VARIABILITY STUDIES IN THE SEEDLING PROGENIES OF T x D COCONUT (*Cocos nucifera* Linn.) HYBRIDS

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Variability studies in the seedling progenies of T x D Coconut (Cocos nucifera Linn.) hybrids" 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 to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis is a record of research work done independently by Miss. Valsala, P.A. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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C E R T I F I C A T E

We, the undersigned members of the Advisory Committee of Kum. Valsala, P.A. a candidate for the degree of Master of Science in Horticulture with major in Horticulture agree that the thesis entitled "Variability studies in the seedling progenies of Tall x Dwarf hybrid palms" may be submitted by Kum. Valsala, P.A. in partial fulfilment of the requirements for the degree.

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Introduction

INTRODUCTION

Coconut palm (<u>Cocos</u> <u>nucifera</u>, L) is a humid tropical plant and is cultivated in over 7.50 million ha. in the world mostly in South-East Asian countries. India ranks third in acreage and production of coconut with about 1.125 million ha. and 6121.7 million nuts as per 1978-79 figures. Kerala is the largest producer of coconut in India and the area and production according to 1978-79 statistics are 6.606 lakh ha. and 3211 million nuts. It is estimated that over 10 million people in the country are provided with full time or part time employment in coconut culture and industry.

However an alarming decline in the productivity of coconut in Kerala has been noticed since the last two decades. The average yield of nuts during 1957-58 was 6832 per ha. It was only 4860 per ha. in 1978-79. This shows a decline of 28.86 per cent in 22 years. Considering the fact that palms capable of yielding over 35,000 nuts per ha. are in existence in many coconut growing areas of the State, the gap between the potential and realised yield is indeed very wide.

One of the reasons attributed to this low productivity is the poor genetic make up of the vast majority of palms in cultivation. Coconut palm is predominantly outbreeding and hence highly heterozygous. Therefore selection of parents from a population for further propagation is dependent on the performance of the parents and their progeny in controlled mating. Indiscriminate planting of seedlings obtained from unselected mother palms have contributed to a good deal to the present state of coconut production in our state.

Work on varietal improvement in coconut was initiated more than six decades back in India. Varieties from New Guinea, Cochin China, Siam, Java, Philippines, Fiji, Ceylon, Laccadive Islands, Andaman Islands, etc., were introduced and planted at the Agricultural Research Station, Pilicode in 1924. Data on the performance of these introduced lines showed that Laccadive Ordinary, Philippines, Cochin China, New Guinea and Andaman Ordinary are better than the local West Coast Tall. Considering the superior performance of Laccadive Ordinary it has now been recommended for large scale cultivation in Kerala.

Hybridization work for production of superior hybrids was first started in India in 1930. It was Patel (1937) who first conceived the idea of utilising the precocious bearing habit of dwarf variety in the production of Tall x Dwarf

(T x D) crosses. He produced a large number of such crosses and planted at the Coconut Research Station, Nileshwar in 1934. Studies on the performance of these crosses have shown that they combined the early bearing character of the dwarfs with economic nut character of the talls. Comparison of yield data of hybrids and West Coast Tall showed that while the average production of copra in West Coast Tall was 14.2 kg that of the hybrid was above 18 kg per palm per annum. However it was noticed that all T x D hybrids did not perform equally well and some of them were comparatively poor in yield even under well managed conditions. Undesirable characters like alternate bearing, buckling of leaves and bunches, production of barren nuts,etc., were also met with in some of the hybrids. This is presumed to be due to the indiscriminate selection of parents of unknown breeding merit for mating. Identification of prepotent palms by progeny tests and utilising them in controlled crosses would obviate to a great extent the deficiencies noticed in T x D hybrid palms.

Inspite of the existence of some undesirable characters in T x D hybrids the demands for seedlings of this hybrid has increased greatly since the last 10 to 15 years. Lakhs of hybrid plants are being produced and distributed to the cultivators through the departmental nurseries.

These palms have started to give yield and it is likely that many of them will be high yielders. Therefore, the natural tendency of the cultivators will be to collect seed nuts from these hybrid palms for production of seedlings and planting under the impression that they will also have the good characters of T x D hybrids.

Studies on the performance of seedlings obtained from open pollinated seednuts of T x D is very meagre. The present study has, therefore, been taken up with the following objectives in view.

1. To study the performance of T x D progenies (F_1) derived from different parent palms and to identify palms of high breeding merit.

2. To assess the extent of variability in the seedling progenies obtained from open pollinated seed nuts (F_2) of T x D palms.

3. To fix up characters of prepotent T x D palms on the basis of seedling studies.

4. To assess the influence of season on the seed nut and seedling characters.

5. To study the feasibility of utilising the chlorophyll content of leaf as an index of seedling vigour.

Review of Literature

REVIEW OF LITERATURE

A number of scientists all over the coconut growing countries are engaged in the research on various aspects of this important oil yielding plant and a large volume of literature have been published in India and abroad. The study presented here is confined to certain breeding aspects of the crop and an attempt has been made to review the available literature relating to the present investigation.

1. Tall and Dwarf Coconut

Two distinct varieties have been identified in coconut based mainly on the growth characteristics of the stem and the age at first flowering. They are the Tall and the Dwarf. There are a number of geographical races in the tall variety and according to the place of their origin they are known as West Coast Tall, East Coast Tall, West African Tall, Philippines, Java, Cochin China, Laccadives, etc. Dwarf coconuts are known to occur in most of the coconut growing countries. Handover (1919) was of the view that the dwarfs might have occurred as a mutant of the tall variety probably in Java. Recent studies according to Thampan and Markose (1973) confirmed the earlier assumption that the dwarfs were off-types of <u>Cocos nucifera</u> resulted either by mutation or chromosomal aberrations. Swaminathan and Nambiar (1961) on the other hand had suggested that the dwarf and semi-dwarf coconuts occurring in different countries might be products of inbreeding in different tall varieties. Though there was difference of opinion as to the mode of origin of dwarf coconuts, Ninan and Satyabalan (1964) were of the view that, their derivation from ancestral tall was never disputed and evidences of morphology, breeding system and cytology unequivocally pointed to this conclusion.

A number of different dwarfs were reported to occur in different countries. Rao and Koyamu (1955) described two important dwarf types commonly found in Chowghat area in Kerala, viz. Chowghat Dwarf Green and Chowghat Dwarf Orange. Thampan and Markose (1973) had reported about a number of dwarfs grown in various countries. Among them Malayan dwarf was reported to be very promising type out-yielding the traditional tall types. It had three distinct colour forms, viz., Ivory yellow, apricot red and green. The Malayan dwarf was also reported to be resistant to the devastating "Lethal Yellowing" disease in Jamaica. From Sri Lanka also three colour forms had been reported in the dwarf, viz., pumilla, erburnea and regia. Other dwarfs reported to occur in other countries were Laccadive or Maladive dwarf in Laccadive and Maladive islands, Andaman dwarf in Andaman islands, Coco-nino or Baby coconut, Pugai, Lincoranay, Pagara, Pilipoy and Mangipod in the Philippines, N'uleka and N'dam in Fiji islands and Gangabondam a semi tall type in Andhra Pradesh.

Though a large percentage of the progenies of dwarfs breed true to type, a small percentage of semi-tall types were also met with in their progenies. Rao and Koyamu (1955) reported that about 80 per cent of the progenies of Chowghat Dwarf Orange and 95 per cent of the progenies of Chowghat Dwarf Green breed true to type. In Malayan Dwarf also a certain proportion of the progenies turned out to be semi-tall types. Jack (1925) was of the opinion that such progenies were possibly hybrids resulting from natural crossing of the dwarfs with talls. Dwyer (1938), Tammes (1949, 1955) and Liyanage (1958) also mentioned the occurrence of natural hybrids among talls. Satyabalan (1956) reported that in the dwarf orange type studied by him the natural cross seedlings could be easily picked up by their extra vigorous growth. These palms were reported to yield very high compared to West Coast Tall and also tall x dwarf hybrids. A detailed study of the genetical status of these off-type seedlings was made by Ninan and Satyabalan (1964) with seedlings of dwarf orange and green types obtained by natural, self and cross pollination (with talls). The off-type segregates were found not only in the progenies obtained by natural and cross pollination but even in selfed progenies. This according to the authors could be heterozygous segregates from dwarfs possibly with imposed hybridity. However, the authors were of the opinion that the problem of the genetical status of the off-type progenies of dwarfs was quite intreguing.

