EVALUATION OF SUPER MOTHER PALMS OF COCONUT BY SEEDLING PROGENY ANALYSIS

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DECLARATION

I hereby declare that this thesis entitled "EVALUATION OF SUPER MOTHER PALMS OF COCONUT BY SEEDLING PROGENY ANALYSIS" 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 the award of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Vellayani,
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CERTIFICATE

Certified that this thesis entitled "EVALUATION OF SUPER MOTHER PALMS OF COCONUT BY SEEDLING PROGENY ANALYSIS" is a record of research work done independently by Sri. Thomas Mathew, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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INTRODUCTION

INTRODUCTION

Coconut (<u>Cocos</u> <u>nucifera</u> L.) the tall, stately, unbranched tree, with a terminal crown of lush green leaves is one of nature's greatest gifts to man. It provides food, drink, oil, medicine, fibre, timber, thatch, mats, fuel and domestic utensils to man. But this perennial crop is beset with many unique breeding problems. In the first place, coconut is one of the very few crop plants in which the life time of the observer is less than that of the observed. The long generation period, the great heights which the palm attains making access to the flowers of the mature palm very difficult, the apparent impossibility of clonal propagation, the long pre-bearing period, the length of time required to attain steady bearing after flowering, the extensive field requirements for growing sufficient numbers of progeny for experimental purposes etc., are some of the major problems associated with the crop improvement programmes in coconut.

Over sixty species of palms were earlier included under the genus <u>Cocos</u> belonging to the sub family Coccoidea. The new trend is to give coconut a monotypic status, leaving coconut, <u>C.</u> <u>nucifera</u> as the sole species. Other species earlier included under this genus are now split into nine genera of which the major ones are <u>Syagrus</u> and <u>Butia</u>. The three varieties of <u>C.</u> <u>nucifera</u> their common name, common use and probable place of origin are as follows.

Cocos nucifera L.

var. *aurantiaca* Liy. King coconut; used for drinking purposes; originated in Sri Lanka.

var. *nana* (Griff.) Nar. Dwarf coconut; used for oil purpose; originated in Malaysia.

var. *typica* Nar. Tall coconut; also used for oil purposes; originated in pantropical region (Purseglove, 1975).

In this study, the *typica* cultivar West Coast Tall (WCT), the most popular one in Kerala was used. Other *typica* cultivars now under cultivation in Kerala are Laccadive Ordinary and Andaman Ordinary.

A perusal of area and production under coconut shows that the all-India figures for area under coconut cultivation are showing an increase from 0.622 million hectares in 1950-51 to 1.082 million hectares in 1980-'81. The corresponding figures for Kerala are 0.432 and 0.666 million hectares respectively. Thus at present Kerala accounts for 61.55 per cent area under coconut. At the same time, the all-India average yield of nuts has come down from 5756 nuts per hectare in 1950-'51 to 5249 nuts in 1980-'81, whereas Kerala has recorded 6926 and 4556 nuts per hectare during the respective periods. This reduction in yield is only partly due to the devastating root (wilt) disease which is slowly killing these graceful palms. At this juncture, there is great demand for superior quality planting material to replace the dead and dying palms and newly reclaimed areas all over the state. This demand leads to supply of inferior quality planting material from various sources which ultimately leads to a reduction of cultivar purity and resultant genetic erosion in the valuable WCT germplasm. To combat this malady, and to meet the demand for quality coconut seedlings, identification of prepotent palms (superior genetic transmitters) and their use in raising seedlings assumes importance.

The present study aims at identifying such prepotents among super palms. Iyer et al. (1979) classified super palms as those yielding more than two hundred nuts annually, and those remaining unaffected by root (wilt) disease and showing the above said yielding ability. Meanwhile, M.S. Swaminathan addressing International Symposium on Coconut Research and Development (ISOCRAD, 1976) emphasised the need for undertaking a systematic survey and scientific study of all palms yielding over two hundred nuts per year to use them as starting material for breaking the yield barrier in coconut. Following the recommendations of Faculty Research Committee of Kerala Agricultural University, in this study, the yield minimum for selecting super mother palms was fixed at an annual yield of three hundred nuts per palm.

In line with views expressed at ISOCRAD, seedling progeny analysis was undertaken in super mother palms in comparision with average mother palms having an yielding ability of not less than eighty nuts per annum. In a crop like coconut, with a long generation time, the relationship of early growth features with adult performance, according to Nambiar and Nambiar (1970) and Sathyabalan and Mathew (1977), would help in elimination of inferior genotypes at an early stage.

Hence, in nutshell, this study aims at evaluation of selected super palms of coconuts to identify prepotents, so that, such palms can be directly used in production of superior planting material. This study also aims at investigating the possibility of identifying prepotent mother palms solely on the basis of nut yield.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

1. Super palms of Coconut:

The yield of coconut palms can be expressed in terms of number of nuts, weight of copra or weight of oil. (Menon and Pandalai, 1958). In India, the most important criterion is the number of nuts. Coconut trees were grouped into high, medium, and low yielding groups by Sathyabalan et al. (1969). According to the authors, trees with over 80 nuts, 40 - 80 nuts, and less than 40 nuts per tree annual yield were grouped as high, medium, and low yielders. Nambiar and Nambiar (1970) proposed the yield based categories like over 120 nuts, 101 - 120, 81 - 100, 61 - 80, 41 - 60, and below 40 nuts per tree per year. Kannan and Nambiar (1979) classified the yield groups as those yielding more than 80 nuts as high yielders, those giving below 20 nuts to be low yielders, and those coming in between these two to be medium yielders.

Hali (1977) reported the prescence of an extremely high yielding palm in the root (wilt) disease affected Thazhava area of Quilon district. The palm, according to the author, produced nearly 600 nuts a year and had twice the rate of production of leaves and spadices when compared to ordinary West Coast Tall palms. The palm remained unaffected even when the surrounding palms had succumbed to this dreaded disease. The author gave the name 'Super palm' to such palms. Following this, Iyer et al. (1979) located such palms in various parts of the state. The yield minimum for a super palm was set at 200 nuts per year by the authors. According to them, such palms after appropriate progeny testing, if found prepotent, have great use in producing planting material directly and in future breeding works. Those found not superior can be vegetatively propagated and the high yielding trait can be reproduced.

2. Progeny analysis/test:

The breeding behaviour of an individual plant is learned by growing its progeny. Selection of superior plants from a mixed population is usually made on the basis of appearance or phenotype. Progeny analysis provides an opportunity to evaluate the genotype of the selected plant (Poehlman and Borthakur, 1969).

*Louis de Vilmorin in 1856 developed the progeny test with reference to sugar beets and the method developed is known as Vilmorin's isolation principle. This principle briefs that, the only sure means of knowing the value of an individual plant selection is to grow and examine its progeny.

Individual plant selection combined with progeny testing helped *Hays (1888) to develop centgener plan of plant breeding. This method led to evolution of spring wheat varieties like Improved Fife and Minnesota 163.

*Johanssen (1903, 1909) placed individual plant method of selection and progeny testing on a firm scientific base through developing the pureline theory.

* quoted by Hayes et al. (1955).

a) Progeny analysis in coconut improvement:

Since the time mentioned above, progeny analysis has been of use in improvement of annual crops. But the use of this basic tool in perennial crop improvement is recent. So much so, in coconut improvement, Harland (1957) was the first person to stress the need for progeny analysis. Later, complete (adult) progeny test was used in coconut improvement by Ninan and Pankajakshan (1961); Liyanage (1967, 1972); Abraham and Ninan (1968); Tammes and Whitehead (1969) and Kannan and Nambiar (1979).

b) Seedling progeny analysis in coconut improvement:

Ninan and Pankajakshan (1961) suggested that if sufficiently large numbers of mother palms are tested, trees which combine high yield, low standard deviation value, and superior progeny characters could be detected, though such of them are very few. Since it is seen that trees giving superior seedlings in one year continue to do so in the next year, it becomes evident that in detection of such trees, data of progeny for one year may be sufficient.

Nambiar and Nambiar (1970) reported the relative advantages of seedling progeny analysis over a complete (adult) progeny testing. The authors opined that, in coconut which has a long generation interval, by relating seedling growth characters with adult palm performance, inferior genotypes can be eliminated at an early stage.

Sathyabalan and Mathew (1977) observed that prepotent palms can be identified from the nursery studies itself on the basis of growth rate and seedling vigour as measured by girth-at-collar, and leaf production. The authors also observed that correlation of these growth characters from the first to ninth months with those of tenth month indicated a high and positive correlation from fifth month onwards, thereby showing that it might be possible to identify palms of superior genetic value from over fifth month for prepotency.

3. Prepotency and Prepotent palms:

Darwin (1859) was the first to use the word 'prepotent' which he explained as follows: "When two species are crossed, one has sometimes a prepotent power of impressing its likeness on the hybrid, and so I believe it to be with varieties of plants. With animals, one variety certainly often has this prepotent power over another variety".

Allard (1960) defined the phenomenon of prepotency, in a similar sense, as the capacity of a parent to impress characteristics of its offspring, so, they resemble that parent and each other more closely than usual. Liyanage (1972) was of the opinion that prepotency can be compared to general combining ability phenomenon observed in field crops. General combining ability is manifested by additive genetic variance and this variation is credited to the additive action of quantitative genes (Welsh, 1981).

According to Harland (1957) a palm is said to be prepotent due to the fact that it is sufficiently possessed of dominant yield factors. It is also capable to transmit the high yielding character to their progenies, in spite of having being indiscriminately pollinated by miscellaneous male parents. He further observed that just as the progeny of a single female parent may be superior, whatever the nature of the male parent, the reverse situation also held good. That is, the pollen of female transmitters could be used to cross with other superior female parents.

According to Ninan and Pankajakshan (1961), palms with genetic superiority are of two types, the first having a favourable combination of genes in the heterozygous condition or hybrid phase and the second, which are sufficiently possessed of dominant genes to ensure that their progeny are also high yielding. Those high yielders which continue to maintain significantly high progeny values irrespective of the type of pollinating male are no doubt inherently superior and may be regarded as having sufficient load of dominant yield factors to be called prepotents.

Prepotent palms showed high phenotypic and breeding values, with open pollinated progeny consistently high yielding with a low coefficient of variation (Liyanage, 1967).

Abraham and Ninan (1968) categorised palms to be prepotent when most of their progeny turned out to be high yielding.

According to Thampan (1981) a mother palm is evaluated for its high yield and its ability to maintain consistency in superior progeny performance. Mother palms which produced superior progeny are considered to have the highest breeding value.

4. Identification of prepotent palms:

Ninan and Pankajakshan (1961) observed that on the basis of seedling performance, it is possible to isolate high yielders which yield superior progeny from those yielding inferior progeny.

Liyanage (1967, 1972), and Abraham and Ninan (1968) observed that individual trees which show markedly superior progeny performance both for hybrids and their corresponding controls can be identified by testing sufficiently large numbers of mother palms. Such trees combine high yield, low standard deviation value, and superior progeny characters. Since it is seen that trees giving superior seedlings in one year continue to do so in the next year, it becomes evident that in detection of such trees, data of progeny for one year may be sufficient which in turn would expedigte the process.

Mantriratne (1965) noted that desirable genotypes for breeding could be provisionally identified by observing the number of leaves produced per plant per family during the forty months after transplanting. Similar views were expressed by Fremond and Brunin (1966), and Liyanage (1966b, 1967).

Liyanage (1967) explained the programme of identifying superior transmitters by noting the leaf production in 40 months after transplanting of their progeny. The open pollinated progeny are grown and the number of leaves produced in each palm is scored at six monthly intervals until they are forty months old. The families with high mean number of leaves per plant indicate the prepotent parents.

The author further reported a quick method of identifying good genotypes by studying the inbreeding depression on endosperm and embryo weight of nuts. If either of these are under genic control, one would expect differential behaviour between genotypes when selfed depending on the nature of genes involved. If it is largely due to prepotency exhibited by additive effects of genes (general combining ability), the inbreeding depression may not be well marked or even negligible than when it is controlled by hybrid vigour expressed by dominance or epistasis. This provides with a possibility that palms of high breeding value could be isolated from phenotypically superior palms by selfing them and studying the depression on endosperm and embryo weight per nut relative to those of the open pollinated nuts from the same palm. This method takes only twelve months to test the breeding value of a palm, against twelve years required by progeny testing.

Thus in a crop with a large generation interval like coconut, the relationship of early growth features with adult palm performance will help the elimination of inferior genotypes at an early stage (Nambiar and Nambiar, 1970).

5. Selection criteria in coconut breeding:

A three stage selection programme is most effective in improving coconut viz., selection of mother palms, selection of seed nuts, and selection of vigorous seedlings. Fremond et al. (1966); Apacibla and Mendoza (1968); Silva and George (1970) and Kannan and Nambiar (1979) firmly concluded the need and applicability of this three tier selection programme.

A. Mother palm selection (Maternal or Maternal line selection):

Menon and Pandalai (1958) are credited for using the synonyms, maternal and maternal line selection in coconut improvement by mother palm selection.

Ninan and Pankajakshan (1961) reported that it is possible to isolate high yielders on the basis of seedling performance. So a switch over from mass selection to progeny row breeding (acknowledged to Dwyer, 1938), will be necessary to identify high yielders of outstanding breeding merit for use in propagation as well as breeding works.

Liyanage (1964, 1967) advocated selection of mother palms by selecting the best ten per cent palms based on weight of husked nut and yield respectively. This procedure gave similar positive results to Mantriratne (1965), and Abraham and Ninan (1968) while isolating palms for breeding.

Liyanage (1966) advocated selection of high yielding palms with desirable agronomic characters.

According to Liyanage (1967) whenever selection differential was increased on an upward basis, the response to progey increased. But five per cent palms gave progeny with a yield of 14.4 per cent higher than the mean of the entire progeny population, as against 7.9 per cent for best 15 per cent palms.

Mass selection of palms yielded good results to Pomier (1967) and Tammes and Whitehead (1969).

Need for selection among dwarf pollen parents based on nut and copra characters for producing superior Tall x Dwarf hybrids was observed by Sathyabalan et al. (1968). The different mother palm characters studied in this investigation were age of the palm, number of leaves, spadices, bunches, and nuts per bunch at the time of harvest of seed nuts.

(i) Age of the palm:

Palms come to full bearing stage when they attain 21 - 30 years of age. (Menon and Pandalai, 1958; Sathyabalan et al., 1972). According to Sathyabalan et al. (1972), maximum stabilised yield was obtained on the 28th year.

(ii) Number of leaves:

A high yielding palm in its middle age will usually have 30 - 40 fully opened leaves on the crown. Effect of total number of leaves and factors affecting variation in annual yield of palms were studied by Sathyabalan et al. (1969). Nambiar and Nambiar (1970) observed that high yielding palms (yield being more than 100 nuts) were superior to lower yielding palms with respect to leaf production and number of functional leaves on the crown. The authors further observed that in low yielding palms, superior progeny with improvement in characters like number of leaves and rate of production of leaves could be achieved by using elite pollen.

Significant positive correlation of $r = 0.385 \pm 0.091$ was obtained by Liyanage (1972) between the total number of leaves after transplanting seedlings and the mean yield of adult progeny per family when they were 13 - 16 years old.

Sathyabalan et al. (1972) obtained strong positive correlation between yield and number of functional leaves on the crown in this crop.

(iii) Number of spadices and bunches:

Menon and Pandalai (1958) observed rate of production of spadices to be dependent on the rate of production of leaves. The authors further observed that on a month wise basis, 11 - 15 per cent of total number of spadices produced a year, emerged during the months of March, April, and May.

