut populations in the Philippines. Oliagineux. 32

Bavappa,K.V.A., Sukumaran,C.K. and Mathew,J. (1973). A study of F_1 hybrids of Tall X Dwarf coconuts and its bearing on the genetics of dwarfness. J. Plant. Crops. 1(Suppl) : 1-6

Bhaskaran,U.P. and Leela,K. (1964) Hybrid coconut - Tall X Dwarf - a comparative study with parental types. Agric. Res. J. Kerala. 1(2) : 67-84

Bhaskaran,U.P. and Leela,K. (1983) Seasonal influence on yield of Tall X Dwarf and West Coast Tall varieties of coconut. In Coconut Research and Development. ed. N M Nayar. Wiley Eastern Limited, New Delhi. pp. 518

Child,R (1974) Coconuts. Longman, London. pp.335

Davis,T.H. (1954). A leaf sampling knife suited for coconut and similar palms. Indian Cocon. J. 8 : 26-29

Federer,W.T. (1967) Experimental Design - Theory and Application. Oxford and IBH publishing Co. Calcutta, Bombay, New Delhi. pp. 544

Gangolly,S.R., Kamalakaran,A.K., Balakrishnan,T.K. and Pandalai,K.M. (1961). Studies on the pollen in the coconut (Cocos nucifera.L). Its importance, output in different varieties and composition in the still air. Indian cocon. J. 14 : 49-65.

Iyer,R.D., Bhaskara Rao,E.V.V and Govindankutty,M.P. (1979). Super yielders in Coconut. Indian Farming.

*Jack,H.W. (1932) Annual variation in coconut crops. Malay. agric. J. 20 :61-66

*Jack,H.W and Sands,W.N. (1922) The dwarf coconut in Malaya. Malay. agric. J. 10 : 4-13

*Jack, H.W. and Sands,W.N. (1929). Observations on the dwarf coconut palm in Malaya. Malay. agric. J. 17 : 140-70

*Juliano,J.B. (1926). Origin, development and nature of the stony layer of the coconut (cocos nucifera). Philipp. J. Sci. 30 : 187-200

*Juliano,J.B. and Quisumbing,E. (1931). Morphology of male flower of Cocos nucifera Lin. Philipp. J. Sci. 45 : 449-58.

Krishnan,P. and Nambiar,K.P.P. (1972). Effect of different dwarfs on the performance of tall X dwarf hybrids. Cocon. Bull. 11(10) : 2-5.

*Liyanage,D.V. (1950). Sex life of coconut palm. Ceylon cocon. Q. 1 : 33-35.

*Liyanage,D.V. (1954). Controlled pollination of coconut palms. Ceylon cocon. Q. 5 : 135-39.

*Liyanage,D.V. (1961). Genetic improvement of coconut palm. Sym. Trop. Crop. Improv., 10th Paci. Sc. Comm., Nounea :39-50

*Louis,H.I. (1981). Genetic variability in coconut palm (Cocos nucifera. L). Madras Agric. J. 68(9) : 588-593

*Marechal,H. (1928). Observations and preliminary experiments on the coconut with a view to developing improved seed nuts for Fiji . Agri. J. Fiji. 1 : 1-4

Mathew,T, Gopimony,R. and Gangadharan,P. (1984). Evaluation of super mother palms of coconut by progeny analysis. Agric. Res. J. Kerala. 22(2) : 186-190

Menon,K.P.V. and Pandalai,K.M. (1960). The Coconut Palm - A monograph. Indian Central Coconut Committee, Ernakulam. pp.384

Nambiar,M.C., Mathew,J. and Kamalakaran,A.K. (1970) Seasonal variation in nut production and sex expression in coconut. Indian J. Genet. 3 : 557-564

Nambiar,M.C., Mathew,J. and Sumangalakutty,S. (1970) Inheritance of nut production in coconut. Indian J. Genet. 3 : 599-603

*Nambiar,M.C. and Nambiar,K.P.P. (1970) Genetic analysis of yield attributes in cocos nucifera, var. West Coast Tall. Euphytica. 19 : 543-551

Nambiar,M.C. and Ravindran,P.S. (1974) Pattern of genetic variation in the reproductive characters of coconut.