2. Coconut breeding

Improvement of coconut by breeding had been attempted since the last more than half a century both in India and abroad. Introduction of varieties and strains, artificial self-pollination and selection in self-fertilized lines, hybridization-natural and artificial, mass selection and strain building, close and line breeding, etc., and plant-to-row method were some of the methods adopted by coconut breeders. Among these, hybridization had given encouraging results.

2.1. Hybrid vigour of T x D

The dwarf variety attained importance because of its reported use as a parent in evolving high yielding hybrids. Patel (1937) was the first to show that hybrid vigour was met with in the coconut from a study of seedling characters of crosses between selected palms of tall variety as female and dwarf variety as male. John and Narayana (1943) from a study of the progenies to the bearing stage found that they combine the desirable early flowering nature of the dwarf parent with the economic nut characters of the tall parent. Rao and Koyamu (1952) reported the existence of hybrid vigour in the seedlings obtained by crossing tall and dwarf. Liyanage (1955) observed marked hybrid vigour in certain combinations of varieties and forms of coconut. Liyanage (1956) also confirmed the early flowering nature of Tall x Dwarf hybrids and noticed the production of inflorescence at shorter intervals due to the extra vigour of F_1 progenies. The mean age of first flowering of the hybrid was 48.6 months from the date of sprouting of the seednuts, while the dwarf and tall took 38.0 and 74.3 months respectively. Within the first four years 88 per cent of the dwarf palms and 61 per cent of the hybrids were in flower as against none in the tall variety. Ninan (1960) found that tall x dwarf hybrids combined the early bearing habits of the dwarfs with the economic nut characters of the tall. He noticed no consistent manifestation of F_1 superiority since variation between individual hybrids arising from different parents was noticed. Bhaskaran and Leela (1963) reported that tall x dwarf flowered earlier than tall and that it attained steady bearing stages much earlier than tall type. They also found that the rate of leaf production and annual yield was more in T x D than in parental types. According to Fremond (1961) breeding of coconut palms on the tropical pacific Atolls was based on the performance of heterosis.

Bavappa et al. (1973) studied the genetic divergence in nine F_1 families of West Coast Tall x Dwarf green coconut hybrids for 13 vegetative characters and yield components. Bulk F_1 population of the same cross as well as open pollinated progenies of West Coast Tall were studied. It was suggested that with proper choice among the tall and dwarf varieties efficient exploitation of the hybrids could be effected. At Veppankulam in Tamil Nadu, tall x dwarf hybrids exhibited heterosis in their growth characters according to Ramachandran et al. (1975). Even during the years of unfavourable season, tall x dwarf hybrids performed better than East Coast Tall. Superiority of nut characters over East Coast Tall had also been recorded. Satyabalan and Menon (1968) reported some of the undesirable characters of tall x dwarf such as alternate bearing, low copra content, small sized nuts and occurrence of barren nuts. They also opined that these characters might be either due to the incompatibility or differences in dwarf pollen parents used in crosses or both.

2.2. Other promising hybrids

Apart from tall x dwarf a number of other hybrids had also been produced using other parental combinations and their performances had been studied. Satyabalan *et al.* (1964) found that Tall x Gangabondam hybrid took less time for sprouting than tall x dwarf and it was superior to tall x dwarf in respect of girth at collar. Pandalai and Satyabalan (1965) reported hybrid vigour in tall x Gangabondam and that all combinations do not give progenies possessing uniformly desirable characters. Kannan and Nambiar (1974) after a detailed study of six tall types crossed with Gangabondam reported that Laccadive ordinary x Gangabondam was superior to all other hybrids in respect of annual leaf production, setting percentage, annual yield of nuts and copra output. Liyanage (1958) in Ceylon reported that the (F_1) palms of Typica x Pumilla showed considerable heterosis and they combined the physiological vigour of Typica and early flowering habit of Pumilla to give high yields as early as the sixth year after planting. Manthrirathna (1970) also in Ceylon reported about CRIC-65, a high yielding variety developed from tall x dwarf crossing. The CRIC-65 exhibited hybrid vigour for leaf size, leaf number, trunk size and yield of fruit.

Existence of hybrid vigour in seedlings obtained from dwarf x tall, the reciprocal cross of tall x dwarf had been reported by Rao and Koyamu (1952). Liyanage (1956) reported that dwarf x tall hybrids had similar characteristics as that of T x D but flowered later although earlier than Typica. The seedlings were distinguishable by their marked vigour. Satyabalan (1956) compared the performance of Natural cross dwarf tree (Dwarf x Tall) with those of tall, typical dwarf and controlled tall x dwarf hybrids. Natural cross dwarfs were found to be early and potentially good bearers closely resembling, tall x dwarf palms in many respects. From another study Satyabalan (1958) reported that natural cross dwarf coconut seedlings showed vigorous growth than pure dwarf seedlings with signs of being early and prolific bearers.

Resistance to root (wilt) disease had been reported in dwarf x tall by Rawther and Pillai (1972). Harries and Romney (1974) had also reported that the cross between Malayan dwarf and Panama tall (Maypan) produced bigger nuts and satisfactory resistance to lethal yellowing disease.

2.3. Combining ability of Tall and Dwarf

According to Pankajakshan (1967) among the different varieties used as pollen parents, Kappadam gave the highest nut size and highest copra content per nut. Nuts obtained by pollination with varieties having big sized nuts and high content of copra in general showed better copra content compared to those resulting from pollinating with small nuts and poor copra content. Satyabalan *et al.* (1968) on a comparative study of tall x dwarf green and tall x dwarf orange hybrid seedlings obtained from the same tall female parents found that tall x dwarf orange hybrids were superior in terms of hybrid vigour. Selection of male parents from the dwarf orange variety - on a basis of nut and copra characters had been recommended. From another study by Satyabalan *et al.* (1970) with dwarf green, dwarf orange and Gangabondam as male parents it was found that dwarf orange and Gangabondam were preferred male parents. Heterosis appeared in all the hybrids in the weight of the husked nut, nut water and kernel but not in fruit weight. Bavappa and Satyabalan (1971) also reported that tall x dwarf orange hybrids were superior to tall x dwarf green in both nut and copra characters. Krishnan and Nambiar (1972) stressed the importance of selection of dwarf pollen parents in the production of tall x dwarf hybrids from a study utilising different dwarfs as males. Among the dwarfs studied they found Laccadive dwarf to be superior to other dwarfs as pollen parent.

Manthriratna (1971) assessed the relative merits of forms of Pumilla, Eburnea and Regia of Var. Nana as pollen parents in Ceylon for production of Typica x Nana (F_1) hybrids. All these dwarf forms gave early bearing hybrids which out yielded Typica forms. Owing to its robustness Eburnea hybrid was particularly recommended.

3. Performance of open pollinated progenies of hybrids

With the popularisation of coconut hybrids the possibility of collecting seednuts from such palms for further multiplication had increased. Studies on the performance of open pollinated seednuts of hybrids were very scarce. Joseph (1959) conducted a comparative study of (F_1) and (F_2) progenies of tall x dwarf crosses for their relative performance in nursery stage. The (F_2) progenies were raised by intercrossing the (F_1) hybrids and also by open pollination. Analysis of data on seedling characters like height, number of leaves and girth at collar of (F_1) and (F_2) progenies indicated that (F_2) was significantly superior to (F_1) despite the fact that there were a few seemingly dwarfish segregants in the (F_2). No appreciable difference could be observed between (F_2) obtained by controlled or open pollination. The author was of opinion that if the vigour exhibited by the (F_2) seedlings was really a predisposition towards high yield, it was possible to obtain quality planting material by selection of vigorous (F_2) progenies.