A study on production of spadices in coconut was made by Sathyabalan et al. (1969) while analysing factors affecting variation in annual yield of palms. A higher rate of spadix production was observed in regular bearers. A significant positive correlation was also obtained between yield and female flower production except when female flower production was high. Variation in female flower production in turn appeared to be related more to the number of opened spadices than to the number of flowers per bunch.

Heritability values estimated by Nambiar and Nambiar (1970) based on parent - progeny regression were low for number of spikes, and spikes with more than one female flower. Hence, the authors concluded that selection for large number of spikes with one or two female flowers would contribute towards reducing the instability in West Coast Tall.

Fernando (1976) observed that var. typica produced an average 11 - 17 spadices (inflorescences) per year. Iyer et al. (1979) after studying the super palms reported even higher number of bunches and/or spadices. In regular bearers, the production of leaves and spadices is more or less the same, ie., 12 - 15 per annum (Thampan, 1981).

(iv) Number of nuts per bunch:

Average yield of trees over five years recorded by Rao and Koyamu (1952) showed 6.6 and 9 nuts per bunch in Dwarf Green and Dward Orange respectively (quoted by Menon and Pandalai, 1958). West Coast Tall palms produce an average of 8.8 nuts per bunch (Nambiar, 1971 and Purseglove, 1975).

Harries (1982) used this trait in the newly formulated Niu Kafa-Niu Vai Introgression (NKNVI) method for comparing coconut varieties and cultivars. This method is based on the idea that different varietal characteristics come from the two contrasting ancestral types. The Niukafa types were evolved by selection, but Niuvai were domesticated by man for its sweetwater. These two in cultivation produced many intermediate forms by introgression. This method is applied to actual measurements taken from many individual palms in the population.

B. Seed nut selection based on Fruit Component Analysis:

Seed nut selection forms the second phase in coconut improvement by mother palms or maternal selection (Fremond et al., 1966; Apacibla and Mendoza, 1968 and Silva and George, 1970).

Significant correlations could not be obtained between nut characters and breeding value by Liyanage (1966b) after analysing yield of coconut for four years. In the growth of three tall varieties, intervarietal and intravarietal difference in mean nut size was compared by employing growth analysis technique and was shown that neither genotype nor nut size had any sustained effect on plant size (Foale, 1968).

The method of 'Block nut' selection was advocated by Cheyne (1952) instead of 'Individual mother palm basis'. The best nuts were picked out from the heaps of nuts produced by the best blocks or fields of really good estates with consistent records of high annual yield and good copra production.

Agreeing results were obtained by Kannan and Nambiar (1979) when the performance of the progeny of palms selected at random irrespective of their yield from high yielding blocks (bulk mother palms) was as good as the progeny of high yielding palms.

Me Unier et al. (1977) in a study to determine the number of nuts per tree necessary for sampling in nut component analysis found that 24 nuts per tree was sufficient to compare trees planted in the same trial.

Ramachandran et al. (1977) reported that the weight of unhusked nut, weight of husked nut, weight of kernel, and weight of copra per nut were important in seed nut selection.

Fruit component analysis using observations on fruit components like quantity of endosperm, oil content, fatty acid, and composition of oil, and protein content of residual meal were used in the NKNVI method by Harries (1982).

(i) Weight of unhusked nut:

The weight and volume of seed nut failed to show any influence on the flowering period or the yield of copra of the adult palm. Progeny of palms with heavy or larger nuts produced fewer nuts than those bearing smaller nuts. For any particular parent, the weight and volume of the seed nut did not influence differences in yield between progeny (Anonymous, 1956).

It was found desirable to select palms giving large and heavy nuts, about 4000 cc in volume (Liyanage and Abeywardena, 1957). Pillai and Sathyabalan (1960) observed that largest nuts were produced in any palm during summer.

Nambiar et al. (1969) observed that the development of the nut occurred in three distinct phases, comprising one of slow progressive growth for about three months, then rapid growth for about four months, after which, the growth rate declined sharply for about two months. The rate of growth during the most active period of development was found to be closely related with the final volume and weight of husked nut.

Crosses of West Coast Tall with Dwarf Orange and Gangabondam failed to show heterosis for weight of fruit (Sathyabalan et al., 1970).

(ii) Weight of husked nut:

This trait has been suggested by Ramachandran et al. (1977) to be important in seed nut selection and study of nut components

Heritability values for weight of husked nut was found to be high (Lakshmanachar, 1959). A high hertability estimate was obtained by Liyanage and Sakai (1960) also.

Two selection indices for two Ceylonese (Sri Lanka) populations were developed by Sakai (1960) based on the heritability and genetic correlation estimates of weight of husked nuts in pounds per plant per year and three other characters.

An analysis of variance of yield and weight of husked nuts was made among selected open pollinated progeny of unselected seed parents. It was found that parents could be classified, according to their breeding values from the above mentioned analysis (Anonymous, 1964).

Pandalai et al. (1965) found that among Tall x Dwarf, Tall x Gangabondam, and Dwarf x Dwarf hybrids, the first two crosses were found to be superior in terms of weight of husked nut.

Selection on the basis of weight of husked nuts was found effective by Mantriratne (1965). The author also observed that a higher frequency of palms of good performance for yield of copra was obtained by testing the ten per cent palms with the highest husked nut yield in a population.

From an analysis of four year's coconut yield in terms of weight of husked nuts and by taking the breeding value as being twice the deviation of the progeny mean from population mean for weight of husked nut, nine parents were selected from 223 tested (Liyanage, 1966b).

Studies on weight of husked nuts of Green and Orange Dwarf parents were undertaken by Sathyabalan et al. (1968) for producing Tall x Dwarf coconut hybrids. Observations showed the mean value to be 135.4 g., range 83.7 - 328.4 g. and coefficient of variation 49.9 per cent for Dwarf Green and 513 g., 425 - 639 g and 11.7 per cent respectively for Dwarf Orange.

Contrary to some of the earlier mentioned reports, Abraham and Ninan (1968) opined that, genetic progress in the progeny is likely to be more if the seed parent is selected on high yield of copra and nut, rather than on weight per husked nut.

Nambiar et al. (1969) while studying the pattern of nut development in coconut, observed that the rate of growth during the most active period of development (4th - 7th months after fertilisation) was found to be closely correlated with weight of husked nuts.

(iii) Weight of meat:

Since coconut meat and copra are in substance one and the same, reference pertaining to these two have been combined and dealt with together.

Narayana and John (1949) used observations on copra weight as a criterion for assigning letter codes to identify varieties and forms in coconut.

Experiments on methods of selection showed that it was immaterial whether seed nuts were selected from high yielding palms or seedlings were selected for early germination, vigour and resistance to diseases and pests and earlier flowering to get markedly higher yields of nuts and copra. (Anonymous, 1953).

The unselected seedlings of high yielding mother palms gave significantly lower yield of copra than the selected seedlings from similar seeds. The flowering period was also found to be negatively correlated with yield of copra (Anonymous, 1956).

Sathyabalan (1956) reported one of the objectives in effecting crosses between tall and dwarf types of local and exotic origin to be, combining production of high quality copra along with high yield, early maturity, and high oil content.

Lakshmanachar (1959) reported high heritability estimates for yield of copra. Liyange and Sakai (1960) reported a heritability value of 0.67 for yield of copra.

Seasonal variations were found in copra content and nut characters amongst some of the exotic coconuts growing at the Coconut Research Station (now, Central Plantation Crops Research Institute) Kasaragod. The maximum copra content in West Coast Tall palms were obtained during summer (Pillai and Sathyabalan, 1960).

Sakai (1960) used heritability and genetic correlation estimates of copra yield and some other characters for formulating selection indices in coconut populations.

Ziller (1960) isolated the factors influencing copra content of coconuts to be variety, climate, major element nutrition, and the number of nuts produced per tree.

Ninan et al. (1963) obtained highly significant differences in the copra content of nuts of two laccadive strains by using pollen of different varieties, compared to nuts obtained by pollination with spicata pollen in one trial and West Coast Tall pollen in another trial. Kappadam as the male parent gave an increase of 23.5 g and 22.6 g of copra. Gangabondam and Andaman Giant also gave results on par with Kappadam.

While studying the development of abnormal endosperm in Philippine makapuno coconuts, Abraham et al. (1965) found that the buttery consistency of the nuts in question was associated with outgrowths on the inner surface of the endosperm, which continued to grow in a manner resembling neoplasms and eventually filled the nut.

Pandalai et al. (1965) observed heterosis for copra characters in Tall x Dwarf, Tall x Gangabondam, and Dwarf x Dwarf hybrids.

Liyanage (1967) noticed that for breeding, genotypes could be better isolated when the parents were selected on yield of copra rather than when they were taken at random.

Nathanel (1967) observed that on a dry weight basis, 68 - 70 per cent of the coconut kernel was oil while sugars and protein comprised 6.7 and 6.4 per cent respectively.

Tests using Laccadive varieties as females showed that the amount of copra in a nut depended partly on the pollen which had fertilised (Pankajakshan, 1967).

Abraham and Ninan (1968) are of the opinion that genetic progress in the progeny is likely to be more if the seed parent is selected on the basis of high yield of copra.

Comparative study of Dwarf Green and Dwarf Orange palms by Sathyabalan et al. (1968) showed the mean copra content, range and coefficient of variation of Dwarf Green to be 57.1 g 30.9 - 117.0 g and 48.6 per cent respectively. The same for Dwarf Orange were 160.3 g 137 - 177.7 g and 10.7 per cent respectively.

Copra content and rate of growth of nut during the most active period of development were found to be correlated (Nambiar et al., 1969).

Sathyabalan et al. (1970) obtained heterosis for kernel content in crosses of West Coast Tall with Dwarf Orange and Gangabondam.

Seed parents can be selected at random or as best ten per cent of the palms in a block, based on the background yield of copra. Also, inbreeding depression on endosperm can be used as a quick method of identifying good genotypes (Liyanage, 1972).

Mantriratne (1972) while evaluating the performance of dwarf varieties (var. nana) as a plantation crop in Sri Lanka, (Ceylon) observed that the dwarfs yielded no more than 1.25 - 2.50 tonnes of copra per hectare. The author also noticed that dwarfs yielded 85 - 115 g copra per nut which was low when compared with Sri Lankan typica giving about 226 g per nut.

The influence of origin of pollen on the characters of the endosperm were studied by Rognon and Lamothe (1976). Accordingly, the ability of two varieties (parents) to combine to give a large copra in the seed can be linked to the productivity of the hybrid arising from that seed.

Ramachandran et al. (1977) used observation on kernel weight per nut and copra weight per nut for critical study of any new type, form or variety of coconut.

Harries (1982) proposed the use of weight of endosperm (fresh and as copra) in comparing and contrasting the existing cultivars and varieties of coconut by the NKNVI method for better understanding of the taxonomic and evolutionary positions of the existing cultivars of this crop.

(iv) Thickness of meat:

One of the earliest records of using this observation was in the study conducted at Coconut Research Station (now, Regional Agricultural Research Station) at Pilicode by Narayana and John (1949) to frame out a systematic classification. The authors classified forms of coconut palms with copra thickness less than 0.82 cm as thin and above 1.2 - 1.3 cm as thick.

Menon and Pandalai (1958) reported the meat in ordinary nut to be about 1.3 cm thick but occasionally the thickness went upto 2.0 cm. In dwarf and ornamental cultivars, the kernel was generally very much thinner.

(v) Size of embryo (Diameter of eye):

The eyes of coconut according to Juliano (1920), (as quoted by Menon and Pandalai, 1958), showed morphological peculiarities and when one embryo developed, one eye became functional and the other two became nonfunctional. The eye bearing the functional embryo was found to be large and soft (Menon and Pandalai, 1958).

Observations on embryo was used by Liyanage (1972) to identify good genotypes quickly. The principle was, to use loss of embryo fresh weight as an indication of inbreeding depression. If the size of embryo was governed by additive genetic effects, one would expect a lower degree of depression.

Kartha (1981) observed that the single cotyledon of coconut embryo, consisted of a coleoptile (as growth advances, that part of apical mass encircling plumule differentiates into a tubular structure), coleorhiza (the radicle is encircled by coleorhiza, a part of cotyledon at its base) mesocotyl (the coleoptile and coleorhiza are connected to each other through a mesocotyl), and haustorium (basal mass of embryo which attacks and proceeds to digest kernel).

(C) Seedling selection:

'Progeny selection' has been defined by Rieger et al. (1976) in 'Glossary of Genetics and Cytogenetics' as the evaluation of an individual's progeny as customarily employed in artificial selection. Methods of progeny selection vary with the type of matings that are possible. Selection may be based on the performance of self pollinated progeny, of progeny from crosses to an inbred (test cross) or of progeny from crosses to daughter (back cross). When selection of outstanding individuals is based on progeny performance, consideration must be given to the magnitude of phenotypic variance, the heritability of the character being selected and degree of genetic relationships.

The final phase in coconut improvement by maternal selection is the seedling selection (Ninan and Pankajakshan, 1961; Apacibla and Mendoza, 1968; Silva and George, 1970; Rognon, 1972; Ninan, 1978 and Kannan and Nambiar, 1979).

Abraham and Ninan (1968) found that trees which produced progeny with superior growth rate and vigour, also produced uniformly good seedlings and progeny testing is the most reliable method to detect genetically superior palms. The importance of progeny testing has been emphasised by Tammes and Whitehead (1969) also.

Foale (1968) suggested that under unfavourable condition for photosynthesis, large nuts produced larger seedlings. Hence, any seedling selection was advocated to be carried out in a favourable nursery environment so that emphasis was placed on differences in seedling vigour due to genetic variation.

The importance of seedling selection in maternal line selection and heterosis breeding of coconut was emphasised by many authors.

Sathyabalan (1958) observed that natural cross dwarf coconut seedlings made more vigorous growth than pure dwarf seedlings.

Variability in progeny was not significantly reduced by self pollination, when compared with open pollination, but vigour was markedly reduced in seedlings (Sathyabalan and Lakshmanachar, 1960 and Patel, 1973).

Ninan and Pankajakshan (1961) did not observe any significant or specific relationship between seedling characters and yield in high yielders.

Studies on growth rate and seedling vigour in 204 seedlings from ten West Coast Tall trees showed significant differences between families (Ninan et al., 1964).

Considerable difference were exhibited by three cultivars of tall type in seedling growth upto 2 months, but the differences did not persist (Foale, 1968).

Cross pollination produced better seedlings than self pollination and seedlings from high yielding groups were more vigorous than those from low yielding palms, especially those yielding below 40 nuts (Sathyabalan and Nambiar, 1968).

Seedling selection according to Kannan and Nambiar (1979) though necessary, need not be as strict and rigid as it was advocated at present, the reason being, the yield difference between vigorous and intermediate seedlings was not significant.

Selection criteria:

The characters that are presently suggested for the selection of planting material from coconut nurseries are based on the vigour of seedlings as indicated by germination, height, girth-at-collar, leaf number, and early splitting of leaves, (Menon and Pandalai, 1958 and Patel, 1973). Growth being a function of drymatter production,information on relationship between the different seedling characters and total leaf area is also of importance (Ramadasan et al., 1980).

(i) Germination:

In selecting seed parents, it is advised to select palms giving nuts which sprout early (Anonymous, 1953).

According to Davis and Anandan (1957), a nut may be considered to have germinated when the embryo broke the lid of the soft eye and this took place usually six weeks after the nut was sown.