Indian J. Genet. 34A :75-82

Nampoothiri,K.U.K. (1970). Pollen studies in coconut (Cocos nucifera.) with special reference to a sampling procedure. Indian J. Agric. Sci. 49 457-460.

Nampoothiri,K.U.K., Satyabalan,K. and Mathew,J (1975). Phenotypic and Genotypic Correlations of certain characters with yield in coconut. 4th FAO Tech. Wkg. Pty. Cocon. Prod. Prot. and Processing. Kingston, Jamaica.

Ohler,J.G. (1984). Coconut, tree of life. FAO Plant production and protection paper 57. Food and Agricultural Organisation, United Nations, Rome. pp. 446

Patel,J.S. (1938). The Coconut - A monograph. Govt. Press, Madras. pp 313

Ramachandran,M., Venkateswaran,A.N., Balasubramaniam,K. and Muralidharan,V.N. (1975) Performance of Tall X Dwarf hybrid palms at Veppankulam. Cocon. Bull. 6(5) : 1-4

*Ramanathan,T. (1984) Character Association in coconut. Madras Agric. J. 71 : 191-192.

Rao,C.R. (1952). Advanced Statistical Methods in Biometric Research. Hafner Publishing Company, Darien, Conn. pp 390

Satyabalan,K. Mathew,J. and Radhakrishnan,V. (1972). Yield variation and its relationship with age and growth of under planted coconut palms. Oleagineux. 27 : 257-259.

Satyabalan,K. and Pillai,R.V. (1977). Yield performance and nut and copra characters of eight germplasm introductions in coconut. Indian J. agric. Sci. 47 :430-4.

Satyabaln,K., Sankar,N. and Ratnam,T.C. (1969). Studies on the bearing tendency of coconut palm II. factors affecting variation in annual yield of palms. Trop. Agric. (trin). 46 :353-357.

Shamsuddin,V.M. and Nampoodiri,K.M.N. (1979). Variation in pollen characteristics of eight coconut cultivars. J. Plant. Crops. 7 : 61-62.

Singh,R.K. and Choudhary,B.D. (1977). Biometrical methods in Quantitative Genetic Analysis. Kalyani Publisers, New Delhi- Ludhiana. pp.304

Stanley,R.G. and Linskens,H.F. (1974). Pollen - Biology , Biochemistry, Management. Springer - Verlag. Berlin, Heidelberg, New York. pp. 307

Suresh,K.M. (1986). Standardisation of techniques of clustering genotypes using Mahalanobis D^2 and Wilks' Λ criterion. Thesis submitted to Kerala Agricultural University.

Thampan,P.K. (1975). Handbook on Coconut palm. Oxford and IBH publishing Co., New Delhi, Bombay, Calcutta. pp.305

Varkey,T. and Davis,T.A. (1960). Studies on coconut pollen with reference to the leaf and root(wilt) disease. Indian Cocon. J. **14** : 1-7.

Vijayakumar,G. and Satyabalan,K (1982) Yield and nut characteristics of open pollinated progeny of west coast tall and its hybrids with Chowghat dwarf orange and gangabondam. Placrosym V.

* not seen the original.