Nambiar (1971) reported on a study of open pollinated (F_2) progenies of tall x dwarf. It was found that over 90 per cent of the progenies did not record precocity as in the case of tall x dwarf. However, because of the rigid selection of seedlings in the nursery the yield recorded by the progenies was satisfactory when compared with the yield of their parents. Wide range of variation was noticed in respect of height of palm, weight of nut and copra content in the progenies of the same parent. This according to him indicated the unsuitability of open pollinated T x D seed-nut for being used for propagation.

Kannan (1976) made a detailed study of adult performance of 140 seedlings raised from open pollinated seednuts obtained from 10 T x D palms. The progenies exhibited wide variation in respect of age at first flowering. Only one flowered in 4 years, 12 in 5 years, 15 in 6 years and 8 in 7 years. The rest of the palms took 8 years and more for flowering. This was in contrast to 4 to 5 years took by their parents for first flowering. Height and girth of trunk were more in (F_2) progenies than in (F_1) progenies. While the annual rate of leaf production in T x D was 13.5 it was only 11.5 to 12.8 in the progenies of T x D. In respect of yield, seven out of 10 parents produced progenies giving mean yield higher than the parents while the yield of the progenies of the remaining parents were lower. The mean annual production of copra per tree was also higher than the parents. It was also of interest to note that all progenies of the same parent did not beheve uniformly in respect of yield. The percentage of high yielders ranged from 21.40 in the progenies of parent palm VIII/32 to 100 in parent palm VIII/48. Concluding the study the author reported that considerable reduction in the expression of hybrid vigour was observed from the first generation T x D to the second generation open pollinated progenies. In respect of age at first flowering, growth rate and leaf production they were more equal to West Coast Tall than T x D. However about half the population gave higher yield of nut and copra than the parents. A few of the parent palms produced high percentage of high yielders which might be due to prepotency.

4. Parent tree yield and progeny performance

Patel (1937) reported that nuts produced by trees which had a high setting percentage were distinctly superior to the rest in respect of early germination. Early germination being a criteria for high yield it was presumed that high yielding trees would give high yielding progenies. However, Cheyne (1952) reported no significant difference in progenies of high and low yielding mother palms and from these selected at random. Nambiar and Nambiar (1970) after a detailed genetic analysis of yield attributes of coconut reported that choice of mother palms with high yield either for crossing purposes or for progeny testing appeared reliable provided that there was sufficient genetic diversity within the population. The seedlings of 12 months old from high yield group were better than others in the number of green leaves, height and girth of the collar. When the young palms were five years old, differences between yield groups were significant for the mean number of days for the emergence of successive leaves, number of leaves on the crown, length of leaf and number of leaflets. The same palms at bearing showed that the high yield groups (over 120 nuts per year and 101 to 120 nuts per year) were significantly superior to the rest as to the number of bunches emerged, number of female flowers produced, female flowers set and percentage set.

In a study conducted with progenies of three yield groups Nambiar and Nair (1963) found that progenies of high yielding mother palms were superior to progenies of poor yielding mother palms in respect of field survival and vegetative growth. Kannan and Nambiar (1979) reporting on the same palms at bearing found that palms yielding more than 80 nuts per annum and palms selected at random (bulk mother palms) produced high yielding progenies. Palms giving an yield of less than 20 nuts were definitely unsuitable for seednut selection. Liyanage (1953) from his study in Ceylon found that phenotypic selection of mother palms for high yield was ineffective as a means of genetic improvement. Further studies by Liyanage (1958) confirmed that no correlation existed between mother palm and progeny yields under open pollination. He recommended controlled pollination between high yielding palms as a means of improving the genetic quality of the palms and suggested the establishment of elite seed gardens. Harland (1957) pointed out that all high yielders need not necessarily transmit their high yield to progenies and that the real genetic improvement was possible only through the identification of prepotent palms. Liyanage and Sakai (1960) found that the genetic progress in the progenies was likely to be more if the seed parent was selected on high yield of copra and nuts rather than on weight per husked nut and flowering period.

Crammer as quoted by Menon and Pandalai (1960) stated that many seedlings of the high yielding original mother trees showed themselves good yielders and there was a great resemblance between the apparent descendents of the same mother palm. Rockwood (1953) claimed that the remarkable results obtained by him in his estate were due, among others, to the use of planting material derived from high yielding selected mother palms instead of from "Block nuts of doubtful origin.

5. Utilisation of prepotent palms

Harland (1957) used the term prepotency to describe palms that were able to transmit the high yielding character to their progenies inspite of having been indiscriminately pollinated by miscellaneous male parents. Only palms with dominant yield genes could be relied upon to transmit their superiority to their progeny. According to Charles (1961) the most effective method to detect genetically superior palms was progeny testing. Liyanage (1967) observed a significant and positive correlation between the total number of leaves produced per plant within a family during 40 months after transplanting seedlings and the mean yield of adult progenies per family when they were 13 to 16 years old. There was good evidence of an association between leaf production of the young progeny and the breeding value of the parent. Desirable genotypes for breeding could be identified provisionally after 40 months by using this technique. Liyanage (1969) suggested another quick method of identifying good genotypes by studying the inbreeding depression on endosperm and embryo weight of nuts. If the weight of either of these character was under genetic control one would expect differential behaviour between genotype when selfed, depending on the nature of genes involved. If it was largely due to the additive effects of genes then the inbreeding depression might be less marked or even negligible than when it was controlled by dominance or epistates. A study of seedling characters and yield attributes of 43 open pollinated progenies of eight high yielding palms of West Coast Tall, planted in 1953 made by Satyabalan et al. (1975) had shown that the progenies of three palms were high yielding and that they were superior in spathe production and female flower production to others, indicating that they were prepotents. The possibility of identifying such prepotent palms in the nursery was indicated.

6. Seedling characters

6.1. Germination of nuts and seedling growth

Number of days taken for germination of seednuts had been reported to have profound influence on the growth of seedlings. Patel (1938) after a detailed study reported that early germinated nuts produced seedlings having a faster rate of leaf production while nuts which germinated late produced seedlings having a slow rate of leaf production. The number of leaves and time taken for germination were correlated for 1007 seedlings and it was found that a negative correlation amounting to 0.609 ± 0.0141 existed between the time taken for germination and the number of leaves in the seedling. Highly significant positive correlation of 0.437 between sprouting of seednuts and flowering of palms and a negative correlation of 0.424 between sprouting and yield were obtained by Liyanage (1955) showing thereby that seednuts sprouted early gave rise to palms that flower in a shorter period and more productive than those sprouted later. Jack and Sands (1929) were also of the same conclusion that early germinated seedling will flower early. Higher yields in the early years of bearing had been reported to have obtained from seedlings grown from early sprouting nuts by Charles (1959). Srinivasa and Ramu (1971) reported that coconut seedlings from nuts which germinated early (within 4 months) had more leaves than those nuts germinated later. The splitting of leaves into leaflets also occurred earlier.

6.2. Influence of seedling girth, height and number of leaves on palm performance

Nampoothiri _et al._ (1975) reporting about the phenotypic and genotypic correlation of 9 characters with yield in coconut stated that girth at collar of the seedling, time taken for flowering, spathe production and number of female flowers had correlations with yield. There was a significant genetic correlation between yield and number of leaves at seedling stage. A study of 37 mother palms and their progeny conducted by Ninan and Pankajakshan (1961) revealed no relationship between the yield of the parent and the progeny characters like girth and number of leaves nor between parent girth and progeny yield. Kannan and Nambiar (1979) found vigorous and intermediate seedlings significantly superior to poor seedlings in the initial growth as well as in the annual nut and copra yield. No significant difference was noticed between vigorous and intermediate seedlings.

6.3. Effect of season of harvest of nuts on seedling performance

George (1964) observed that seednuts collected during February, March and April recorded the best germination and gave highest percentage of seedlings compared to those harvested in other months. Regarding the time taken for germination January-March nuts were the earliest and took only an average of 2 months while nuts harvested in May, September, October and November took unusually long time (4-5 months). According to Menon (1961) seednuts collected in the month of April were the best. February to May in the West Coast and April to June in the East Coast were the optimum months for seednut collection (Aiyadurai, 1962). Patel (1938) reported that the nuts harvested in February had a lower percentage of germination than the nuts harvested in March and April. While the germination percentage in February harvested nuts was 79.9, those of March and April had 94.8 and 95.9 per cent germination.