Early sprouting along with early flowering and high initial yield are reliable early characters of a high yielding adult palm (Liyanage and Abeywardena, 1957).

Menon and Pandalai (1958) after reviewing the works of a number of researchers, noted that the mean number of days for germination for Tall, Tall x Dwarf and Dwarf were 98.1, 70.2 and 55.3 days respectively.

Nathanel (1959) showed that the weight of oil per nut did not increase during the first 18 weeks of germination. By about 15th week of germination, the haustorium attained about 15 - 20 g weight (Child, 1964).

Sathyabalan et al. (1964) noticed that Tall x Gangabandam coconut hybrids germinated significantly earlier when compared to Tall x Dwarf and Tall x Tall.

Whitehead (1965) showed that 'Malayan Dwarf' and 'San Blas' germinated rapidly, taking 30 - 140 days for 80 per cent of the nuts to sprout, when compared to 60 - 220 days for 'Jamaica Tall'.

Growth of young coconut palm and the role of the seed and photosynthesis on seedling growth upto 17 months were studied by Foale (1968). The contribution by the endosperm fell at four months after germination to a level that remained roughly constant upto 17 months. By four months, the haustorium had reached the full size, but thereafter, relative contribution from the endosperm via the haustorium gradually diminished until by 15 months, almost full dependence on photosynthesis was attained. By 17 months, less than 10 per cent of the endosperm remained in the nut.

Performance of hybrids of Tall with Dwarf Green and Dwarf Orange revealed significant differences in mean number of days taken for germination viz., 95.9 and 75.0 respectively (Sathyabalan et al., 1968).

In a germination study by Silva and George (1970) on seednuts of three sizes (15, 17.5 and 20 cm short axis) and three stage of maturity, (fallen over ripe nuts, first bunch nuts, and second bunch nuts) each factor was shown to influence the sprouting period independently. Medium sized nuts from the first bunch had the best overall germination rate (95%). During 10th - 16th weeks, 70 per cent of second bunch nuts also sprouted irrespective of size.

Zuniga et al. (1971) investigated the effect of coconut water transfusion on the germination and growth of waterless coconuts in a strain of Coco-Nino dwarf. The nuts were waterless even when the husk was green and about 15 cc of coconut water when transfused stimulated the embryo to germinate.

Studies involving West Coast Tall, Chowghat Dwarf Green, Laccadive Ordinary, Gangabondam, Strait Settlement Apricot, and Tall x Dwarf showed variation in the number of days taken to germinate after harvesting or after sowing. The cultivar Straight Settlement Apricot took fewer days to germinate (Nampoothiri et al., 1972).

Kenman (1973) noted that horizontally planted nuts with some husk removed from over the germpore germinated faster than untreated horizontally placed nuts.

Studies by Santo (1974, 1976) revealed the optimum temperature and days to germination for coconut to be 30 - 35°C and 107 days respectively.

The coconut seed has no dormancy and growth of the embryo and seedlings are continuous. Germination may begin while the fruits are still attached to the palm, as can happen in 'Malayan Dwarf' and 'San Blas' when left unharvested (Purseglove, 1975).

Based on germination percentage of Dwarf x Tall hybrid seeds, and recovery of hybrids in open, self, and cross pollination, dwarf parents could be selected for breeding programmes (Ninan, 1978).

Harries (1982) used rate of germination as a criterion in the NKNVI method for comparing and contrasting cultivars and varieties of coconut.

(ii) Seedling growth analysis:

The study of seedling growth is usually undertaken by recording and analysing the observations on plant height, girth-at-collar, number of leaves, total leaf area, and age at leaf splitting.

(a) Height of seedling:

Plant height, as in any other crop is an important phenotypic manifestation of growth in coconut seedlings also.

Liyanage and Abeywardena (1957) elucidated that mother palm selection could be made more efficient by selecting trees which would produce a higher percentage of tall vigorous seedlings. Menon and Pandalai (1958) reported the average height of seedlings of Tall, Tall x Dwarf, and Dwarf origin to be 83.56, 103.63, and 87.54 cm respectively after reviewing the works of Rao and Koyamu conducted in 1952.

Observations on height and number of leaves in over 14,000 seedlings led to the conclusions that both occurred about independently. But a positive correlation was obtained between height and girth-at-collar (Pankajakshan and George, 1961).

Sathyabalan et al. (1968) reported significant difference is seedling height between Tall x Dwarf Green and Tall x Dwarf Orange hybrids viz., 113.96 and 118.86 cm respectively.

Adult performance of hybrids involving three varieties of coconut viz., Tall, Dwarf, and Semitall was analysed by

Mathai (1979). Observations on height of seedlings of Tall x Dwarf and Tall x Gangabondam which were crosses between widely different varieties exhibited hybrid vigour beyond the seedling stage. Tall x Dwarf was found to be on par with Tall x Gangabondam in respect of seedling height.

Ramadasan et al. (1980) considered that plant height can be employed in deriving out shoot dry weight as an index of vigour in coconut seedlings. The authors observed that seedling height had a high coefficient of correlation and very low direct effect on shoot dry weight.

(b) Girth-at-collar:

After reviewing a number of reports, Menon and Pandalai (1958) observed that girth-at-collar of Tall, Tall x Dwarf, and Dwarf seedlings are 9.14, 10.67 and 9.65 cm respectively. The authors further observed that vigour in seedlings was indicated by many vegetative characters and girth-at-collar was one among them. Girth-at-collar was observed to be more correlated with weight of seedling (an indication of vigour) than any other character studied.

Pankajakshan and George (1961) obtained positive correlations between girth-at-collar with both height and leaf number and these two relationships were found to account for over 60 per cent of the variation in girth.

Tall x Gangabondam recorded superior, though not significant, collar girth when compared to Tall x Dwarf hybrids and both were found to be distinctly superior to Tall x Tall hybrids in this character (Sathyabalan et al., 1964).

Tall x Dwarf Orange hybrids were found to be significantly superior in collar girth to Tall x Dwarf Green hybrids with means 12.12 and 10.96 cm respectively (Sathyabalan et al., 1968).

Silva and George (1970) reported that seedlings of fallen over ripe nuts with large size (20 cm short axis) produced seedlings with maximum girth-at-collar.

Tall x Dwarf and Tall x Gangabondam hybrids exhibited similar degrees of hybrid vigour in collar girth even after nursery stage (Mathai, 1979).

Ramadasan et al. (1980) found that girth-at-collar had a high direct effect on the shoot dry weight of seedling (seedling vigour).

(c) Number of leaves:

Menon and Pandalai (1958) quoting the works of Patel (1937), and Rao and Koyamu (1952) obtained the number of functional leaves of seedlings to be 3.8, 5.0, and 5.0 for Tall, Tall x Dwarf, and Dwarf seedlings respectively.

According to Charles (1959) seedling selection is based on the vigour of seedlings as judged by spread and colour of leaves and other measurable characters like collar girth, rapidity of growth, and sturdiness of seedlings.

Pankajakshan and George (1961) observed number of leaves and height to manifest themselves independently. However, leaf number was found to be positively correlated with girth-at-collar.

A comparative study of Tall x Dwarf, Tall x Gangabondam and Tall x Tall hybrids by Sathyabalan et al. (1964) showed close resemblence in leaf production between these hybrids in nursery.

Data collected from open pollinated progeny of Tall x Dwarf hybrids indicated their superiority in leaf production when compared to West Coast Tall (Anonymous, 1965).

Foale (1968) noted that rate of leaf production was constant with time after tracking the growth of young coconut palms upto 17 months of age.

In another study on comparing the different dwarf parents for use in Tall x Dwarf hybrid production, it was found that Tall x Dwarf Green and Tall x Dwarf Orange produced 6.70 and 7.00 leaves in a year respectively (Sathyabalan et al., 1968).

Mathai (1979) observed that Tall x Dwarf and Tall x Gangabondam exhibited same degree of hybrid vigour during and even after seedling stage in relation to number of leaves produced.

Leaf number could be used as a component in computing seedling vigour in terms of shoot dry weight, based on linear multiple regression equation incorporating other seedling characters like height, girth-at-collar, and leaf area. This study by Ramadasan et al. (1980) revealed that the number of leaves had only less or even negligible direct effect on seedling vigour.

(d) Total leaf area:

Correlation studies between leaf area and length, and width of leaves were undertaken in coconut seedlings by Marar and Pappachan (1964). They coined a method for estimating the leaf area ie., to multiply the product of length and width of leaf lamina by a coefficient of 0.878.

By following and critically analysing the growth of the young coconut palm upto 17 months of age, Foale (1968) observed that leaf area increased almost exponentially with increasing age.

Ramadasan et al. (1980) observed that in addition to other seedling characters mentioned elsewhere, leaf area should be an important criterion in selecting coconut seedling. The author calculated the leaf area using a regression equation $Y = a + bX$ where Y represented leaf area, $a = 27.3861$, $b = 0.6139$ and X = product of length and width of leaf. This study also revealed that the more contributing factor for the vigour of seedlings as indicated by shoot dry weight are leaf area and girth-at-collar. Moreover, leaf area showed maximum direct effect and positive correlation with shoot dry weight.

(e) Age at leaf splitting:

Apart from characters mentioned above, another sign of vigour in the seedlings is early splitting of leaves into leaflets. When the seedlings had eight to ten leaves, roughly eighteen months after sowing, it commenced to produce leaves which tend to split into leaflets. So Menon and Pandalai (1958) concluded that early leaf splitting was a sign of precocity. Signs of leaf splitting became manifested early in seedlings with the largest number of roots (Thampan, 1981).

(iii) Miscellaneous characters used in seedling selection:

Other characters not dealt with in earlier pages are also used in seedling selection process to increase the efficiency of mother palm selection.

(a) Petiole colour:

Genetic studies showed that a seedling with a bronze rachis was a hybrid resulting from a cross involving Malayan dwarf, which had a green rachis, as female parent (Anonymous, 1966). In F_1 from red or yellow Malayan dwarf x Tall, the offsprings had petiole colour characteristic of the tall parent (Whitehead et al., 1966).

Rognon (1972) also suggested the use of petiole colour in selection of hybrids at germination. The Nain x Nain (dwarf) selfs could be thus isolated from Nain x Grand (Tall) hybrids on the basis of petiole colour.

(b) Shoot dry weight:

A multiple linear regression equation based on height of seedlings, number of leaves, girth-at-collar, and leaf area was worked out by Ramadasan et al. (1980) for estimating dry shoot weight. The equation read out as

$$Y = -112.4464 + 12.5885\,X_1 + 0.2295\,X_2 - 5.6338\,X_3 + 0.0143\,X_4$$

where Y represented shoot dry weight

X_1 - girth-at-collar, X_2 - height of seedling,

X_3 - number of leaves and X_4 - leaf area.

The authors observed that shoot dry weight can be used as an index of vigour in seedling selection process in coconut improvement.

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment was conducted in the Department of Plant Breeding, College of Agriculture, Vellayani during the period from January 1981 to June 1982.

A. MATERIALS.

The materials consisted of two types of mother palms i.e., super mother palms and control mother palms.

Super mother palms were categorised as those giving an annual yield of not less than 300 nuts per palm in addition to other general selection criteria fixed as per Package of practices recommendations (Anonymous, 1981).

Control mother palms were categorised as those yielding not less than 80 nuts per palm per year with other general characters listed in the Package of practices recommendations.

Altogether ten super mother palms (Nos. 1-10) were selected from different locations in Trivandrum and Quilon districts of Kerala state. Five groups of control mother palms (Nos. 11-15), each consisting of 5 trees representing a location from where a super palm was selected were also included in the study. In addition to these five control groups, a general control (No. 16) comprising a random sample of 70 seed nuts collected by the Department of Agriculture, Kerala state, from the seed nut procurement belt in North Kerala (Badagara) was also included in this experiment.

Details of super mother palms and control mother palm groups with respect to location, age, and treatment number allotted are given in Table - 1.

Table - 1. Details of experiment material.

Sl. No.	Treatment No.	Location	District	Age
SUPER MOTHER PALMS				
1.	1	Mayyanad	Quilon	28
2.	2	Mayyanad	Quilon	28
3.	3	Mayyanad	Quilon	24
4.	4	Mayyanad	Quilon	30
5.	5	Vadayakkad	Trivandrum	19
6.	6	Vellayani	Trivandrum	40
7.	7	Kazhakootam	Trivandrum	61
8.	8	Kottarakkara	Quilon	38
9.	9	Vellayani	Trivandrum	40
10.	10	Kottarakkara	Quilon	38
CONTROL MOTHER PALMS				
1.	11	Vellayani	Trivandrum	40
2.	12	Kazhakootam	Trivandrum	21
3.	13	Kottarakkara	Quilon	26
4.	14	Mayyanad	Quilon	33
5.	15	Vadayakkad	Trivandrum	20
6.	16	Badagara	Calicut	40

B. METHODS.

1. Seed nut procurement:

Procurement of seed nuts was done during the period from January 1981 to April 1981 in two harvests.

Seed nuts were collected separately from each super mother palm and bulk collected from each group of control mother palms. Thus, there were altogether sixteen lots of seed nuts. Each seed lot comprised of 60 - 70 seed nuts after rejecting malformed and barren nuts.

All the seed nuts were given the respective identity numbers and stored in a room in sand till June 1981.

Random samples of five nuts were drawn from each seed lot and subjected to fruit component analysis.

2. Seedling nursery:

Seed nuts were sown in the nursery during June 1981. The lay out plan followed a Randomised Block Design with 16 treatments and 3 replications. Representing each treatment, 20 seed nuts were sown in a replication.

Seed nuts were sown in raised beds of size 2.25 x 7.20 m. giving a spacing of 45 x 45 cm. Nuts were 'vertically' sown in furrows sprinkled with sand and BHC 5% dust.

3. Studies on mother palms:

The following observations were recorded on the mother palms.

(i) Age of the palm:

Age of the palm was recorded in years. Age was determined by counting the leaf scars on the trunk. Roughly 12 - 14 successive scars left on a tree corresponded to a year of growth of the tree.

(ii) Number of leaves:

Number of leaves were recorded when seed nuts were first harvested from each palm.

(iii) Number of spadices:

All spadices in which either male or female flowers were in anthesis, unopened but fully emerged and partially emerged spadices were counted.

(iv) Number of bunches:

Bunches were counted down from the youngest inflorescence in which the fruits had set, to the oldest bunch, on each tree.

(v) Number of nuts per bunch:

Number of nuts in a bunch combined with number of bunches gave an idea of the yielding ability of the palm. Nuts were counted on all bunches of each mother palm and mean number of nuts per bunch obtained.

4. Fruit component analysis:

(i) Weight of unhusked nut:

Unhusked nuts were weighed on a top pan balance and mean weight expressed in grams.

(ii) Weight of husked nut:

The same seed nuts were used in recording this observation also. The nuts were husked, cleaned, weighed and mean weight expressed in grams.

(iii) Weight of meat:

Meat was excised out of the shell, weighed and mean weight was expressed in grams.

(iv) Thickness of meat:

Meat thickness was recorded for each kernel and mean meat thickness (cm) of the five kernels was used in the study.

(v) Diameter of eye:

Eyed-shells of each seed nut used in fruit component analysis was used in recording this observation. The hole on the shell corresponding to the soft eye was carefully cleaned and diameter recorded along two axes. Mean of these two values gave the mean eye diameter of a nut. Grand mean of such five mean values gave the mean eye diameter of the treatment in centimetres.