PLATES

Plate-1 Early male phase

Plate-2 Early female phase

Plate-3 Typical tree of Cluster I

Plate-5 Typical tree of Cluster III

Plate-4 Typical tree of Cluster II

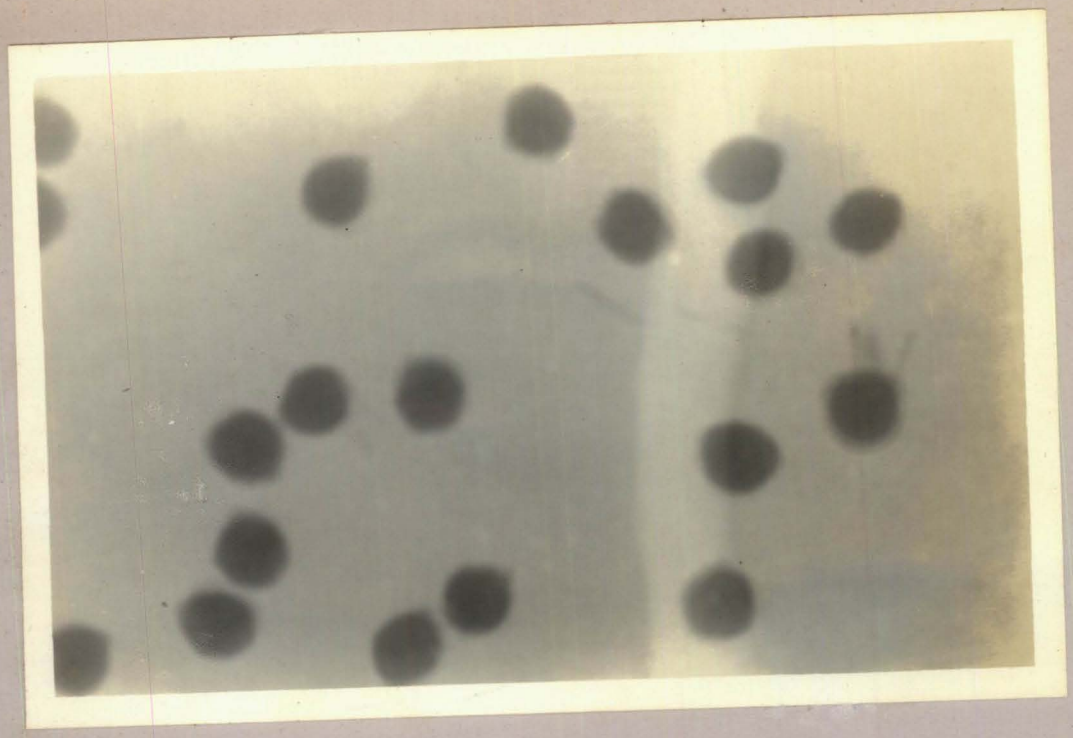


Plate-6 Normal fertile pollen (×600)

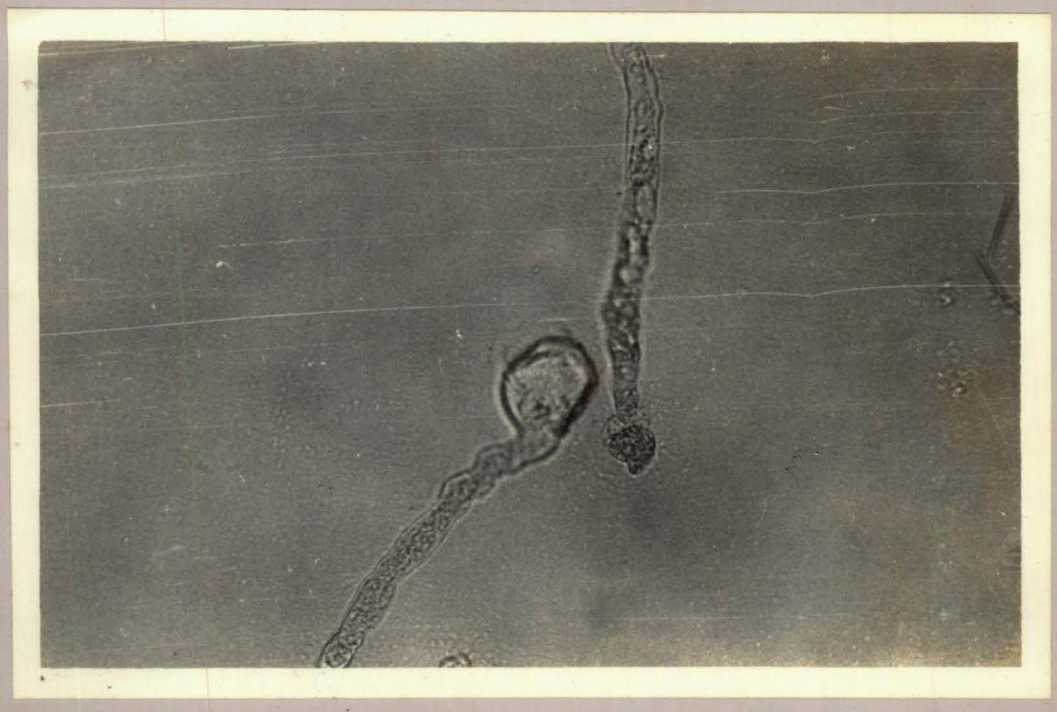


Plate-7 Normal pollen-tube growth
in 25% sucrose solution(×150)