7. Influence of nut characters on progeny performance

7.1. Size and shape of seednut

The seednut size as reflected by the polar diameter, equitorial diameter and volume of the nut had been reported to have some influence on the germination of nuts. When the volume of any nut in the bunch was too small or too big from the mean volume, this invariably never germinated or germinated very late (Patel, 1938). Smith (1933) reported better germination from medium sized nut than from larger nut. Silva and George (1971) from a study of seednuts of 3 sizes (15.0, 17.5 and 20.0 short axis) found that the overall germination rate and seedling growth were better in medium sized nuts, six months after sowing. Thomas (1978) observed that nut size influenced the earliness and total germination though not to the level of significance. According to Macedeu (1933) with equal volume, round nuts germinated earlier than the oblong nuts. However no difference in percentage of germination between oblong and round nuts was found. The length of leaves of seedlings was not influenced by the shape of nuts. But it influenced the number of leaves, number of roots and seedling weight.

7.2. Weight of seednuts

Patel (1938) concluded from germination studies that greater number of nuts from heavy bunches (12 nuts or more) germinated much quicker than those of light bunches (6 nuts and below) and that light seednuts (weighing 680 gm and below) gave much reduced germination than heavy ones (weighing 680 gm and above). Umali (1940) also reported the same conclusion. According to Thomas (1978) planting large seeds (1000-1300 gm) horizontally was preferable.

8. Chlorophyll content in relation to yield

Chlorophyll among the plant pigments is unique in that it is one of the essential ingredients in photosynthesis and consequently in dry matter production. Wide differences in the chlorophyll content among different varieties were reported by Griffith et al. (1944) in tobacco, Starness and Hadly (1965) in soyabean and Yadav and Mathai (1972) in arecanut.

Mathew and Ramdasan (1973) studied the C.S.I. index values for different varieties of coconut and indicated the possibility of a correlation between C.S.I. values and drought resistance in coconut.

Distinct differentiation in the different coconut cultivars and hybrids, in the chlorophyll content had been reported by Mathew and Ramdasan (1974). The high yielding types possessed higher quantities of chlorophyll content on area basis, than in low yielders. Mathew and Ramdasan (1973) observed significantly higher C.S.I. values in the West Coast Tall (20.7) compared to the Tall x Dwarf (13.2), Dwarf x Tall (13.0), Dwarf Green (13.7) and Dwarf orange (10.6). Hybrids recorded low C.S.I. values indicating perhaps their superiority in drought tolerance over the West Coast Tall. Chlorophyll content in terms of total chlorophyll, chlorophyll-a and chlorophyll-b were highest in the hybrids of Tall x Dwarf and Dwarf x Tall and lowest in Dwarf orange variety (Mathew and Ramdasan, 1974). The same authors (1975) also correlated the rate of apparent photosynthesis in the West Coast Tall coconut palm with the annual yield of nuts and the leaf chlorophyll content. The chlorophyll content was also correlated with the annual yield of nuts.

The most representative sample of leaf for the estimation of chlorophyll content was N/2 or (N+½) leaf in the crown according to Mathew and Ramdasan (1974). The mean chlorophyll content in this leaf was fairly high and the coefficient variation was the lowest in this leaf in relation to the total number of leaves.

Materials and Methods

MATERIALS AND METHODS

The present studies were undertaken at the Research Station and Instructional Farm of College of Horticulture, Vellanikkara during the year 1979-80 with the objective of assessing the extent of variability in seedling progenies obtained from open pollinated seednuts of Tall x Dwarf (F_1) palms. The performance of T x D progenies (F_1) derived from different family groups and the influence of season of harvest on the seednut and seedling characters were also studied. It was attempted to assess the feasibility of utilising the chlorophyll content of leaf as an index of seedling vigour in the nursery.

1. Collection of seednuts

The materials for the study were collected from the Coconut Research Station, Nileshwar. A total number of 30 West Coast Tall x Chowghat Dwarf Green (F_1) palms belonging to six family groups from the world's first T x D plantation were selected for seednut collection. The palms were about 45 years old and were grown in red sandy loam soils and received regular irrigation during summer months. The family group and progeny numbers from which seednuts were collected are presented below:

Family group	Progeny number
VIII/23	109
	112
	113
	114
	115
1/58	165
	167
	168
	169
	174
1/109	141
	142
	144
	146
	148
VIII/158	153
	155
	156
	159
	160
1/76	126
	128
	129
	135
	136
VIII/143	41
	49
	50
	52
	99

Fully ripe seednuts (12 month old) were collected for five months from January to May, 1979 and immediately after collection they were transported to the Research Station and Instructional Farm, Vellanikkara. They were sown in the nursery one month after collection.

2. Climate and soil

The experimental site is situated at 10.32° N latitude and 76.12° E longitude at an altitude of 22.25 metres above M.S.L. Typical humid tropical climate is prevalent in the area. Soil is a deep well drained sandy loam.

3. Season and weather conditions

The study was conducted during the period from January, 1979 to June 1980. The details of meteorological observations recorded during the period are presented in appendix I.

4. Lay out

The experiment was laid out in completely randomised design with family as treatment and progenies as replications.

5. Preparation of nursery

The nursery area was selected in an open place without any shade. The land was ploughed thrice and weeds and pebbles were removed. Sufficient quantity of sand was added and mixed with the soil. Beds of size 1.8 m. width, 5.4 m. length and 20 cm. height were prepared. B.H.C. 5 per cent dust was also added to the soil to prevent termite attack.

6. Preparation of nuts for sowing

Nuts stored for one month after harvest were planted after removal of perianth parts.

7. Planting

The nuts were sown in the nursery vertically with the stalk end up at a spacing of 30 cm. each in the row and between rows. The top two cm. of the nut was kept exposed. The soil was pressed lightly around each nut. The beds after sowing were mulched with paddy straw. First sowing of January harvested nuts was done on 25th February 1979. Subsequent sowings were done at monthly intervals. The last sowing was in the month of June.

8. After care of nursery

Regular watering was done on alternate days during the summer months. Over head pandal was erected with plated coconut leaves to provide partial shade from February to May as a protection against scorching sun. The nursery beds were drenched with bordeaux mixture thrice as a precautionary measure against Rhizectonia rot. To control scale insect and leaf eating caterpillars Ekalux 0.05% was also sprayed thrice.

Observations recorded

The following observations of individual nuts as well as seedlings were recorded. The nut characters were recorded before sowing and seedling characters were recorded from the 6th month after sowing at monthly intervals for a period of 6 months.

1. Nut characters

1.1. Polar circumference

The polar circumference is the measure through the base and apex of the nut and was measured in cm. using a measuring tape.

1.2. Equitorial circumference

The equitorial circumference is the measure through the middle portion of the nut and was recorded in cm. using a measuring tape.

1.3. Weight of nut

The weight of each nut was recorded with husk at the time of sowing and was recorded in gm.

1.4. Volume of nut

The volume of nut was determined by water displacement method and expressed in cc.

2. Days taken for sprouting of nuts

Days taken for sprouting was calculated as the number of days taken from sowing of nuts to the emergence of shoot or plumule through the soft eye and to make a growth of about 2.5 cm. The shoot at this stage is referred to as the "crow's beak". The sprouting period of each nut was recorded in number of days.

3. Seedling characters

Recording of the characters was started six months after sowing and continued every month for a period of six months.

3.1. Girth at Collar of seedling

Girth at collar is a measure of circumference of the shoot at a level of 5 cm. above the base. This was recorded in cm. using a twine and scale.

3.2. Height of seedling

Height was measured from the base of the seedling to the tip of the longest leaf with the help of a meter scale and recorded in cm.

3.3. Total number of leaves

Total number of fully opened leaves on the crown of the seedling was recorded every month.

3.4. Colour of petiole

The colour of petiole was examined by visual observation and recorded as yellow, orange, brown or green as the case may be.