5. Nursery studies:

(i) Germination of seed nuts:

Germinated nuts were scored at weekly intervals starting from the first week after sowing. Emergence of beak at the stalk end was considered the sign of germination. Germination counts were continued upto six months. Other biometric observations were limited to seedlings emerged from seed nuts germinated within the six month period.

(ii) Seedling growth analysis:

The following observations were recorded on all the seedlings in the nursery at monthly intervals from July 1981 to April 1982.

(a) Seedling height (cm):

Height of seedling was measured from the base of the emerging shoot to the highest extremity. Height was measured using a graduated metre scale.

(b) Girth-at-collar (cm):

A non-extendible plastic string was used to measure collar girth. The string was would three times around the collar, unwound and length measured. This measurement divided by three gave the girth-at-collar.

(c) Number of leaves:

Number of leaves present on each seedling was scored.

(d) Leaf area (sq.cm):

An empirical formula developed by Ramadasan et al. (1980) was used in calculating leaf area, according to which,

$$Y = a + bX$$

Where Y = leaf area

$a = 27.3861$

$b = 0.6139$ and

X = product of length and breadth of leaf lamina.

Leaf area of each leaf was calculated separately and added up to give the total leaf area.

(e) Age at leaf splitting:

The seedlings were systematically observed for early leaf splitting character and the observations were recorded as months from date of sowing.

6. STATISTICAL ANALYSIS:

Data collected on various aspects mentioned above were systematically tabulated and subjected to different statistical procedures to obtain worthwhile results.

(i) Seedling vigour index:

A vigour index based on the six seedling characters viz., germination percentage, height of seedling, girth-at-collar number of leaves, leaf area, and age at leaf splitting was worked out.

For each group of seedlings derived from each mother tree, mean ($\bar{x}$) and standard deviation (S.D.) were worked out for each character. Accordingly, three classes with class limits

(1) below $\bar{x}$ - 0.5 S.D.

(2) between $\bar{x}$ - 0.5 S.D. and $\bar{x}$ + 0.5 S.D.

(3) above $\bar{x}$ + 0.5 S.D. were formed. These three classes were attributed with the respective index scores of 0, 1 and 2. Thus, six sets of index scores corresponding to the six characters were obtained for each seedling. These scores were

added upto obtain the total index score or vigour index of each seedling. The maximum vigour index that could be scored by any seedling was thus 12 and minimum, zero.

Based on the vigour index scored, seedlings were classified as

seedlings with	- low vigour	- index ranging from 0 - 4
	- medium vigour	- index ranging from 5 - 8
	- high vigour	- index ranging from 9 - 12

Of the three groups mentioned above, seedlings with medium and high vigour were considered together as quality seedlings based on the recommendation of Kannan and Nambiar (1979). Based on this grouping, the following estimates were worked out.

(1) Percentage of quality seedlings to total number of seedlings

(2) Percentage of quality seedlings to total number of seed nuts sown.

(ii) Analysis of mother palm characters:

Average super mother palm and control mother palm characters were compared by employing 'Student's' t test for small samples. (Panse and Sukhatme, 1957).

(iii) Analysis of Variance of seed nut characters:

Variance analysis of seed nut characters was done following the procedure of Completely Randomised Design (Federer, 1955) with 16 treatments and 5 replications.

(iv) Analysis of Variance of seedling characters:

Analysis of variance in Randomised Block Design with 16 treatments and 3 replications was followed (Federer, 1955).

(v) Simple Correlation Coefficients:

Correlation between mother palms, seed nut and seedling characters and between mother palm and seedling vigour index were worked out following the method suggested by Snedecor and Cochran (1967).

(vi) Heritability (in broad sense):

Heritability estimates were computed from the Analysis of Variance (ANOVA) tables following the method of Henson et al. (1956).

Genotypic Variance $V_{(G)}$

$$= \frac{\text{Mean squares (Treatment)} - \text{Mean squares (Error)}}{\text{Number of replications}}$$

Environmental Variance $V_{(E)}$ = Mean square (Error)

Phenotypic Variance $V_{(P)}$ = $V_{(G)} + V_{(E)}$

Heritability h^2 = $\frac{V_{(G)}}{V_{(P)}} \times 100$

(vii) Coefficient of Variation.

Both Genotypic and Phenotypic Coefficients of Variation were calculated as suggested by Burton (1951).

Genotypic Coefficient Variation (GCV)

$$GCV = \frac{\sqrt{V_{(G)}}}{Mean} \times 100$$

Where $V_{(G)}$ = Genotypic Variance

Phenotypic Coefficient of Variation (PCV)

$$PCV = \frac{\sqrt{V_{(P)}}}{Mean} \times 100$$

Where $V_{(P)}$ = Phenotypic Variance

(viii) Coheritability, Genotypic, Phenotypic, and Environmental Correlation Coefficients between seedling characters:

These parameters were worked out from the respective ANOVA and ANCOVA (Analysis of Covariance) tables. (Al-jibouri et al., 1958 and Singh and Chaudhary, 1979).

Genotypic Covariance between x and y

$$\text{Cov. (G) x, y} = \frac{\text{M.S.P. (Treatments) - M.S.P. (Error)}}{\text{Number of Replications}}$$

where M.S.P. = Mean Sum of Products

Environmental Covariance between x and y

$$\text{Cov. (E) x, y} = \text{M.S.P. (Error)}$$

Phenotypic Covariance between x and y

$$\text{Cov. (P) x, y} = \text{Cov. (G) x, y} + \text{Cov. (E) x, y}$$

$$\text{Coheritability} = \frac{\text{Cov. (G) x, y}}{\text{Cov. (P) x, y}} \times 100$$

Genotypic Correlation Coefficient

$$r\,(G) = \frac{\text{Cov. }(G)\ x.\ y}{\sqrt{V_{(G)}\ x.\ V_{(G)}\ y}}$$

Phenotypic Correlation Coefficient

$$r\,(P) = \frac{\text{Cov. }(P)\ x.\ y}{\sqrt{V_{(P)}\ x.\ V_{(P)}\ y}}$$

Environmental Correlation Coefficient

$$r\,(E) = \frac{\text{Cov. }(E)\ x.\ y}{\sqrt{V_{(E)}\ x.\ V_{(E)}\ y}}$$

(ix) Regression of seedling vigour index on seed nut characters of mother palm:

Simple linear regression equations were developed between seed nut characters of mother palms and seedling vigour index which were found to have positive and significant correlation. The regression equation read as

$$Y = a + bX$$

Where Y = seedling vigour index

X = seed nut character of mother palm

(x) Metroglyph analysis:

Metroglyph analysis was done to represent graphically, the relative position of each mother palm in relation to its seedling characters. The analysis was done as suggested by Anderson (1957). Each mother tree was represented as a glyph.

All seedling characters except girth-at-collar and leaf area were represented as rays at different positions on the glyph. The scatter diagram was constructed using girth as ordinate and leaf area as abscissa.

RESULTS

RESULTS

Outcome of various statistical analyses of the tabulated data are detailed in this chapter.

1. Mother palm characters:

The observations recorded on mother palm characters are presented in Table - 2. Since only a single tree comprised a treatment in the case of super mother palms, an analysis of variance of tree characters was not attempted. Instead, 'Student's' t test for small samples was applied to effect a general comparison between the two types of mother palms i.e., super mother palms and control mother palms. Details of this analysis are shown in Table - 3.

The mother trees did not significantly vary from each other with reference to age, number of leaves and spadices on crown. But the two types of palms showed significant difference with respect to number of bunches and number of nuts per bunch. As seen from mean values given in Table - 3, super mother palms are superior to control mother palms even in characters not showing superiority at significant levels.

2. Seed nut characters:

Seed nut characters were studied on randomly selected seed nuts. Analysis of variance was done for all seed nut characters. The details are presented in Tables 4 - 8.

Table - 2 Observations on mother palms.

Sl. No.	Treatment No.	Age	Number of leaves	Spadices	Bunches	Nuts/ bunch
SUPER MOTHER PALMS						
1.	1	28.00	26.00	2.00	18.00	22.00
2.	2	28.00	38.00	3.00	20.00	28.00
3.	3	24.00	32.00	3.00	13.00	27.50
4.	4	30.00	52.00	3.00	22.00	26.00
5.	5	19.00	38.00	2.00	15.00	48.00
6.	6	40.00	33.00	3.00	17.00	25.67
7.	7	61.00	28.00	3.00	16.00	38.50
8.	8	38.00	67.00	7.00	19.00	26.00
9.	9	40.00	38.00	3.00	17.00	27.00
10.	10	38.00	63.00	7.00	21.00	25.67
CONTROL MOTHER PALMS						
1.	11	40.00	33.20	2.80	15.60	10.00
2.	12	21.00	29.40	2.80	12.80	10.60
3.	13	26.00	19.50	2.75	16.50	8.75
4.	14	33.00	40.00	3.80	14.20	16.20
5.	15	20.00	30.10	3.00	11.20	10.30
6.	16	40.00	33.60	4.60	8.20	10.10

Table - 3 General comparison of super mother palm and control mother palm characters.

Character	Super mother palm			Control mother palm				
	$\bar{x}_1$	$S.D._1$	C.V.	$\bar{x}_2$	$S.D._2$	C.V.	S.D.	t_{14}
Age	34.60	11.15	32.23	30.00	8.23	27.43	10.85	0.82 N.S.
Number of leaves	41.50	13.58	32.72	32.63	3.70	11.34	11.73	1.46 N.S.
Number of spadices	3.60	1.74	48.33	3.29	0.69	20.97	1.54	0.39 N.S.
Number of bunches	17.80	2.64	14.83	12.98	2.71	20.88	2.85	3.28**
Number of nuts/bunch	29.43	7.39	25.11	10.99	2.40	21.84	6.44	5.55**

$\bar{x}_1$ and $\bar{x}_2$ — Mean

$S.D._1$ and $S.D._2$ — Standard Deviation

S.D. — pooled estimate of standard deviation

C.V. — Coefficient of variation

** — Significant at 1 per cent level

N.S. — Not significant.

(i) Weight of unhusked nut:

It is seen from the abstract of ANOVA in Table - 4 that 'F' value for treatments is highly significant. Comparison of mean values shows that T_4 is significantly superior to the rest. T_{11}, T_3 and T_{13} are the next superior trees, but they do not differ significantly among themselves. But these three trees are significantly superior to other treatments listed in the table.

Table - 4. Weight of unhusked nut (g).

Abstract of ANOVA

Source	S.S.	d.f.	M.S	F
Treatments	3015319.68	15	201021.31	38.00**
Error	338521.20	64	5289.39	

Mean weight of unhusked nut (g)

T_4	1149.20	T_{16}	620.00
T_{11}	771.00	T_{14}	608.40
T_3	770.80	T_8	573.60
T_{13}	760.00	T_9	517.40
T_{10}	676.20	T_2	488.20
T_1	666.40	T_{12}	453.60
T_{15}	630.00	T_5	355.60
T_6	629.20	T_7	267.00

C.D. at 5 per cent level = 91.535

** Significant at 1 per cent level.

(ii) Weight of husked nut:

Variance analysis of husked nut weight (Table - 5) also showed significant difference between treatments. Comparison of mean weight of husked nuts revealed the following results. T_4 is found to be significantly superior to all other trees. Next to T_4, T_1 and T_{10} recorded similar nut weight. T_1 is found to be significantly superior to other trees in the rank. But T_{10} is found to be on par with T_{15}, T_{14}, T_{11}, T_3 and T_6 but varies significantly from treatments ranked thereafter.

(iii) Weight of meat:

As observed in the earlier mentioned seed nut characters, here also 'F' value for treatments is highly significant. (Table - 6).

Mean weight of T_4 is found to be significantly superior to all other trees. The next superior tree is T_{10} but is on par with T_1, T_{15}, T_6 and T_3.

(iv) Thickness of meat:

Table - 7 shows abstract of ANOVA for the character and also the mean values in the descending order of superiority. Trees listed from T_9 to T_{10} are on par. T_9 shows significant differences with trees T_6 to T_{11}.

Table - 5. Weight of husked nut (g).

Abstract of ANOVA

Source	S.S.	d.f	M.S.	F
Treatments	1651991.38	15	110066.76	47.15**
Error	149397.60	64	2334.34	

Mean weight of husked nut (g).

T_4	776.60	T_{13}	310.40
T_1	476.40	T_{16}	309.80
T_{10}	421.00	T_8	295.20
T_{15}	415.00	T_9	262.40
T_{14}	412.20	T_2	253.20
T_{11}	392.00	T_{12}	242.60
T_3	391.60	T_7	153.40
T_6	383.60	T_5	147.00

C.D. at 5 per cent level = 60.809

** Significant at 1 per cent level.

Table - 6. Weight of meat (g).

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Treatments	890724.80	15	59381.65	29.00**
Error	131030.40	64	2047.35	

Mean weight of meat (g)

T_4	551.20	T_{14}	176.60
T_{10}	269.40	T_{16}	161.60
T_1	260.60	T_9	158.00
T_{15}	250.80	T_8	155.00
T_6	248.20	T_2	154.80
T_3	221.60	T_{12}	123.20
T_{11}	202.60	T_5	85.60
T_{13}	177.40	T_7	81.80

C.D. at 5 per cent level = 56.948

** Significant at 1 per cent level

Table - 7. Thickness of meat (cm).

Abstract of ANOVA

Source	S.S.	d.f.	M.S.	F
Treatments	0.3195	15	0.0213	2.7099*
Error	0.5030	64	0.0079	

Mean thickness of meat (cm)

T_9	1.05	T_6	0.93
T_{16}	1.03	T_1	0.92
T_2	1.00	T_7	0.90
T_4	0.99	T_{15}	0.89
T_3	0.95	T_5	0.88
T_{14}	0.95	T_{12}	0.85
T_8	0.94	T_{13}	0.85
T_{10}	0.94	T_{11}	0.82

C.D. at 5 per cent level = 0.117

* Significant at 5 per cent level.

(v) Diameter of eye (Size of embryo):

From abstract of ANOVA given in Table - 8, it is observed that treatments vary significantly even at 1 per cent level of 'F' values. Comparison of mean values show T_8 to be significantly superior to all other trees. Other trees in the rank namely, T_{11}, T_{10}, T_5, T_{15}, T_4 and T_7 are on par with each other.

Table - 8. Diameter of eye (cm).

Abstract of ANOVA.

Source	S.S.	df	M.S.	F
Treatments	2.1705	15	0.1447	9.8102**
Error	2.9440	64	0.0148	

Mean diameter of eye (cm)

T_8	1.46	T_2	1.07
T_{11}	1.23	T_9	1.05
T_{10}	1.17	T_6	1.03
T_5	1.16	T_{12}	1.02
T_{15}	1.14	T_{14}	1.00
T_4	1.10	T_{16}	0.96
T_7	1.09	T_3	0.82
T_{13}	1.08	T_1	0.70

C.D. at 5 per cent level = 0.153

** Significant at 1 per cent level.

(vi) General comparison of seed nut character of super mother palms and control mother palms:

Table - 9 shows the comparative assessment of the two types of mother palms with reference to their seed nut characters by 'Student's' t test for small samples. The value of 't' shows that the super mother palms and control mother palms do not vary significantly in relation to the seed nut characters. It is also seen from the table that, super mother palms record a relatively higher amount of variation in the characters - weight of unhusked nut, husked nut, and meat. The corresponding values for the control palms are relatively low.