APPENDIX

APPENDIX

Weather parameters for different standard weeks from 15th oct. 1985 to 14th oct.1986

Standard week (1)	Temperature in OC max. (2)	min. (3)	Rainfall in mm (4)	Relative humidity FN (5)	AN (6)
Oct. 15-21	30.9	22.0	98.9	83	64
22-28	32.1	22.4	110.9	87	62
Nov. 29- 4	32.0	23.5	-	80	59
5-11	31.6	23.5	11.7	81	67
12-18	31.7	22.4	-	86	65
19-25	32.2	22.3	2.7	90	62
Dec. 26- 2	31.9	20.7	-	67	41
3- 9	32.0	23.3	2.2	79	48
10-16	32.1	21.8	54.6	79	48
17-23	32.5	23.1	-	78	44
24-31	32.3	22.8	-	73	39
Jan. 1- 7	31.8	21.5	-	64	37
8-14	31.9	23.7	-	67	55
15-21	32.4	21.9	1.2	78	52
22-28	33.2	23.0	-	67	37
Feb. 29- 4	34.3	21.3	-	77	35
5-11	34.5	22.5	-	78	44
12-18	32.7	21.7	0.7	85	49
19-25	35.1	22.8	1.2	68	34
Mar. 26- 4	35.8	23.3	-	73	30
5-11	36.4	24.5	-	67	37
12-18	36.2	24.5	-	85	49
19-25	35.8	24.6	8.4	87	51
Aprl.26- 1	36.1	25.3	-	82	44

Continued.

	(1)	(2)	(3)	(4)	(5)	(6)
April	2- 8	36.4	25.4	-	79	49
	9-15	36.4	25.7	-	81	52
	16-22	35.9	24.9	-	82	58
	23-29	35.4	24.8	23.2	84	59
May	30- 6	34.0	25.0	27.1	90	59
	7-13	35.0	24.5	1.3	79	52
	14-20	34.1	24.6	49.0	84	57
	21-27	34.5	25.3	0.4	85	57
Jun.	28- 3	32.3	23.3	31.8	86	66
	4-10	31.9	23.4	27.5	87	65
	11-17	30.2	22.8	146.9	93	82
	18-24	29.0	22.8	205.6	94	85
Jul.	25- 1	27.6	22.9	328.2	96	84
	2- 8	29.7	24.0	17.9	88	72
	9-15	28.8	22.7	142.6	95	80
	16-22	29.2	22.8	117.5	95	78
	23-29	30.0	23.3	64.3	94	73
Aug.	30- 5	30.0	23.0	33.6	92	76
	6-12	27.4	21.9	305.0	96	88
	13-19	29.3	23.3	19.9	88	76
	20-26	30.1	23.2	-	93	68
Sept.	27- 2	31.3	23.0	-	90	60
	3- 9	30.9	22.0	23.7	92	60
	10-16	31.0	23.0	3.4	93	65
	17-23	29.3	22.5	192.2	94	80
Sept.	24-30	30.3	23.2	77.1	93	74
Oct.	1- 7	30.5	23.1	114.1	94	72
	8-14	31.8	23.3	27.4	94	65

VARIABILITY STUDIES ON CERTAIN T X CDO F_1 HYBRIDS OF COCONUT

(*Cocos nucifera* L.)

By

P. C. SREELATHA

ABSTRACT OF THE THESIS

submitted in partial fulfilment of
the requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agricultural Botany
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1987

ABSTRACT

Investigations conducted on variability in 14 F_1 parental combinations of T X CDO coconut hybrids at the KADP farm attached to the College of Horticulture, Vellanikkara revealed no significant difference between pollen parents in their contribution to the progenies in any of the 17 characters studied, unlike the female parents. The number of spadices was found to be highly correlated with the number of buttons set followed by the number of functional leaves and number of female flowers produced.

The fourteen parental combinations were grouped into three clusters using Mahalanobis' D^2 analysis. Clusters I and II were the most divergent ones.

Production of spadices and female flowers were found to be high during March, April and May and absent during October, November and December. Heavy rain during active female phase was found to affect setting of button adversely. Fertility and viability of pollen were found to be very high except during April and May due to high temperature.