3.5. Time taken for splitting of leaves

Time taken for splitting of leaves was calculated as the number of days from sowing of nuts to the splitting of a few leaflets in the fully opened leaf.

4. Classification of seedlings based on vigour

The seedlings were grouped into poor, medium and vigorous based on the three measurable characters of girth at collar, height of seedling and total number of leaves at 12 months age. The criteria adopted for the grouping is given below:

Category of seedling	Collar girth (cm.)	Height (cm.)	Total number of leaves
Poor	Below 7.5	Below 70	1 to 3
Medium	7.5 to 10	70 to 100	4 to 5
Vigorous	Above 10	Above 100	6 and above

5. Chlorophyll analysis

A total number of 372 seedlings raised from nuts harvested in the month of March and sown in April were used for chlorophyll analysis. Chlorophyll 'a', 'b', a/b and total of the leaf samples from each seedling were estimated by spectrophotometric method as described by Mackinney (1941), Starness and Hadley (1965). The analysis was carried out in the month of July, 1980 when the seedlings were 14 months old.

The topmost fully opened leaf being ranked as one, the third leaf from the top was taken for analysis. A representative sample was taken from different portions of the fresh leaf after removing the mid rib of the leaflet. To a one gm. sample of the leaf a small quantity of calcium carbonate was added to prevent pheophytin formation. The tissue was extracted with acetone (80 per cent) in a mortar. The supernatant liquid was decanted and the extraction was repeated till the residue became colourless. The extract was filtered on Buchner funnel and made upto 250 ml. in a volumetric flask. Anhydrous sodium sulphate 1 gm. was added to the solution for drying. An aliquot of the clear solution was used for reading the optical density in a spectrophotometer (1 cm). The optical density was read at 2 different wavelengths ie. 645 and 663 and the contents of chlorophyll 'a', 'b' and total were estimated as follows:-

Chlorophyll	a	:	12.72 A 663 - 2.58 A 645
Chlorophyll	b	:	22.87 A 645 - 4.67 A 663
Chlorophyll	(a+b)	:	8.05 A 663 + 20.29 A 645

The results were checked with the monogram constructed by Sertak (1966) and was found correct.

6. Statistical analysis

The experimental data was subjected to statistical analysis wherever necessary as per Panse and Sukhatme (1978).

Results

R E S U L T S

A detailed study of the mother palm characters, seednut and seedling characters were carried out and the results are presented below.

1. Mother palm characters

Seednuts collected from 30 tall x dwarf green palms (F_1) originated from 6 West Coast Tall grand parents were studied for their progeny performance. The grand parents were at the Central Plantation Crops Research Institute, Kasaragode and the 30 T x D progenies were at the Coconut Research Station, Nileshwar. Details of the grand parents are given in Table 1.1. The maximum nut yield was recorded by VIII/23 (119.4) followed by I/58 (111.2), VIII/143 (110.7), I/76 (109.3), I/109 (94.5) and VIII/158 (74.3). However in respect of mean copra content per nut VIII/158 and I/109, the two low yielders ranked first and second (216.6 and 170.6 gm. respectively).

Data in respect of the mean yield per palm, setting percentage and copra content of the 30 (F_1) palms collected from the Coconut Research Station, Nileshwar are furnished in Table 1.2. Substantial difference in yield between families and within family was noticed. The mean yield

Table 1.1. Palm characters of six West Coast Tall grand parents

Female parent	Mean number* of nuts per year	Mean copra content per nut (g)	Colour of nut	Percentage of oil in copra
VIII/23	119.40	141.0	Green	71.79
I/58	111.20	154.9	Light green	72.46
I/109	94.50	170.6	Green	71.71
VIII/158	74.30	216.6	Light green	70.48
I/76	109.30	129.0	Yellowish green	71.33
VIII/143	110.70	139.2	Light green	69.77

* Average over 33 years (1920-1952)

Table 1.2. Mean nut yield, setting percentage and copra content of Tall x Dwarf (F_1) palms

Family	F_1 progeny No.	Mean No. of nuts per year*	Setting percentage**	Mean copra content per nut (g)
VIII/23	109	88.82	40.84	140.00
	112	94.82	48.36	156.67
	113	72.27	38.37	128.33
	114	72.73	32.92	133.75
	115	98.73	41.01	130.00
Mean		85.47	40.26	137.75
I/58	165	56.82	37.08	155.00
	167	71.09	31.26	203.33
	168	45.91	25.18	118.33
	169	70.18	39.81	93.75
	174	29.82	34.58	86.67
Mean		54.76	33.05	131.42
I/109	141	55.09	41.97	120.00
	142	76.64	27.91	135.00
	144	77.55	43.03	88.75
	146	66.27	31.27	138.33
	148	29.50	27.38	85.00
Mean		61.02	34.06	113.42
VIII/158	153	38.18	27.27	165.00
	155	71.18	42.41	185.00
	156	53.73	27.59	103.33
	159	72.81	31.60	176.25
	160	31.91	25.89	91.67
Mean		53.56	34.62	144.25
I/76	126	44.73	35.85	65.00
	128	62.36	37.09	98.33
	129	65.45	35.53	112.50
	135	83.55	37.38	118.33
	136	99.36	40.71	120.00
Mean		71.09	37.56	102.83
VIII/143	41	82.91	50.31	97.50
	49	87.36	42.76	118.33
	50	98.73	53.59	78.33
	52	36.27	40.78	86.67
	99	47.55	39.00	100.00
Mean		70.56	45.77	95.17

* Average over 10 years

** Average over 4 years

Table 1.3. Distribution of Tall x Dwarf (F_1) palms of each family in different yield groups

Family	Number of palms yielding			
	Less than 40 nuts per year	41-60 nuts per year	61-80 nuts per year	Above 80 nuts per year
VIII/23	0	0	2	3
I/58	1	2	2	0
I/109	1	1	3	0
VIII/158	2	1	2	0
I/76	0	1	2	2
VIII/143	1	1	0	3

varied from 72.27 nuts to 98.73 nuts in the progenies of grand parent VIII/23, 29.82 to 70.18 in I/58, 29.50 to 77.55 in I/109, 31.91 to 72.81 in VIII/158, 44.73 to 99.36 in I/76 and 36.27 to 98.73 in VIII/143. The difference between progenies of VIII/23 was least with 26.46 nuts where as it was maximum in VIII/143 with 62.46 nuts.

The family mean yield was maximum in VIII/23 (85.47) followed by I/76 (71.09), VIII/143 (70.56), I/109 (61.02), I/58 (54.76) and VIII/153 (53.58).

The number of progenies in the four yield groups ie. below 40 nuts, 41 to 60 nuts, 61 to 80 nuts and above 80 nuts per year in the 6 families are given in Table 1.3. Out of five palms in each family two palms gave an yield between 61 to 80 nuts and 3 palms above 80 nuts in the family VIII/23 while the number of palms in each yield group of below 40, 40 to 60, 61 to 80 and above 80 nuts were 1,2,2 and nil in I/58, 1,1,3 and nil in I/109, 2,1,2 and nil in VIII/158, nil 1,2 and 2 in I/76 and 1,1,nil and 3 in VIII/143 respectively. The difference in yield between families and within some of the families was very substantial.