3. Seedling characters:

All seedling characters were subjected to variance analysis in Randomised Block Design. The abstracts of ANOVA, mean tables and results obtained are detailed in the following pages.

(i) Germination percentage:

Table - 9 shows that trees vary significantly with reference to percentage of germination of seed nuts. The mean table shows that trees T_4 to T_{15} record germination percentages which are not showing any significant difference. Among them, T_4 registers the highest percentage of germination.

Table - 9. General comparison of seed nut characters of super mother palms and control mother palms.

Character	Super mother palm			Control mother palm			S.D.	t_{14}
	$\bar{x}_1$	S.D.$_1$	C.V.	$\bar{x}_2$	S.D.$_2$	C.V.		
Weight of unhusked nut	609.36	230.57	37.84	640.50	106.30	16.59	214.58	0.28 N.S.
Weight of husked nut	356.04	174.76	49.08	347.00	63.93	18.42	153.51	0.11 N.S.
Weight of meat	218.62	128.07	58.58	182.03	38.91	21.38	111.20	0.94 N.S.
Thickness of meat	0.95	0.05	5.26	0.89	0.07	7.87	0.06	1.63 N.S.
Diameter of eye	1.11	0.29	26.13	1.07	0.09	8.41	0.25	0.26 N.S.

$\bar{x}_1$ and $\bar{x}_2$ Mean

S.D.$_1$ and S.D.$_2$ Standard Deviation

S.D. Pooled estimate of standard Deviation

C.V. Coefficient of Variation

N.S. Not Significant

Table - 10. Germination percentage of seed nuts.

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Replications	640.98	2	320.49	2.51 N.S.
Treatments	14800.56	15	986.70	7.71**
Errors	3836.89	30	127.89	

Mean germination percentage

T_4	94.17 (76.00)	T_6	70.93 (57.37)
T_{16}	90.00 (71.57)	T_{11}	69.24 (56.31)
T_{10}	85.00 (67.21)	T_8	61.67 (51.75)
T_{12}	82.23 (65.07)	T_{13}	55.00 (47.87)
T_1	81.67 (64.65)	T_9	53.89 (47.23)
T_{14}	78.33 (62.26)	T_2	18.33 (25.85)
T_{15}	76.38 (60.93)	T_5	15.00 (22.79)
T_3	73.89 (59.27)	T_7	13.33 (21.41)

C.D. at 5 per cent level = 18.856

** Significant at 1 per cent level

N.S. Not Significant

Figures in parentheses are values after angular transformation.

(ii) Height of seedling:

Treatments differ significantly among themselves as evidenced by the high value of 'F'. Comparison of mean values of height shows that trees T_{15} to T_{12} are on par. T_4 which showed the best germinability registered mean height, behind the control groups, T_{15} and T_{14}.

Table - 11. Height of seedling (cm).

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Replications	226.16	2	113.08	1.19 N.S.
Treatments	8551.62	15	570.11	6.03**
Error	2838.67	30	94.62	

Mean height of seedling (cm)

T_{15}	99.10	T_{10}	77.16
T_{14}	97.04	T_1	76.79
T_4	96.29	T_{16}	75.05
T_{11}	91.12	T_8	74.94
T_3	88.57	T_{13}	67.47
T_6	87.56	T_2	61.00
T_9	85.44	T_5	56.20
T_{12}	83.26	T_7	54.50

C.D. at 5 per cent level = 16.218

** Significant at 1 per cent level.

N.S. Not Significant.

(iii) Girth-at-collar:

The mean value of girth-at-collar is highest for T_{14} and T_4 which do not vary significantly among themselves. T_{14} is significantly superior to trees T_{15} to T_2. T_4 is on par with T_{15} but, significantly superior to other trees viz., T_{10} to T_2. Table - 12 shows abstract of ANOVA and mean treatment values.

(iv) Number of leaves:

Comparison of mean leaf number of the different treatments shows that trees T_{14} to T_1 are on par. T_{14} differs significantly from treatments T_3 to T_2. T_4 differ significantly from treatments T_8 to T_2. Table - 13 shows abstract of ANOVA and mean leaf number of the different treatments.

(v) Leaf area:

Analysis of variance of total leaf area in Table - 13 shows a very high value for S.S. and M.S. This is due to the high values of leaf area and a wide range of values (866.43 - 4349.54). This character shows the best spectrum of continuous variation when compared to other seedling characters discussed earlier. Treatments ranked first are T_4, T_{14}, and T_{15} , none of which differ significantly from each other. T_4, and T_{14} showed significant superiority over treatments listed from T_6 to T_2. Treatment T_{15} is found to be on par with T_6, T_3, T_{11}, T_{12}, and T_{10}.

Table - 12. Girth-at-collar (cm).

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Replications	4.13	2	2.06	4.56*
Treatments	71.90	15	4.76	10.58**
Error	13.59	30	0.45	

Mean girth-at-collar (cm)

T_{14}	13.17	T_6	10.62
T_4	12.81	T_{16}	10.54
T_{15}	12.17	T_{13}	10.02
T_{10}	11.69	T_8	10.35
T_{11}	11.65	T_9	10.00
T_{12}	11.04	T_5	9.20
T_3	10.93	T_7	9.13
T_1	10.89	T_2	8.29

C.D. at 5 per cent level = 1.122

* Significant at 5 per cent level

** Significant at 1 per cent level

Table - 13. Number of leaves:

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Replications	0.0200	2	0.0100	1.1269 N.S.
Treatments	0.8944	15	0.0599	6.7372**
Error	0.2667	30	0.8889	

Mean number of leaves

T_{14}	6.09 (2.47)	T_3	4.93 (2.22)
T_4	5.91 (2.43)	T_8	4.82 (2.19)
T_{11}	5.62 (2.37)	T_{16}	4.88 (2.20)
T_6	5.56 (2.36)	T_7	4.50 (2.12)
T_{10}	5.54 (2.35)	T_9	4.45 (2.11)
T_{15}	5.47 (2.34)	T_{13}	4.33 (2.08)
T_{12}	5.32 (2.33)	T_5	4.24 (2.06)
T_1	5.24 (2.29)	T_2	4.04 (2.01)

C.D. at 5 per cent level = 0.157

** Significant at 1 per cent level

N.S. Not Significant

Figures in parentheses are values after square root transformation.

Table - 14. Leaf area (sq.cm).

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Replications	617791.04	2	308895.52	1.09 N.S.
Treatments	44986961.30	15	2999130.75	10.63**
Error	8466387.31	30	282212.91	

Mean leaf area (sq.cm)

T_4	4349.54	T_1	2384.90
T_{14}	4091.32	T_8	2132.42
T_{15}	3585.87	T_{16}	1878.89
T_{11}	3130.12	T_9	1749.29
T_6	2807.90	T_{13}	1683.21
T_{12}	2648.12	T_7	1338.95
T_{10}	2639.26	T_5	972.21
T_3	2543.46	T_{12}	866.43

C.D. at 5 per cent level = 885.724

** Significant at 1 per cent level

N.S. Not Significant.

(vi) Age at leaf splitting.

Abstract of ANOVA and mean values of treatments are given in Table - 14. Comparison of means shows that T_4, T_3 and T_1 are on par with each other and significantly superior to other treatments. Next comes, T_8, T_{11}, T_{14} and T_{15} which are on par and significantly superior to the rest of treatments.

(vii) Percentage of quality seedlings to total number of seedlings.

Analysis of variance showed that no significant difference existed between trees with reference to recovery of quality seedlings from total number of seedlings.

(viii) Percentage of quality seedlings to total number of seed nuts.

This parameter yielded significant differences between treatments. Comparision of mean values shows that treatments T_4 to T_{12} are on par. T_4 is significantly superior to treatments T_{13} to T_7. T_3 is significantly better than T_{11}, T_9, T_5, T_2 and T_7.

Table - 15. Age at leaf splitting (months).

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Replications	0.0043	2	0.0021	0.0047 N.S.
Treatments	42.1397	15	2.8093	6.1632**
Error	13.6747	30	0.4558	

Mean age at leaf splitting (months)

T_4	8.30 (3.05)	T_5	0.00 (1.00)
T_3	8.67 (3.11)	T_6	0.00 (1.00)
T_1	9.00 (3.16)	T_7	0.00 (1.00)
T_8	10.00 (3.32)	T_9	0.00 (1.00)
T_{11}	10.00 (3.32)	T_{10}	0.00 (1.00)
T_{14}	10.00 (3.32)	T_{12}	0.00 (1.00)
T_{15}	10.00 (3.32)	T_{13}	0.00 (1.00)
T_2	0.00 (1.00)	T_{16}	0.00 (1.00)

C.D. at 5 per cent level = 1.126.

** Significant at 1 per cent level.

N.S. Not Significant.

Figures in parentheses are values after $(x + 1)^{\frac{1}{2}}$ transformation.

Table - 16. Percentage of quality seedlings to total number of seedlings.

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Replications	9936.36	2	4968.18	11.20**
Treatments	12974.19	15	864.95	1.95 N.S.
Error	13301.69	30	443.39	

Mean percentage of quality seedlings to total number of seedlings

T_4	86.80 (68.69)	T_1	70.59 (57.16)
T_8	84.33 (66.68)	T_9	60.52 (51.07)
T_5	79.74 (63.25)	T_{10}	59.97 (50.75)
T_7	77.84 (61.92)	T_6	58.30 (49.78)
T_{15}	77.51 (61.69)	T_{16}	54.41 (47.53)
T_3	76.99 (61.34)	T_2	50.00 (45.00)
T_{14}	74.62 (59.75)	T_{12}	47.94 (43.82)
T_{13}	71.71 (57.87)	T_{11}	46.04 (42.73)

** Significant at 1 per cent level.

N.S. Not Significant

Figures in parentheses are values after angular transformation.

S.E. ± Mean = 12.160.

Table - 17. Percentage of quality seedlings to total number of seed nuts.

Abstract of ANOVA.

Source	S.S.	d.f.	M.S.	F
Replications	189.81	2	94.90	0.51 N.S.
Treatments	6590.59	15	439.37	2.56*
Error	5579.28	30	185.98	

Mean percentage of quality seedlings to total number of seed nuts

T_4	76.88 (61.26)	T_8	41.49 (40.10)
T_3	55.07 (47.91)	T_{12}	38.91 (38.59)
T_{15}	52.77 (46.59)	T_{13}	37.21 (37.59)
T_{10}	50.00 (45.00)	T_{11}	30.61 (33.59)
T_{14}	50.00 (45.00)	T_9	26.63 (31.07)
T_{16}	48.22 (43.98)	T_5	10.93 (19.31)
T_1	44.69 (41.95)	T_2	8.75 (17.21)
T_6	42.32 (40.58)	T_7	7.79 (16.21)

C.D. at 5 per cent level = 22.737.

N.S. Not Significant

* Significant at 5 per cent level.

Figures in parantheses are values after angular transformation.

(ix) General comparison of seedling characters of super mother palms and control mother palms:

Comparison of super mother palms and control mother palms with reference to their seedlings characters was done by employing the 'Student's' t test for small samples. The details are shown in Table - 18. The 't' value is not significant for any of the characters indicating that the two types of mother palms do not differ in their progeny performance. Considering the amount of variation present in the two types of mother palms, super mother palms registered considerable amounts of variation for seed nut germination, leaf area of seedlings, age of seedling at leaf splitting and percentage recovery of quality seedlings to total number of seed nuts when compared to control mother palm groups.

4. Correlation analysis of mother palm, seed nut and seedling characters:

Simple correlations established between mother palms, seed nut and seedling characters are presented in Table - 19.

It is seen from the table that number of leaves on mother trees is significantly and positively correlated with number of bunches. These results agree with those obtained by Menon and Pandalai (1958).

Number of bunches failed to show significant correlation with any other characters studied.

Table - 18. General comparison of seedling characters of super mother palms and control mother palms.

Character	Super mother palm			Control mother palm				
	$\bar{x}_1$	S.D.$_1$	C.V.	$\bar{x}_2$	S.D.$_2$	C.V.	S.D.	t_{14}
Germination percentage	56.78	29.08	51.22	75.19	10.98	14.60	26.61	1.39 N.S.
Height of seedling	75.85	13.69	18.05	85.51	11.47	13.41	13.79	1.36 N.S.
Girth-at-collar	10.39	1.25	12.03	11.43	1.05	9.19	1.26	1.59 N.S.
Number of leaves	4.92	0.59	11.99	5.28	0.56	10.61	0.62	1.13 N.S.
Leaf area	2188.44	980.60	44.81	2836.26	866.49	30.55	1004.29	1.25 N.S.
Age at leaf splitting	3.59	4.42	123.21	5.00	5.00	100.00	4.97	0.55 N.S.
A	70.51	11.91	16.89	62.04	12.94	20.86	13.15	1.25 N.S.
B	36.46	21.52	59.02	42.95	7.91	18.42	18.90	0.67 N.S.

A Percentage of quality seedlings to total number of seedlings

B Percentage of quality seedlings to total number of seed nuts

$\bar{x}_1$ and $\bar{x}_2$ M Mean

S.D.$_1$ and S.D$_2$ Standard Deviation

S.D. Pooled estimate of standard deviation

C.V. Coefficient of Variation

N.S. Not Significant.

TABLE – 19. SIMPLE CORRELATION BETWEEN MOTHER PALM, SEED NUT, AND SEEDLING CHARACTERS.

Sl.No.	CHARACTER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	NUMBER OF LEAVES	–	0.5351*	0.2750	0.2193	0.2928	0.3161	0.3154	0.6678**	0.1727	0.0686	0.1989	0.0891	0.1597	0.1335	0.3065
2	NUMBER OF BUNCHES		–	0.4639	0.2428	0.3178	0.4075	0.0784	0.3099	–0.1588	–0.1408	–0.1122	–0.0990	0.0069	0.0182	0.3839
3	NUMBER OF NUTS PER BUNCH			–	–0.3818	–0.2119	–0.0788	0.2305	0.0759	–0.5799*	–0.4868	–0.4695	–0.4447	–0.4042	–0.2105	0.2079
4	WEIGHT OF UNHUSKED NUT (g)				–	0.8417**	0.8244**	0.0463	0.0264	0.6400**	0.5529*	0.5819*	0.4188	0.6043*	0.4264	0.6079*
5	WEIGHT OF HUSKED NUT (g)					–	0.9661**	0.1778	0.7944**	0.7332**	0.6837**	0.7464**	0.6655**	0.8046**	0.5733*	0.5677*
6	WEIGHT OF MEAT (g)						–	0.2200	–0.0013	0.6331**	0.5751*	0.6139*	0.5519*	0.6957**	0.4198	0.5532*
7	THICKNESS OF MEAT (cm)							–	–0.1617	0.1295	0.0709	–0.0530	–0.1900	–0.2508	–0.2208	0.0045
8	DIAMETER OF EYE (cm)								–	–0.1859	–0.0631	–0.0132	–0.0131	0.0121	0.0465	0.1133
9	GERMINATION (%)									–	0.7698**	0.8295**	0.7742**	0.7668**	0.4167	0.0599
10	HEIGHT OF SEEDLING (cm)										–	0.8617**	0.8399**	0.8982**	0.6196*	0.1515
11	GIRTH-AT-COLLAR (cm)											–	0.9356**	0.9598**	0.6256**	0.2047
12	NUMBER OF LEAVES												–	0.9439**	0.5436*	0.3851
13	LEAF AREA (sq.cm)													–	0.6688**	0.5107
14	AGE AT LEAF SPLITTING (months)														–	0.5720*
15	A															–
16	B															

A PERCENTAGE OF QUALITY SEEDLINGS TO TOTAL NUMBER OF SEEDLINGS
B PERCENTAGE OF QUALITY SEEDLINGS TO TOTAL NUMBER OF SEEDNUTS

r = 0.4973 AT P (0.05)
r = 0.6230 AT P (0.01)

* SIGNIFICANT AT (0.05) LEVEL
** SIGNIFICANT AT (0.01) LEVEL

Number of nuts per bunch showed negative correlation with weight of unhusked nut, husked nut and meat. This character also showed significant negative correlation with nut germination. Subsequent growth of seedlings and recovery of quality seedlings from total number of seed nuts sown are also negatively affected by an increase in number of nuts per bunch.