The data on number of nuts obtained from the palms during the five month period of experimental studies are

Table 1.4. Number of nuts obtained from each palm during the period from January to May 1979

Family	F_1 progeny No.	January	February	March	April	May	Total nuts
VIII/23	109	14	11	22	28	19	94
	112	10	9	23	25	4	71
	113	3	10	15	13	9	50
	114	4	7	16	15	1	43
	115	10	8	19	10	20	67
Total		41	45	95	91	53	325
I/58	165	0	2	10	18	4	34
	167	5	9	19	11	18	53
	168	1	5	7	22	2	37
	169	6	13	14	18	10	61
	174	2	2	11	14	3	32
Total		14	31	52	83	37	217
I/109	141	0	5	5	25	12	47
	142	3	9	32	8	8	60
	144	9	16	28	20	11	84
	146	0	10	6	21	0	37
	148	1	0	3	6	0	10
Total		13	40	74	80	31	238
VIII/158	153	0	3	6	10	11	30
	155	1	2	8	0	9	20
	156	0	1	7	12	0	20
	159	3	4	6	14	8	35
	160	2	0	6	7	2	17
Total		6	10	33	43	30	122
I/76	126	7	10	12	7	8	44
	128	4	6	6	10	0	26
	129	1	7	2	22	8	40
	135	8	12	31	10	0	61
	136	7	11	20	8	11	57
Total		27	46	71	57	27	228
VIII/143	41	0	8	38	14	9	69
	49	9	11	24	34	8	86
	50	0	7	11	13	18	49
	52	2	9	12	20	0	43
	99	2	6	10	10	7	35
Total		13	41	95	91	42	282

furnished in Table 1.4. Maximum number of 325 nuts was obtained from the progenies of VIII/23 followed by VIII/143 with 282 nuts and I/109 with 238 nuts. The minimum number of 122 nuts was obtained from VIII/158.

2. Seednut characters

2.1. Weight of unhusked nut

The mean weight of unhusked nuts in the different progenies is presented in Table 2.1 and the corresponding critical differences are given in Table 2.1a. Weight of unhusked nut varied considerably between families and within the family. Among the different families, progenies of VIII/158 recorded the maximum mean weight of 1025.83 gm during the five month period and the minimum of 656.08 gm was recorded by the progenies of I/76. The mean nut weight of VIII/23 which gave the maximum mean progeny yield, was only 781.75 gm where as VIII/158 which ranked last in respect of nut yield had the biggest sized nut. There appeared an inverse relationship between nut yield and nut weight.

With respect to mean nut weight of progenies within each family it ranged from 570.15 to 910.00 in VIII/23, 705.67 to 1052.94 gm in I/58, 632.86 to 874.62 gm in I/109, 840.00 to 1196.25 gm in VIII/158, 526.30 to 768.25 gm in I/76 and 607.91 to 862.29 gm in I/76. The difference between the maximum and minimum weight of progenies varied

Table 2.1. Mean weight of unhusked nuts per palm from January to May 1979 (g)

Family	F_1 progeny No.	January	February	March	April	May	Mean of 5 months*
VIII/23	109	771.41	855.45	662.27	586.07	527.37	681.17
	112	844.00	932.22	877.39	877.20	955.00	883.94
	113	1100.00	920.00	900.67	923.08	810.00	910.00
	114	982.50	974.20	815.63	819.33	1040.00	863.48
	115	720.00	668.75	521.58	524.00	525.00	570.15
Mean		883.59	870.12	755.51	745.94	771.49	781.75
I/58	165	-	1130.00	1054.00	1047.22	1037.50	1052.94
	167	714.00	865.56	792.00	907.27	983.89	886.23
	168	1020.00	940.00	960.00	966.82	990.00	963.60
	169	705.00	667.69	689.29	726.11	766.00	705.67
	174	885.00	725.00	694.55	734.29	680.00	724.38
Mean		831.00	865.65	837.97	876.22	891.48	866.56
I/109	141	-	1136.00	988.00	726.00	645.83	777.02
	142	746.67	798.89	650.63	842.50	886.25	734.67
	144	724.44	603.13	603.93	587.00	758.18	632.86
	146	-	941.00	866.67	845.29	-	874.62
	148	940.00	-	753.33	738.33	-	763.00
Mean		803.70	869.76	772.51	747.82	763.66	756.43
VIII/158	153	-	1093.33	1146.67	1068.00	984.55	1058.12
	155	990.00	1420.00	1085.00	-	1324.44	1196.25
	156	-	960.00	895.71	914.17	-	910.75
	159	1376.67	1175.00	1125.00	995.00	1230.00	1124.29
	160	830.00	-	861.67	824.29	-	840.00
Mean		1065.56	1162.08	1022.81	950.36	1179.66	1025.88
I/76	126	548.57	522.00	474.17	610.00	517.14	526.30
	128	572.50	676.67	638.33	884.00	-	731.54
	129	620.00	637.14	575.00	807.27	842.50	768.25
	135	725.00	630.83	615.48	664.90	-	640.96
	136	587.19	588.18	552.50	675.00	720.91	613.34
Mean		610.65	610.96	571.10	728.23	693.52	656.08
VIII/143	41	-	955.00	722.37	696.43	688.89	739.71
	49	612.22	879.09	848.33	683.24	670.00	745.70
	50	-	857.44	682.73	650.77	656.11	689.32
	52	930.00	693.33	640.00	518.00	-	607.91
	99	810.00	706.67	790.00	956.00	980.00	862.29
Mean		784.07	818.31	736.69	700.89	748.75	729.03
C.D. (0.05)**							164.95
Sem.		32.87	29.12	24.27	8.20	37.30	23.07

* Mean ofnuts harvested during 5 month period.

** CD given in Table 2.1a.

Table 2.1a. Critical difference for comparing means of weight of unhusked nuts

Family	Month of harvest	Family				
		I/58	I/109	VIII/158	I/76	VIII/143
VIII/23	January	223.10*	242.88	242.88	210.34	242.88
	February	202.14	214.40	214.40	202.14	202.14
	March	173.52	173.52	173.52	173.52	173.52
	May	238.73	275.66	275.66	275.66	253.21
I/58	January	-	254.01	254.01	223.10	254.01
	February	-	214.40	214.40	202.14	202.14
	March	-	173.52	173.52	173.52	173.52
	May	-	275.66	275.66	275.66	253.21
I/109	January	-	-	271.55	242.88	271.55
	February	-	-	226.00	214.40	214.40
	March	-	-	173.52	173.52	173.52
	May	-	-	308.20	308.20	288.29
VIII/158	January	-	-	-	242.88	271.55
	February	-	-	-	214.40	214.40
	March	-	-	-	173.52	173.52
	May	-	-	-	308.20	288.29
I/76	January	-	-	-	-	242.88
	February	-	-	-	-	202.14
	March	-	-	-	-	173.52
	May	-	-	-	-	288.29

* CD for comparing means of family VIII/23 and I/58

from 241.76 gm in I/109 to 356.25 gm in VIII/158. All progenies except one in VIII/158 produced nuts weighing more than 900 gms while all progenies of I/76 produced comparatively smaller sized nuts.

The influence of month of harvest on nut weight was also studied. The nuts of progenies of VIII/158 were comparatively heavier than all the progenies of other families during all the five months of study. The maximum mean weight was 1179.66 gm in the nuts harvested in the month of May followed by 1162.08 gm in the nuts of February. The lowest weight was recorded in April harvested nuts. The nuts of progenies of I/76 had the least weight in the month of January, February, March and May and the progenies of VIII/143 in the month of April.

The differences between parents in mean weight of unhusked nuts were significant in all months except April.

2.2. Volume of unhusked nuts

Volume of unhusked nuts harvested in different months from the 30 progenies under study was recorded and presented in Table 2.2 and the corresponding critical differences are given in Table 2.2a. The volume of nuts between families and within family differed considerably. The family mean for five month period was maximum in VIII/158 with

Table 2.2. Mean volume of unhusked nuts per palm from January to May 1979 (cc)

Family	F_1 progeny No.	January	February	March	April	May	Mean of 5 months*
VIII/23	109	2504.2	2820.0	1617.6	1659.2	1298.6	1912.1
	112	2518.5	2782.2	2362.9	2320.4	2310.0	2349.6
	113	3365.0	3005.0	2140.6	2513.0	1964.4	2482.1
	114	3235.0	3338.5	2197.6	2531.3	3200.0	2619.5
	115	2063.5	2250.0	1180.0	1457.5	1562.0	1995.2
Mean		2839.1	2839.1	1912.0	2136.4	2067.0	2191.7
I/58	165	-	3945.0	2871.5	2768.8	2842.5	2872.9
	167	2167.0	2524.4	2025.0	2653.6	2630.0	2489.1
	168	3720.0	3192.0	2785.7	2380.0	2635.0	2616.4
	169	2191.3	2125.3	1617.4	1857.3	2095.0	1984.2
	174	2560.0	2505.0	1370.4	1738.5	1886.6	1725.1
Mean		2858.3	2858.3	2153.8	2279.6	2417.8	2339.5
I/109	141	-	3420.0	2239.0	1810.2	1865.8	2041.3
	142	3118.3	2932.2	1880.1	2499.3	2560.0	2189.7
	144	2512.7	1943.4	1626.6	1520.0	1813.6	1715.5
	146	-	2935.5	2511.6	2358.3		2539.1
	148	2670.0	-	2023.3	1771.6	-	1937.0
Mean		2807.7	2807.7	2056.0	1991.9	2079.8	2084.5
VIII/158	153	-	3433.3	2895.8	2853.0	2865.0	2788.1
	155	3975.0	4505.0	2911.2	-	3425.5	3355.2
	156	-	3720.0	2811.4	2511.2		2669.6
	159	4936.6	4012.5	3811.5	3271.4	3763.7	3703.9
	160	2052.5	-	1803.3	1737.1	-	1805.6
Mean		3917.7	3917.7	2846.6	2593.2	3351.4	2864.5
I/76	126	1437.1	1446.5	833.3	1350.0	1165.0	1211.2
	128	1282.5	2020.0	1759.1	2137.5	-	1891.5
	129	2000.0	2072.8	1975.0	2014.0	2192.5	2087.7
	135	2430.6	2262.5	1629.8	1971.0	-	1915.2
	136	2101.4	1873.6	1593.7	1830.0	1982.2	1818.2
Mean		1935.1	1935.1	1558.2	1860.5	1779.9	1784.8
VIII/143	41	-	2553.7	1328.9	1427.8	1466.6	1508.7
	49	1367.4	2529.0	1741.8	1650.7	2352.5	1824.1
	50	-	-	1240.4	1396.1	1523.8	1524.7
	52	2222.5	1544.4	1115.4	1034.0	-	1150.1
	99	2290.0	1555.0	1768.5	1857.0	2402.8	1913.8
Mean		2079.0	2079.0	1439.0	1473.1	1936.4	1584.3
C.D. (0.05)**							591.05
Sem.		149.57	97.51	93.17	81.65	112.94	82.66

* Mean of nuts harvested during 5 month period

** CD given in Table 2.2a.

Table 2.2a. Critical difference for comparing means of volume of unhusked nuts

Family	Month of harvest	Family				
		I/58	I/109	VIII/158	I/76	VIII/143
VIII/23	January	1015.30*	1105.32	1105.32	957.24	1105.32
	February	676.80	717.86	717.86	676.80	676.80
	March	666.12	666.12	666.12	666.12	666.12
	April	575.40	575.40	610.30	575.40	575.40
	May	722.83	834.66	834.66	834.66	766.68
I/58	January	-	1155.98	1155.98	1015.30	1155.98
	February	-	717.86	717.86	676.80	676.80
	March	-	666.12	666.12	666.12	666.12
	April	-	575.40	610.30	575.40	575.40
	May	-	834.66	834.66	834.66	766.68
I/109	January	-	-	1235.79	1105.32	1235.79
	February	-	-	756.70	717.86	717.86
	March	-	-	666.12	666.12	666.12
	April	-	-	610.30	575.40	575.40
	May	-	-	933.17	933.17	872.91
VIII/158	January	-	-	-	1105.32	1235.79
	February	-	-	-	717.86	717.86
	March	-	-	-	666.12	666.12
	April	-	-	-	610.30	610.30
	May	-	-	-	933.17	872.91
I/76	January	-	-	-	-	1105.32
	February	-	-	-	-	676.80
	March	-	-	-	-	666.12
	April	-	-	-	-	575.40
	May	-	-	-	-	872.91

* CD for comparing means of family VIII/23 and I/58

2864.53 cc followed by I/58 with 2339.58, VIII/23 with 2191.73, I/109 with 2084.55, I/76 with 1784.81 and VIII/143 with 1584.34. The nut volume was maximum in the case of treee giving low yield of nuts. Within family also the nut volume varied considerably between the progenies. It ranged from 1595.22 to 2619.57 cc in VIII/23, 1725.15 to 2872.91 cc in I/58, 1715.54 to 2539.19 cc in I/109, 1805.66 to 3703.98 cc in VIII/158, 1211.25 to 2087.75 cc in I/76 and 1150.10 to 1913.86 cc in VIII/143. Four our of five progenies of VIII/158 produced larger sized nuts with a volume of more than 2600 cc. The variations between progenies was maximum in the family of VIII/158 and minimum in the family of I/109. Marked effect of season on nut volumes was also observed. The progenies of VIII/158 recorded maximum volume during all months while the lowest volume was recorded by the progenies of I/76 during the month of January, February and May and those of VIII/143 in March and April. Statistical analysis showed significant difference in all the months.

2.3. Polar circumference of unhusked nut

The mean values of polar circumference of unhusked nuts collected from the progenies under study during all months is presented in Table 2.3 and the corresponding critical differences are given in Table 2.3a. Difference

Table 2.3. Mean polar circumference of unhusked nuts per palm from January to May 1979 (cm)

Family	F_1 progeny No.	January	February	March	April	May	Mean of 5 months*
VIII/23	109	61.79	62.27	56.41	54.04	49.42	50.11
	112	60.60	61.44	60.35	58.62	58.25	53.89
	113	67.00	62.10	61.40	58.77	55.00	55.02
	114	63.00	63.14	57.94	59.73	60.00	54.40
	115	55.95	55.88	50.47	52.60	50.50	48.41
Mean		61.67	60.97	57.31	56.75	54.63	52.37
I/58	165	-	67.00	62.60	61.72	60.00	52.09
	167	55.20	57.44	57.40	58.55	60.11	58.34
	168	65,00	55.31	64.43	61.86	56.50	62.46
	169	57.33	55.31	55.93	55.72	53.80	55.52
	174	65.00	59.50	55.55	54.71	53.33	55.81
Mean		60.63	60.67	59.18	58.51	56.75	56.74
I/109	141	-	63.60	60.20	53.32	52.08	52.27
	142	62.67	62.56	58.16	58.75	59.38	59.27
	144	57.44	55.00	55.46	51.50	53.82	54.42
	146	-	61.80	62.50	58.81	-	60.22
	148	60.00	-	58.00	54.50	-	56.10
Mean		60.04	60.74	58.86	55.38	55.09	56.45
VIII/158	153	-	65.33	64.00	60.20	57.09	60.44
	155	71.00	70.00	64.88	6 -	63.67	65.15
	156	-	70.00	63.43	61.25	-	63.02
	159	75.00	69.50	68.83	64.86	66.75	67.37
	160	52.50	-	62.33	53.00	-	56.67
Mean		66.17	68.71	64.69	59.83	62.50	62.53
I/76	126	52.29	52.60	49.17	50.30	47.75	50.37
	128	50.75	55.33	54.33	53.30	-	53.61
	129	56.00	55.00	58.00	55.14	53.88	55.03
	135	60.00	59.67	56.19	55.30	-	57.33
	136	57.43	54.45	54.80	55.00	55.36	55.19
Mean		55.29	55.41	54.50	53.81	52.23	54.31
VIII/143	41	-	59.63	53.74	51.93	50.89	53.68
	49	50.89	58.64	55.83	52.00	50.38	53.65
	50	-	57.14	51.82	49.92	50.00	51.41
	52	59.50	52.56	51.33	46.10	-	49.53
	99	55.00	58.00	55.80	55.30	56.43	56.11
Mean		55.13	57.19	53.70	51.05	51.90	52.87
C.D. (0.05)**							4.26
Sem.		1.17	0.632	0.591	0.632	0.821	0.592

* Mean ofnuts harvested during 5 month period
** CD given in Table 2.3a.