Weight of unhusked nut showed significant positive correlation with weight of husked nut, meat, germination of nut, seedling height, girth-at-collar, and leaf area. This character is highly correlated with percentage recovery of quality seedlings from total number of seedlings as well as seed nuts sown.

Weight of husked nut exhibited very high positive correlation with weight of meat, diameter of eye, germination of nut, seedling height, girth-at-collar, number of leaves, leaf area, age at leaf splitting, and percentage recovery of quality seedlings from total number of seedlings and seed nuts.

Weight of meat also showed similar correlation with all seedling characters and recovery percentage of quality seedlings.

Meat thickness and eye diameter failed to show significant correlations with any seedling character.

Seed nut germination showed significant positive correlation with seedling height, girth-at-collar, number of leaves, leaf area and percentage recovery of quality seedlings from total number of seed nuts sown.

Seedling height, girth-at-collar and number of leaves showed significant positive correlations with each other and with leaf area, age at leaf splitting and seed nut-to-quality seedlings recovery percentage. Positive correlations were obtained between height and girth-at-collar of seedlings by Pankajakshan and George (1961). Ramadasan et al. (1980) also obtained significant positive correlations between seedling height, girth-at-collar, number of leaves, and leaf area.

Leaf area and age at leaf splitting showed significant positive correlations with each other and with recovery percentages of quality seedlings.

5. Correlation studies between mother palm, and seed nut characters with seedling vigour index:

Simple intercorrelation between mother palm characters including seed nut characters and seedling vigour index are presented in Table - 20.

A perusal of this table shows that seedling vigour index is significantly and positively correlated with weight of unhusked nut, husked nut, and meat. Positive, though not significant correlations are shown by number of bunches, leaves, and nuts per bunch with seedling vigour index.

Table - 20. Correlation between mother palm, and seed nut characters with seedling vigour index.

	Character	Seedling vigour index
Mother palm character	Number of leaves	0.2543
	Number of bunches	0.4404
	Number of nuts per bunch	0.1614
Seed nut character	Weight of unhusked nut	0.5110*
	Weight of husked nut	0.5728*
	Weight of meat	0.5475*
	Thickness of meat	-0.0285
	Diameter of eye	-0.0972

$r = 0.4973$ at $P = 0.05$

* Significant at 5 per cent level.

6. Regression of Seedling vigour index on Mother palm (Seed nut) characters:

Based on the results shown in Table - 18, three characters i.e., weight of unhusked nut, husked nut, and meat were selected for fitting simple linear regression equations between seedling vigour index and mother palm (seed nut) characters. The regression equations with attached Standard Errors are as follows.

(i) Regression of Seedling vigour index (Y) on Weight of unhusked nut (X_1)

$$Y = 4.7585 + 0.0020\, X_1 \qquad (0.0020 \pm 0.0009)$$

(ii) Regression of Seedling vigour index (Y) on Weight of husked nut (X_2)

$$Y = 4.9008 + 0.0032\, X_2 \qquad (0.0032 \pm 0.0012)$$

(iii) Regression of Seedling vigour index (Y) on Weight of meat (X_3)

$$Y = 5.1731 + 0.0041\, X_3 \qquad (0.0041 \pm 0.0017)$$

These linear relationships and the relative position of each mother tree under investigation about the respective regression lines are illustrated in Fig.1, 2, and 3 respectively.

7. Genotypic and Phenotypic Coefficients of Variation of seed nut and seedling characters:

Table 21 shows the genotypic and phenotypic coefficients of variation in different seed nut and seedling characters studied.

Among seed nut characters, weight of meat recorded the highest genotypic and phenotypic coefficients of variation, followed by weight of husked nut, and unhusked nut. In agreement with this, Sathyabalan et al. (1968) obtained simple coefficient of variation of mean copra content in Dwarf Green and Dwarf Orange cultivars to be 48.6 and 10.7 per cent respectively. The authors obtained 49.9 and 11.7 per cent C.V. for weight of husked nut for the two cultivars, Dwarf Green and Dwarf Orange.

FIG. 1 INFLUENCE OF SEED NUT CHARACTER OF MOTHER PALM ON SEEDLING VIGOUR INDEX.

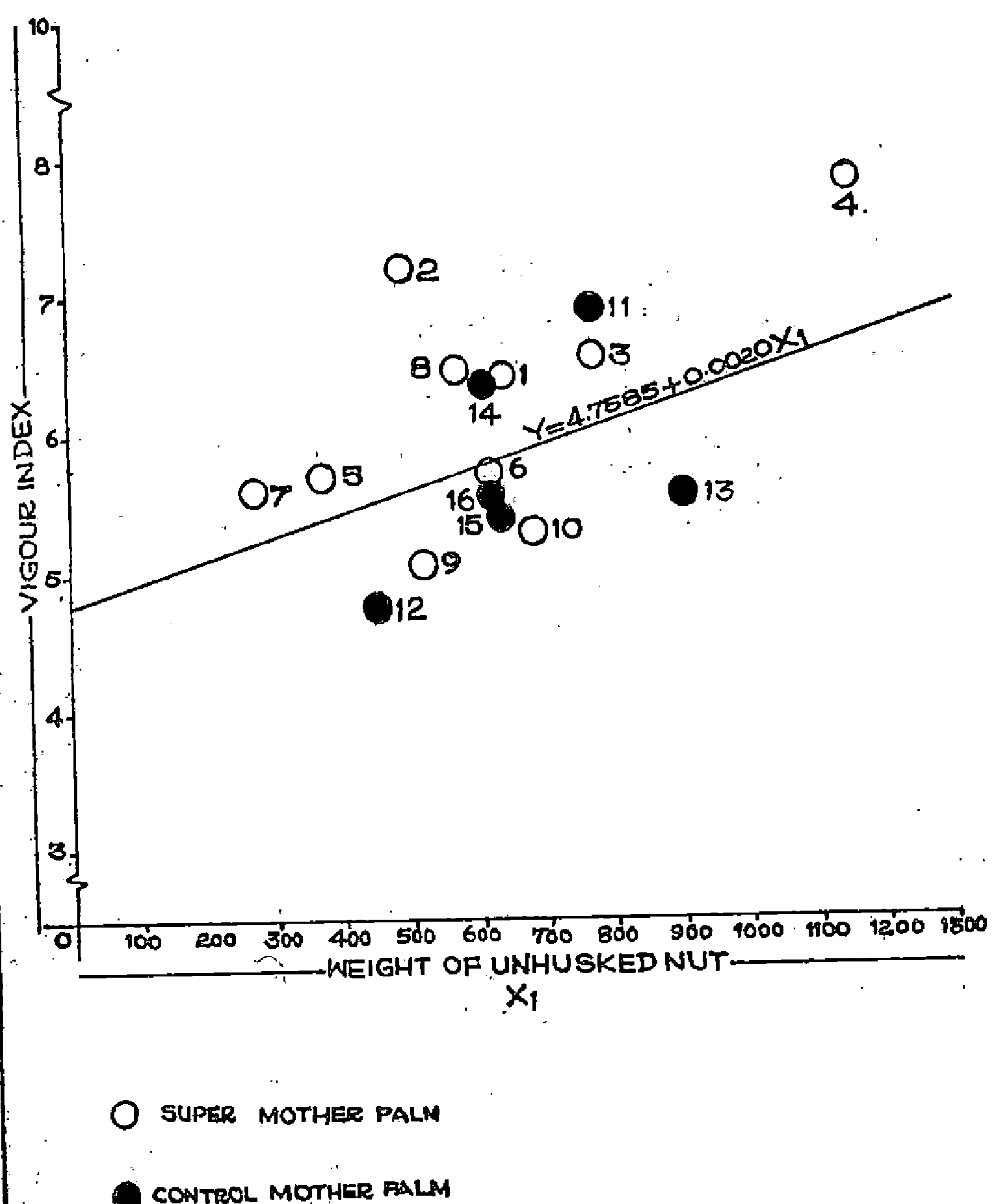


FIG.2 INFLUENCE OF SEED NUT CHARACTER OF MOTHER PALM ON SEEDLING VIGOUR INDEX.

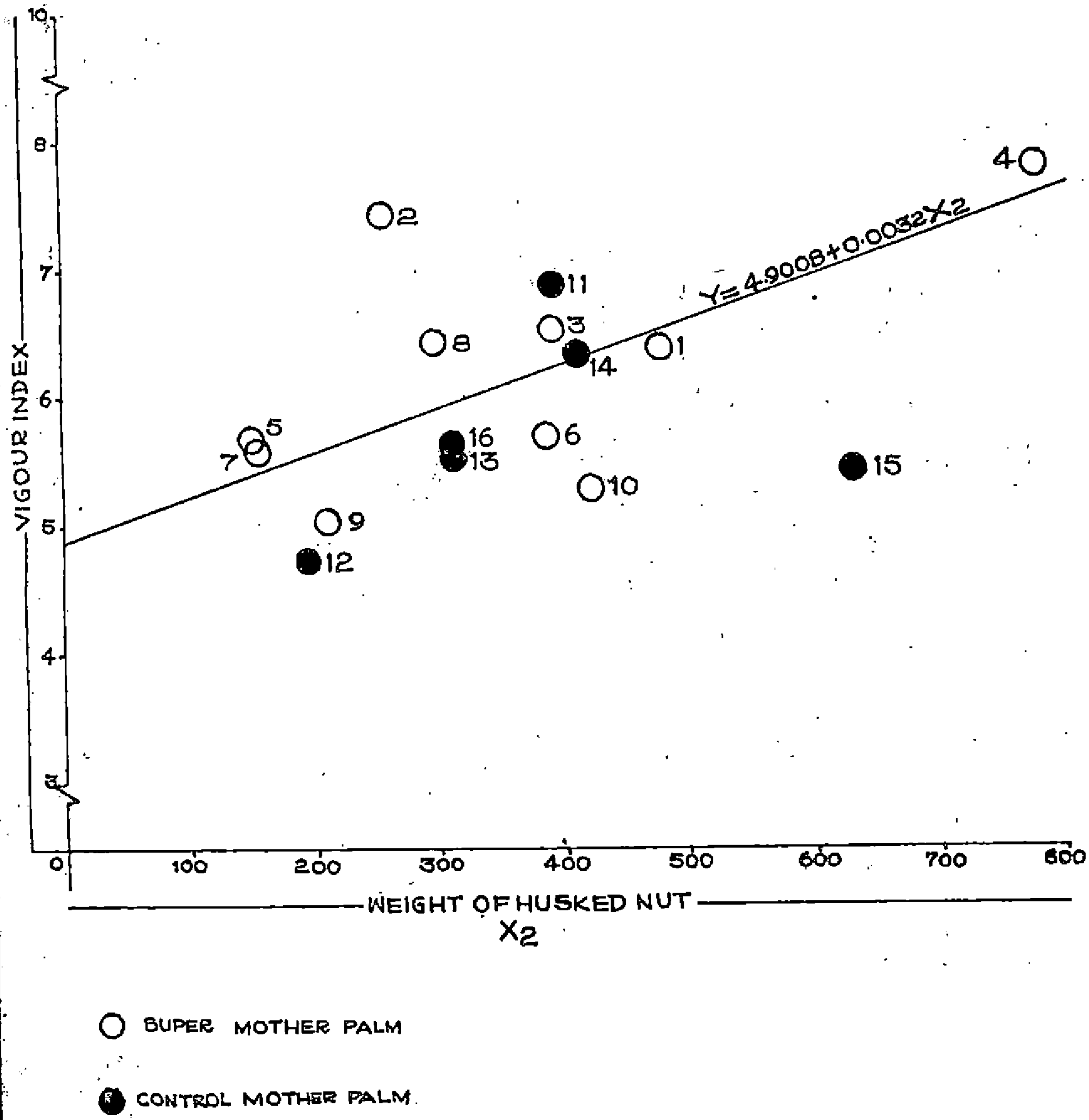


FIG. 3 INFLUENCE OF SEED NUT CHARACTER OF MOTHER PALM ON SEEDLING VIGOUR INDEX.

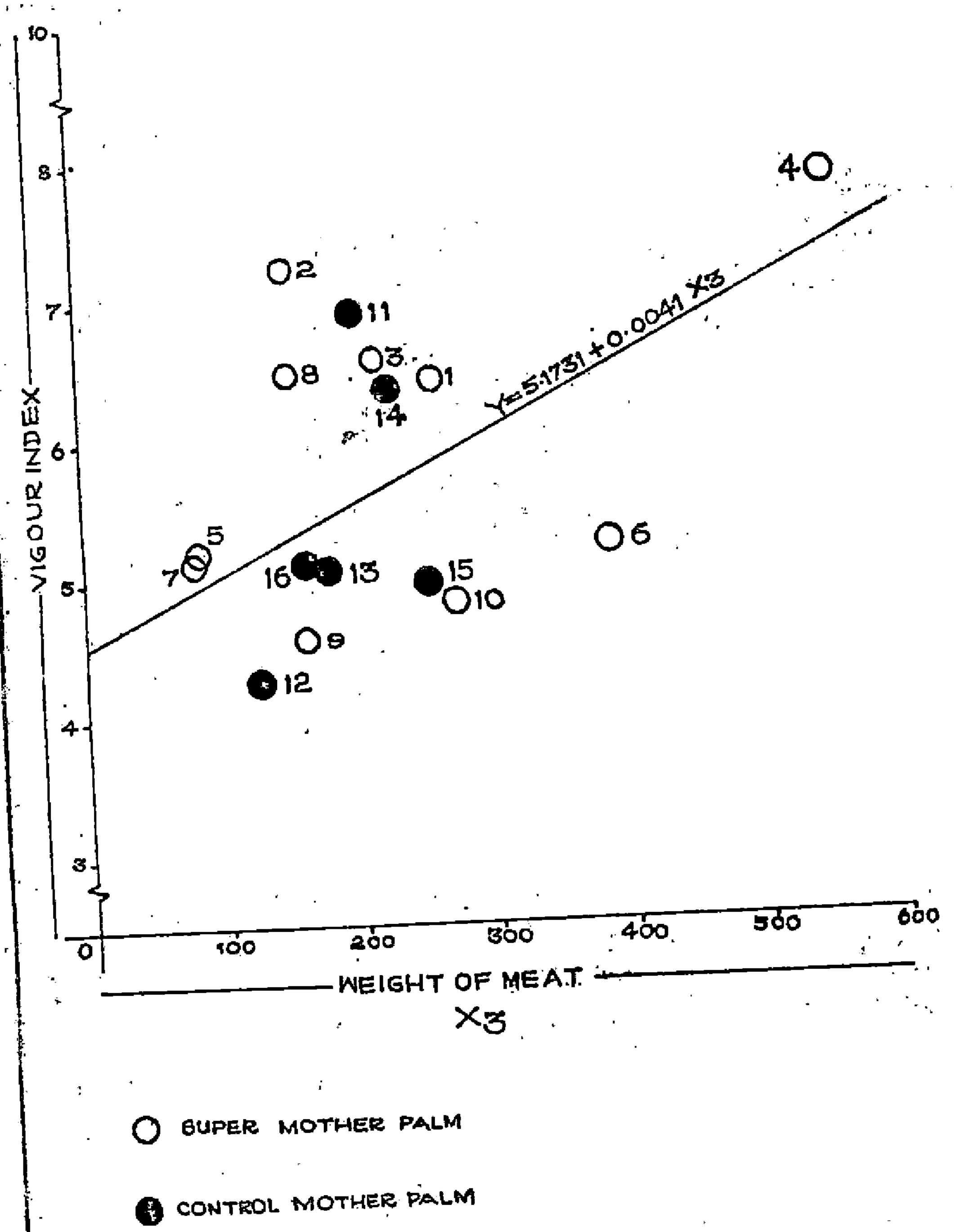


Table - 21. Genotypic and Phenotypic Coefficient of Variation (GCV and PCV) of seed nut and seedling characters.

	Character	GCV (%)	PCV (%)
Seed nut character	Weight of unhusked nut	41.13	42.76
	Weight of husked nut	57.83	75.31
	Weight of meat	67.47	70.99
	Thickness of meat	7.13	11.91
	Diameter of eye	19.40	22.47
Seedling character	Germination percentage	31.12	37.44
	Height of seedling	16.03	20.26
	Girth-at-collar	11.09	12.71
	Number of leaves	5.76	7.13
	Leaf area	39.14	44.83
	Age at leaf splitting	41.78	52.53

8. Heritability estimates (in broad sense) of Seed nut characters:

Table - 22 shows heritability (h^2) computed from Analysis of Variance tables relating to the seed nut characters.

Table - 22. Heritability (in broad sense) of seed nut characters.

Sl.No.	Seed nut character	Heritability (%)
1	Weight of unhusked nut	92.50
2	Weight of husked nut	94.39
3	Weight of meat	90.32
4	Thickness of meat	34.15
5	Diameter of eye	74,53

It is seen from the table, that heritability estimates of weight of unhusked nut, husked nut, and meat are extremely high. Similar results with reference to weight of husked nut and meat were obtained by Lakshmanachar (1959) and Liyanage and Sakai (1960). Diameter of eye also exhibited high heritability whereas, thickness of meat registered a low heritability estimate.

9. Heritability and Coheritability estimates (in broad sense) of seedling characters:

These two genetic parameters were computed from abstracts of respective variance and covariance analyses.

Table - 23. Heritability and Coheritability of seedling characters.

Sl. No.	Seedling character	Heritability	Coheritability					
			1	2	3	4	5	6
1.	Germination percentage	69.12	-	84.39	90.76	93.10	88.15	84.16
2.	Height of seedling	62.62		-	73.29	75.84	72.16	66.39
3.	Girth-at-collar	76.16			-	73.92	79.19	81.12
4.	Number of leaves	65.23				-	79.15	81.38
5.	Leaf area	76.24					-	70.89
6.	Age at leaf splitting	63.25						-

Leaf area and girth-at-collar shows the highest heritability values, followed by germination percentage. Coheritability estimates are high for combination of all characters except height and age-at leaf splitting.

10. Genotypic, Phenotypic, and Environmental correlation between seedling characters:

These parameters were obtained from combined analysis of abstracts of ANOVA and ANCOVA of the respective characters. Table - 24 shows the said parameters. For all characters, it is seen that egenotypic correlation is higher than phenotypic correlation. Likewise, in all cases, except once, phenotypic correlation stands above environmental correlation. Only, the environmental correlation coefficient of seedling height and number of leaves do exceed the corresponding phenotypic correlation coefficient.

Genotypic correlation were positive and significant for all characters studied, except in, comparison of germination and seedling height with age at leaf splitting. Further, it is seen from Table - 24 that age at leaf splitting has registered a comparatively lower genotypic, phenotypic and environmental correlation with other characters.

Table - 24. Genotypic (G), Phenotypic (P), and Environmental (E), correlation between seedling characters.

Sl. No.	Seedling character		1	2	3	4	5	6
1.	Germination percentage	G	-	0.8732**	0.8758**	0.8799**	0.8082**	0.4304
		P	-	0.6807**	0.7002**	0.6347**	0.6656**	0.4325
		E	-	0.3128	0.2386	0.1253	0.2913	0.1855
2.	Height of seedling	G		-	0.8948**	0.5648*	0.9286**	0.4067
		P		-	0.8441**	0.3042	0.8861**	0.3855
		E		-	0.7577**	0.5655*	0.8306**	0.3496
3.	Girth-at-collar	G			-	0.7624**	0.9766**	0.5775*
		P			-	0.7269**	0.9403**	0.5285*
		E			-	0.6584**	0.8219**	0.3149
4.	Number of leaves	G				-	0.9955**	0.5268*
		P				-	0.8869**	0.4158
		E				-	0.6435**	0.2167
5.	Leaf area	G					-	0.5514*
		P					-	0.5460*
		E					-	0.5379*
6.	Age at leaf splitting	G						-
		P						-
		E						-

11. Metroglyph analysis of super mother palms and control mother palms based on seedling characters:

Table - 25 shows the index values and position of rays for all the characters studied.

The frequency diagram (Fig.4) shows that only T_4 gets the maximum index score which is closely followed by T_{14} and T_{15}. Scatter diagram of the glyphs is also presented in Fig.4. This diagram shows the relative position of each mother palm based on seedling progeny performance.

Table - 24.

r = 0.4973 at P = 0.05

r = 0.6230 at P = 0.01

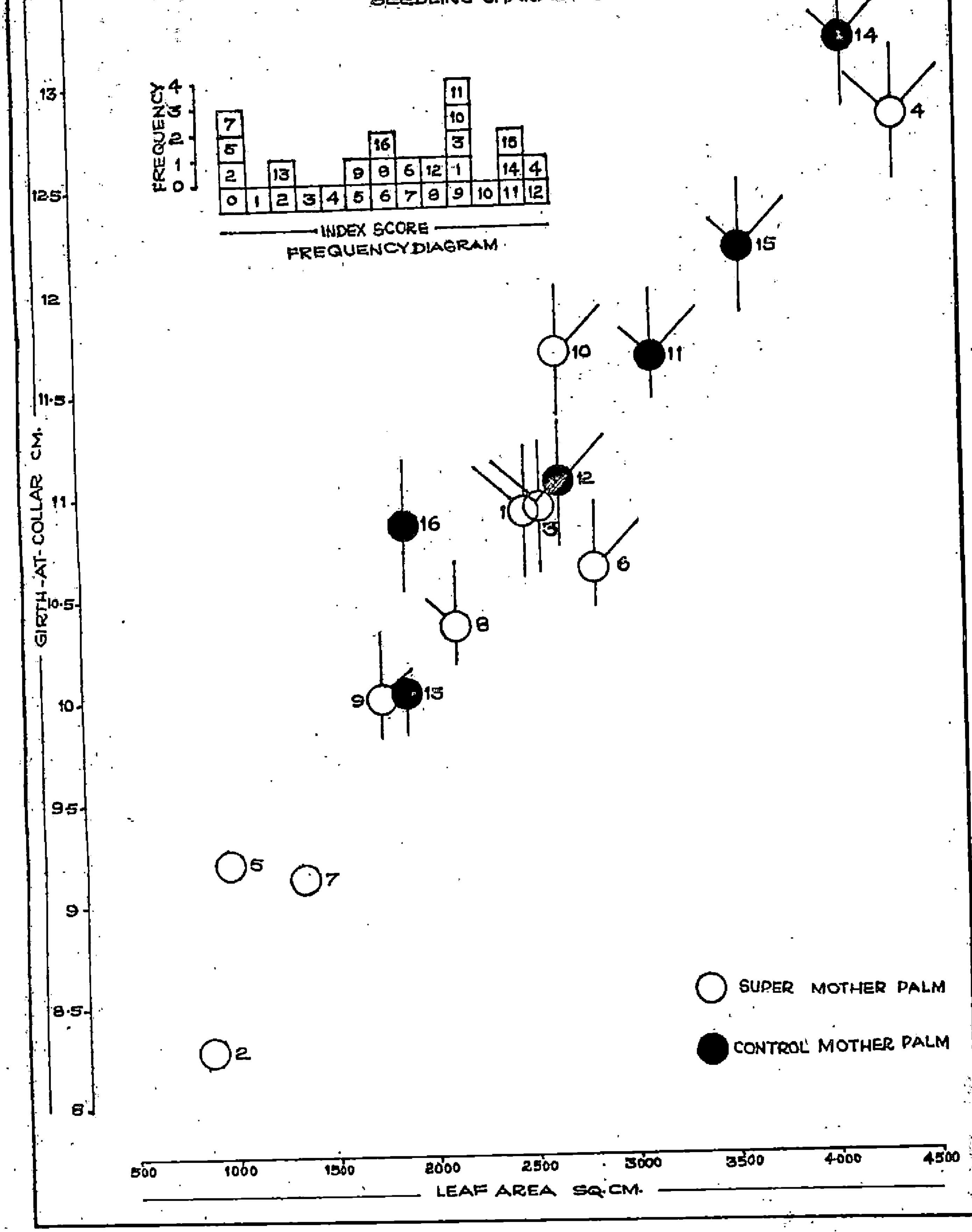
* = Significant at 5 per cent level

** Significant at 1 per cent level

Table - 25. Class intervals, index values, and glyphs of seedling characters of mother palms.

Sl. No.	Seedling character	Index value 0	Index value 1	Index value 2
		0	1	2
1.	Germination percentage	below 39.61 	39.62 to 57.82 	above 57.83 
2.	Height of seedling (cm)	below 69.37 	69.38 to 74.24 	above 74.25 
3.	Girth-at-collar (cm)	below 9.92	9.93 to 11.54	above 11.55
4.	Number of leaves	below 4.63 	4.64 to 5.36 	above 5.37 
5.	Leaf area (sq.cm)	below 2027.80	2027.81 to 3188.17	above 3188.18
6.	Age at leaf splitting (months)	no leaf splitting 	above 9.18 	below 9.17 

FIG. 4 SCATTER DIAGRAM OF MOTHER PALMS BASED ON SEEDLING CHARACTERS.



DISCUSSION

DISCUSSION

A detailed treatise built upon the various results obtained on mother palms, seed nuts and seedlings are presented in this chapter. Various aspects of relevance have been discussed in relation to the already established facts and figures reviewed earlier.

1. Mother palm characters:

The two categories/types of mother palms i.e., super mother palms and control mother palms have been compared in relation to age, number of leaves, spadices, and bunches on the crown and number of nuts per bunch. There exists significant superiority of super mother palms over control mother palms with reference to number of bunches and number of nuts per bunch as evidenced by Table - 3. On observing Tables - 2 and 3, we can see that there exists a clear cut difference between these two types of mother palms in their yielding ability. It is seen from Table - 2 that, T_4, T_8, and T_{10} have extremely high number of leaves on their crowns. Also, T_4 carried on its crown, a very large number of bunches and high number of nuts per bunch. A high rate of spadix (bunch in this case) production has been observed in regular bearers (Sathyabalan et al., 1969). The high number of bunches produced by T_4 (22) is more than the average figure for regular bearers (12) pointed out by Thampan (1981). As against a general average number of 8.5 nuts per bunch (Nambiar, 1971 and Purseglove, 1975) the super mother palms under investigation produced very high number of 29.43 nuts per bunch.

A higher degree of variation noticed in super mother palms with respect to characters such as number of leaves, spadices, bunches and nuts per bunch indicates that they vary among themselves to a considerable extent.

2. Seed nut characters:

A higher ranking of T_4 in relation to seed nut characters viz., height of unhusked nut, husked nut, and meat makes it superior to other palms. In the other seed nut characters studied like, thickness of meat and eye diameter, T_4 has failed to show its supremacy.

Seed nut selection based on weight of unhusked nut is important according to Liyanage and Abeywardena (1957). A more important seed nut character is the weight of husked nut as evidenced by the literature reviewed. If selection is being practised on the basis of weight of husked nut for the best ten per cent palms, T_4 can be selected thus obtaining a high frequency of palms of good performance as envisaged by Mantriratne (1965). Selection of T_4 as a palm showing superior performance has been proved correct by the results obtained in Table 10 - 17 and Fig.2.

Seed nut selection on the basis of copra/meat is also important as seen in literature reviewed. Selection of seed parent as the best ten per cent of the palms based on the background yield of copra makes T_4 eligible among the super palms. The overall superiority of this palm over other super palms and control palms is evidenced by Tables 10, 14, 15, 16, and 17 and Fig. 1, 2 and 3. Hence, selection on the basis of copra or meat as suggested by Liyanage (1967) and Abraham and Ninan (1968), is highly result oriented method for isolating superior genotypes.

Meat thickness and eye diameter have failed to show responses similar to that of weight of unhusked nut, husked nut, and meat.

Super palms and control palms do not vary significantly from each other with reference to any of the seed nut characters studied. This is expected since, the number of nuts per bunch is very high for the super palms, naturally their individual size will be smaller compared to controls. Thus the low figures recorded by most of the super palms like T_4 which produced larger nuts. This ultimately has resulted in a low weight of unhusked nut and relatively similar values for weight of husked nut, meat, meat thickness, and eye diameter when compared to that of control palms (Table - 9).

The comparatively higher values of coefficient of variation for weight of unhusked nut, husked nut and meat indicate the wide spectrum of variation existing between the super palms. At the same time, the coefficient of variation for these characters is low for the control trees indicating

Plate 2 A bunch of seed nuts harvested from super mother palm T_5

their near uniformity in seed nut traits.

3. Seedling characters:

(1) Seed nut germination:

Perusal of Table - 10 shows that T_4 is superior in seed nut germination, closely followed by T_{16}. This shows the relative superiority of seed nuts collected by the State Department of Agriculture from the selected gardens of northern Kerala. T_{16} registered this high germination percentage inspite of the fact that, it could not put up a fair performance in mother palm and seed nut characters as seen in Tables - 2 and 4 - 8. Another fact observed from Table - 10 is the low germination percentage of T_2, T_5 and T_7. It is seen from Table - 2 that these palms had a high number of nuts per bunch. This has led to a resultant reduction in size of nuts as evidenced by Tables - 4 to 6. These small sized nuts with less quantity of nut water, probably dried up during storage extending to about two months. This might have led to their poor germination. This again emphasises the importance of fixing the minimum nut size for seed purpose in coconut.

(ii) Seedling growth parameters:

The seedling growth parameters considered in this study were seedling height, girth-at-collar, number of leaves, and age at leaf splitting. Super palm T_4 is ranked below control palms for seedling height, girth-at-collar and number of leaves as seen from Tables - 11, 12 and 13. The control palm T_{15} registers a better seedling height (Table - 11) and T_{14} shows a better collar girth and total number of leaves (Tables - 12 and 13). The superior performance of the seedling from these two control mother palms could be explained as the effect of the general vigour expressed by the garden from which these were selected. Cheyne (1952) has explained such effects in terms of 'block nut' selection.

The super palm, T_4 has shown superiority over the rest of palms in respect of total leaf area, and age at leaf splitting, (Tables 14 and 15). Since leaf area is an important factor contributing to total vigour of a seedling (Ramadasan et al., 1980) the superiority of T_4 in producing vigourous seedling has become more evident. Leaf splitting occurs at the earliest by eight months after sowing in T_4 which shows the quality of the seedling obtainable from this tree, since early leaf splitting is a sign of precocity (Menon and Pandalai, 1958).

The comparison of seedling characters on the basis of two groups - super mother palms and control mother palms has shown that seedlings belonging to the two categories do not differ significantly in their performance. As observed in general comparison of seed nut characters, here also the better performance of one or two super palms has been eclipsed by the inferior performance of other super palms. Meanwhile, the control palms put up a uniform average performance as evident from the relatively lower coefficient of variation for almost all seedling characters. The relatively higher coefficient of variation for germination, leaf area, and recovery of quality seedlings from total number of seed nuts sown, indicate the degree of variation existing between the super palms. The high value of variation showed by age at leaf splitting indicates that it cannot be taken as a reliable character for identifying vigorous seedlings in such small populations as taken in this study.

4. Recovery of quality seedlings:

Perusal of data on recovery of quality seedlings from total number of seedlings and total number of nuts have shown that T_4 is recording higher mean values of 86.80 and 76.88 per cent respectively (Tables - 15 and 16). This is the best evidence of the superior ability of super palm T_4 to produce progeny with overall superiority, since, the yardstick for recovery of quality seedlings from total number of seed nuts sown is 60 - 65 per cent as per Package of practices recommendations (Anonymous, 1981). These results justify the labelling of T_4 as a prepotent super palm on the basis of seedling progeny analysis because, the performance of progeny at seedling stage is a clear indication of its adult performance as suggested by Nambiar and Nambiar (1970) and Sathyabalan and Mathew (1977).

Perusal of the two recovery estimates with respect to their relative merit, indicate that recovery percentage of quality seedlings from total number of seed nuts sown is a more reliable estimate. This becomes evident from the following observations.

(a) Table - 18 shows that the super mother palms do not show high variation for recovery of quality seedlings indicating that the trees are near uniform in producing quality seedlings, but it is not so. Meanwhile, percentage recovery of quality seedlings from total number of seed nuts shows high variation. Hence it can be used as a reliable estimate.

(b) Table - 19 shows a very high positive correlation existing between different seedling characters and recovery of quality seedlings from total number of seed nuts sown, when compared to recovery of quality seedlings from total number of seedlings.

5. Correlation studies between mother palm, seed nut and seedling characters, and recovery of quality seedlings:

Correlation between number of leaves and bunches of mother palms indicate that, with an increase in number of leaves, there will be a corresponding increase in the bunch number also (Table - 19). This agrees with the observation of Menon and Pandalai (1958) that rate of production of spadices is dependant on rate of production of leaves.

A high number of nuts in a bunch reduces nut size by way of weight of unhusked nut, husked nut, and meat. The effect on weight of unhusked nut is pronounced ($r = -0.3818$ at $P = 0.05$). The negative correlation between nuts per bunch and seedling growth parameters is the result of its negative relationship with germination and the above mentioned seed nut characters. Data presented in Table - 20 show that overall seedling vigour index is positively and significantly correlated to the above mentioned seed nut characters.

Significant positive correlations have been exhibited by these seed nut characters with each other and with seedling characters and recovery of quality seedlings. This indicates the importance of these characters in selecting mother palms. This is further established by the significant positive correlation of these characters with seedling vigour index (Table - 20).

Seedling growth parameters have shown positive correlation with each other and most of them were significant also. All the growth parameters of seedlings showed significant positive correlation with recovery of quality seedlings which is the measure of prepotency. The seedling growth characters recorded higher correlation with seed nut - to - quality seedling recovery percentage, thereby showing the reliability of this measure of prepotency. A similar response has been obtained between weight measurements on seed nut and percentage of quality seedlings to total number of seed nuts sown.

6. Correlation studies between mother palm, and seed nut characters with seedling vigour index:

The relationships as seen from Table - 20 show that selection of mother palms based on seed nut characters is a viable suggestion. The significant positive correlation shown by weight of unhusked nut, husked nut, and meat, with seedlings vigour index indicate that, those are the seed nut characters to be considered while selecting mother trees, especially weight of husked nut and meat. These results suggest that, if selection of mother trees for higher weight of unhusked nut, husked nut and meat are practised, more vigorous seedlings can be obtained. As size of nut increases, the number of nuts per bunch and thus, the number of nuts per tree also gets reduced. Another study showed that heavy and larger nuts produced progeny which will produce fewer nuts than the progeny of those palms bearing smaller nuts (Anonymous, 1956).

Package of practices recommendations of Kerala Agricultural University (Anonymous, 1981) suggests that while selecting mother trees, seed nut selection should be restricted to those recording mean husked nut weight and copra content over 600 and 150 g. respectively. The present study also justifies these recommendations.

Kannan and Nambiar (1979) observed that high and medium vigorous seedlings of high yielding palms equalled in their adult performance. Hence a judicious procedure balancing the number and size of nuts in selecting mother palms is sure to yield more number of quality (vigorous) seedlings than while selecting purely on the basis of number of nuts. A selection procedure for mother palms tailored in this direction will help the plant breeder to identify prepotent palms with better efficiency.

7. Linear relationship between seedling vigour index and seed nut characters of mother palms:

Regression of seedling vigour index on seed nut characters viz., weight of unhusked nut, husked nut, and meat are illustrated in Fig.1, 2, and 3. From these illustrations, it can be seen that T_4 is definitely superior to the rest, by virtue of its isolated and elevated position about the respective regression lines. Observing super palm T_4 alone, seedling vigour index is more related to weight of husked nut, and meat as seen from Fig.2, and 3. Hence, it is derived from these figures that, T_4 which produces seed nuts with highest records of weight of unhusked nut, husked nut, and meat, is sure to produce seedlings with the highest vigour index as well. This conclusion proves that while selecting mother trees, more emphasis can be given to these three criteria and the average vigour index of seedlings produced from such trees can be predicted using these regression equations.

8. Studies on genetic parameters:

(i) Genotypic and Phenotypic Coefficients of Variation:

A medium to high GCV and PCV have been obtained for the weight of unhusked nut, husked nut, and meat as seen from Table - 21. This offers scope for formulating selection procedures on the basis of these characters. This conclusion further supports the findings on the above mentioned nut characters discussed earlier. A fairly high GCV of 57.83 and 67.47 per cent for weight of husked nut, and meat gives an indication of the amount of genetic variability that can be tapped by exercising selection for these characters.

GCV and PCV estimates were computed for the seedling traits with a different purpose. These estimates gave an idea of the amount of variability between seedlings of the different mother palms. But as seen from Table - 20, values of GCV and PCV are comparatively low. Relatively higher values have been shown by germination percentage and leaf area. Though age at leaf splitting shows the highest value of GCV and PCV (41.78 and 52.53 per cent respectively), this is not a reliable trait as it is not a regularly and systematically occurring feature among coconut seedlings in nursery stage. To get reliable estimates on this trait, a very high population will have to be studied. Though girth-at-collar is an important trait in selecting seedlings (Menon and Pandalai, 1958; Pankajakshan and George, 1961 and Ramadasan et al.,1980), it failed to register a high coefficient of variation among the seedlings of different palms studied.

(ii) Heritability estimates of mother palm (seed nut) characters:

The extremely high heritability estimates (in broad sense) for weight of unhusked nut, husked nut and meat explain the amount of genetic factor involved in expression of these traist.

In this context, it is worth mentioning that prepotency is comparable to general combining ability (Liyanage, 1972), and general combining ability in turn, is governed by additive gene action which is responsible for additive genetic variation (Welsh, 1981). Heritability in narrow sense which measures additive genetic variation is only slightly less than heritability in broad sense (Singh and Chaudhary, 1979), which measures total genetic variation. Since all the characters studied are quantitative by expression and inheritance, they are governed by the additive gene action. Hence heritability estimates in broad sense as given in Table 22 can be taken as a measure of prepotency of the palm with respect to any of these characters. Hence by selecting mother palms on the basis of these seed nut characters, seedlings of superior vigour can be obtained (Fig. 1, 2, and 3) indirectly. Thus it becomes further clear that prepotent palms can be selected on the basis of these seed nut characters. But the selection procedure should also take into consideration, the number of nuts per bunch, as mentioned earlier.

(iii) Heritability and Coheritability estimate of seedling characters:

Heritability estimates are medium to high for all the seedling characters viz., germination, height, number of leaves, leaf area and age at leaf splitting. The coheritability estimates for any two of these characters are also high, (Table - 23). This indicates that the effect of environment is comparatively less on these characters and that, selection for these characters will yield genetically superior and genuinely vigorous seedlings. The coheritability estimates are useful in predicting heritability of any character when selection is being practised for some other related character. Thus when coconut seedlings are selected on the basis of germination, the seedlings in the next generation will also show better height, girth, number of leaves, leaf area, and age at leaf splitting.

(iv) Genotypic, Phenotypic and Environmental Correlations between seedling characters:

High genotypic correlation between the characters indicate the predominance of additive gene action governing the expression of these characters (Allard, 1960). Table - 24 justifies this conclusion by virtue of the presence of highly significant positive genotypic correlation between most of the seedling characters.

9. Metroglyph analysis:

The frequency diagram (Fig. 4) shows that T_4 is getting the highest and maximum score of 12 when subjected to classifactory analysis done on the basis of Index score method suggested by Anderson (1957). The scatter diagram (Fig.4) based on Table - 25 shows that T_4 is placed well above the other palms by virtue of the superior performance of its seedlings. Control palm, T_{14} shows a relatively elevated position along the direction of the ordinate because of its slightly higher mean collar girth. But the full rays of T_4 glyph along with its elevated position in the direction of abscissa indicates its overall superiority over the best control group T_{14}.

On the basis of these elaborate discussion of the various results obtained and not to preclude an element of human preference of the breeder, than sticking steadfast onto figures blindly, super palm T_4 can be labelled as a prepotent palm. Such a palm will thus combine high yield and superior progeny characters, though such of them are very few (Ninan and Pankajakshan, 1961). Liyanage (1967) could identify only one per cent of palms tested as prepotent. But once such a palm of super yield and outstanding breeding merit is identified, it can be used in propagation as well as breading works, (Ninan and Pakkajakshan, 1961 and Iyer, et al., 1979). As opined by Liyanage (1967), identification of prepotent palms is a slow process, but the great advantage is that once good genotypes are identified, they can be used for further propagation as well as breeding purposes for a long period, as coconut remains productive for 60 - 80 years. To obtain conclusive results on the palms selected on the basis of seedling performance, adult progeny analysis should be conducted.

SUMMARY

SUMMARY

The experiment on evaluation of super mother palms of coconut by seedling progeny analysis was conducted in the Department of Plant Breeding, College of Agriculture, Vellayani during the period 1980-'82.

The materials of the experiment consisted of two types of mother palms such as super mother palms (giving an annual yield of not less than 300 nuts) and control mother palms (average mother palms giving an annual yield of not less than 80 nuts). Seed nuts were collected from the palms situated in various locations in Trivandrum and Quilon districts in two harvests during January to April, 1981. The seed nuts were stored, and sown in June, 1981 in a replicated field trial. Observations were recorded on various mother palm, seed nut, and seedling characters. These observations and various statistical estimates worked out from them helped in drawing the following conclusions:

(1) Super mother palms are significantly superior to control mother palms in relation to two mother palm characters namely number of bunches and number of nuts per bunch. These two types of palms were on par with respect to other seed nut and seedling characters.

(2) Super mother palm T_4 produced a relatively higher number of bunches (22) on its crown. It showed significant superiority over other mother palms in seed nut characters

like weight of unhusked nut, husked nut, and meat. It also showed relative superiority by scoring the highest germination percentage, high value for leaf area, and earliest age of leaf splitting.

(3) The high values for girth-at-collar and leaf number of seedlings recorded by control palms T_{14} and T_{15} can be explained in terms of 'Block nut' selection procedure devised by Cheyne (1952).

(4) Super palm T_4 showed the highest recovery of quality seedlings from total number of seedlings and seed nuts sown, indicating its prepotent ability.

(5) Correlation studies showed that as number of nuts in a bunch increased, the size of nut (weight of unhusked nut, husked nut, and meat) got reduced and this in turn resulted in the low germination and poor growth of seedlings.

(6) Percentage recovery of quality seedlings from total number of seed nuts is a more reliable estimate than recovery of quality seedlings from total number of seedlings as a measure of prepotency.

(7) Significant positive correlations obtained between seedlings vigour index and weight of unhusked nut, husked nut and meat indicate the importance of these characters in selecting mother palms.

(8) Linear relationships established between seedling vigour index and the above mentioned seed nut characters can be used as a ready reckoner in predicting the seedling vigour index when selection is practised for seed nut characters of mother palms.

(9) Medium to high GCV and PCV have been obtained for weight of unhusked nut, husked nut, and meat, thus offering scope for formulating selection on the basis of these characters.

(10) High amount of genetic factor is involved in the expression of the above mentioned seed nut characters, and seedling characters as evidenced by the respective heritability and coheritability values.

(11) Relative superiority of super palm T_4 is again illustrated by the Figs. 1, 2, 3, and 4.

(12) Super mother palm selection should include all the traits mentioned in package of practices recommendations (Anonymous, 1981), but emphasis should be given to a balance between number of nuts per bunch and nut size.

(13) Super mother palm T_4 can be selected as a prepotent palm capable of impressing its superior characters on its progeny in the form of superior seedling characters, and seed nut characters.

(14) Seedling progeny analysis is found to be useful in identifying superior mother palms.

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* Originals not seen.

EVALUATION OF SUPER MOTHER PALMS OF COCONUT BY SEEDLING PROGENY ANALYSIS

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ABSTRACT

Seedling progeny analysis was conducted in super mother palms of coconut (annual yield not less than 300 nuts) in comparison with control mother palms (average mother palms with annual yield not less than 80 nuts). The aim was to evaluate these super palms for their prepotent ability to produce quality seedlings.

The super mother palms were selected from different locations in Trivandrum and Quilon districts, and from the same locations, control mother palms were also selected. A seed lot from north Kerala (Badagara) collected by the State Department of Agriculture was also included.

Observations were recorded on mother palms, samples on seed nuts collected from these palms, and on seedlings raised in a replicated field trial.

Critical analysis of the compiled data showed super mother palms to be significantly superior to control palms in number of bunches and nuts per bunch. But the two types of mother palms failed to show significant differences in nut, and seedling characters. Among super palms, T_4 showed superiority over rest of palms in mother palm, seed nut, and seedling characters. This super palm also registered the highest recovery of quality seedlings indicating its superior prepotent ability.

Estimates on recovery of quality seedlings from total number of seed nuts was found to be more reliable than the recovery from total number of seedlings, as a measure of prepotency.

Selection of super mother palms as prepotent trees, on the basis of nut yield alone was found to be non-viable. Instead, a balance between nut size and number of nuts per bunch is sought.

Significant correlations between seedling vigour index and seed nut characters (weight of unhusked nut, husked nut, and meat) led to elucidation of the linear relationships between vigour index and seed nut characters for use as ready reckoners for improving mother palm selection programme.

Studies on genetic parameters showed that a high amount of genetic factor is involved in the expression of seed nut characters (weight of unhusked nut, husked nut, and meat) and seedling characters (germination percentage, height, girth-at-collar, number of leaves, leaf area, and age at leaf splitting) as evidenced by high GCV, heritability, coheritability and genotypic correlation values.

The results obtained in this seedling progeny analysis will get absolute confirmation only on completion of an adult progeny analysis.