Table 2.3a. Critical difference for comparing means of polar circumference of unhusked nuts

Family	Month of harvest	Family				
		I/58	I/109	VIII/158	I/76	VIII/143
VIII/23	February	4.38*	4.64	4.64	4.38	4.37
	March	4.25	4.25	4.25	4.25	4.25
	April	4.45	4.45	4.72	4.45	4.45
	May	5.28	6.10	6.10	6.10	5.60
I/58	February	-	4.64	4.64	4.38	4.38
	March	-	4.25	4.25	4.25	4.25
	April	-	4.45	4.72	4.45	4.45
	May	-	6.10	6.10	6,10	5.60
I/109	February	-	-	4.89	4.64	4.38
	March	-	-	4.25	4.25	4.25
	April	-	-	4.72	4.45	4.45
	May	-	-	6.82	6.82	6.38
VIII/158	February	-	-	-	4.64	4.64
	March	-	-	-	4.25	4.25
	April	-	-	-	4.72	4.72
	May	-	-	-	6.82	6.38
I/76	February	-	-	-	-	4.38
	March	-	-	-	-	4.25
	April	-	-	-	-	4.45
	May	-	-	-	-	6.38

* CD for comparing means of family VIII/23 and I/58

were noticed between families and also within family in respect of polar circumference of unhusked nuts. The family VIII/158 recorded maximum polar circumference of 62.53 cm followed by I/58 with 56.74 cm and I/109 with 56.45 cm. The least measurement of 52.37 cm was in VIII/23. The progenies within the families alse showed marked variation. It ranged from 48.41 to 55.02 cm in VIII/23, 52.09 to 62.46 cm in I/58, 52.27 to 60.22 cm in I/109, 56.67 to 67.37 cm in VIII/158, 50.37 to 57.33 cm in I/76 and 49.53 to 56.11 cm in VIII/143.

The differences between parents in mean polar circumference was significant in the nuts harvested in the months of February, March, April and May and not significant in the month of January. Progenies of VIII/158 recorded maximum circumference in all months and VIII/143 had the minimum circumference in all months except February.

2.4. Equitorial circumference of unhusked nut

The equitorial circumference of unhusked nuts also showed almost the similar trend as the polar circumference. The data are presented in Table 2.4 and the corresponding critical differences are given in Table 2.4a. The family VIII/158 recorded maximum circumference of 53.44 cm followed by I/58 with 50.31 cm and VIII/23 with 48.87 cm.

Table 2.4. Mean equitorial circumference of unhusked nuts per palm from January to May 1979 (cm)

Family	F_1 progeny No.	January	February	March	April	May	Mean of 5 months*
VIII/23	109	50.50	51.18	45.82	43.32	40.79	45.38
	112	50.30	51.44	51.39	50.08	51.75	50.80
	113	56.67	52.80	51.33	51.08	47.00	51.10
	114	55.10	56.71	50.69	51.60	56.00	52.52
	115	47.35	47.13	42.16	42.60	45.30	44.55
Mean		51.99	51.85	48.28	47.74	48.17	48.87
I/58	165	-	60.00	56.00	53.56	53.25	54.62
	167	47.30	50.11	49.90	50.18	52.06	50.48
	168	58.00	53.40	53.00	51.32	53.00	52.19
	169	49.17	47.77	47.64	47.17	47.70	48.91
	174	50.00	49.00	44.82	44.64	45.00	45.37
Mean		51.12	52.06	50.27	49.37	50.20	50.31
I/109	141	-	58.20	53.20	46.84	45.33	48.34
	142	54.83	58.67	47.97	50.38	51.63	50.73
	144	47.89	46.19	44.51	41.95	46.00	45.10
	146	-	53.20	53.83	49.90	-	51.43
	148	50.00	-	48.33	44.17	-	45.99
Mean		50.91	54.07	49.78	46.65	47.65	48.32
VIII/158	153	-	58.33	59.17	53.33	52.27	54.68
	155	57.00	62.00	55.38	-	57.56	57.10
	156	-	54.00	52.57	50.25	-	51.18
	159	61.67	57.75	58.35	54.93	57.75	57.06
	160	53.00	-	48.33	44.57	-	47.20
Mean		57.22	58.02	54.76	50.77	55.86	53.44
I/76	126	39.57	39.30	37.30	41.00	37.38	38.64
	128	39.75	46.17	46.17	46.90	-	45.59
	129	45.00	46.29	49.00	46.77	47.75	45.70
	135	47.63	47.83	45.00	45.90	-	46.05
	136	47.21	43.27	44.60	45.63	45.91	45.16
Mean		43.83	44.57	44.35	45.24	43.68	44.23
VIII/143	41	-	49.13	42.79	41.21	41.56	43.07
	49	38.78	49.36	48.58	44.32	43.88	45.50
	50	-	44.43	41.82	41.46	39.89	41.39
	52	46.00	40.56	39.58	35.95	-	42.92
	99	49.50	50.83	48.10	49.60	48.86	45.03
Mean		44.76	46.86	44.17	42.51	43.55	43.58
C.D. (0.05)**							4.22
Sem.		0.892	0.800	0.761	0.742	0.821	0.592

* Mean of nuts harvested during 5 month period

** CD given in Table 2.4a.

Table 2.4a. Critical difference for comparing means of equitorial circumference of unhusked nuts

Family	Month of harvest	Family				
		I/58	I/109	VIII/158	I/76	VIII/143
VIII/23	January	6.05*	6.58	6.58	5.70	6.58
	February	5.56	5.90	5.90	5.56	5.56
	March	5.45	5.45	5.45	5.45	5.45
	April	5.21	5.21	5.53	5.21	5.21
	May	5.99	6.91	6.91	6.91	6.35
I/58	January	-	6.88	6.88	6.05	6.88
	February	-	5.90	5.90	5.56	5.56
	March	-	5.45	5.45	5.45	5.45
	April	-	5.21	5.53	5.21	5.21
	May	-	6.91	6.91	6.91	6.35
I/109	January	-	-	7.36	6.58	7.36
	February	-	-	6.22	5.90	5.90
	March	-	-	5.45	5.45	5.45
	April	-	-	5.53	5.21	5.21
	May	-	-	7.73	7.73	7.23
VIII/158	January	-	-	-	6.58	7.36
	February	-	-	-	5.90	5.90
	March	-	-	-	5.45	5.45
	April	-	-	-	5.52	5.53
	May	-	-	-	7.73	7.23
I/76	January	-	-	-	-	6.58
	February	-	-	-	-	5.56
	March	-	-	-	-	5.45
	April	-	-	-	-	5.21
	May	-	-	-	-	7.23

* CD for comparing means of family VIII/23 and I/58

The least measurement of 44.23 cm was recorded by I/76. The circumference ranged from 44.53 to 52.52 cm in VIII/23, 45.37 to 54.62 cm in I/58, 45.13 to 51.43 cm in I/109, 47.20 to 57.10 cm in VIII/158, 38.64 to 46.05 cm in I/76 and 41.39 to 45.50 cm in VIII/143. It was also observed that there was variation in the equitorial circumference of the nuts harvested in the different months. Among the different families, VIII/158 had the maximum circumference in all months followed by I/58 in the month of March, April and May, VIII/23 in the month of January and I/109 in the month of February. The progenies of VIII/143 recorded the minimum circumference in most of the months. Statistical analysis of the data showed significant difference among families at 1% level in all the months except May and at 5% level in the month of May.

3. Number of days taken for germination of nuts

The nuts collected from each progeny during the different months were sown separately after a storage period of one month. The number of days taken for sprouting was recorded.in all progenies and are presented in Table 3 and the corresponding critical differences are given in Table 3a. It varied between families and also within each family. The maximum number of 114.16 days was taken by family

Table 3. Mean number of days for sprouting of nuts harvested from January to May 1979

Family	F_1 progeny No.	January	February	March	April	May	Mean of 5 months*
VIII/23	109	139.15	113.27	107.47	109.70	108.18	121.07
	112	142.25	116.00	110.36	97.52	107.50	110.79
	113	111.50	112.56	117.92	100.77	93.75	107.65
	114	131.75	118.50	105.12	94.33	74.00	105.28
	115	131.44	111.17	112.41	91.70	83.63	103.43
Mean		131.23	114.30	110.66	98.85	93.41	109.64
I/58	165	-	121.00	80.90	90.65	91.25	89.67
	167	127.40	110.56	104.00	92.60	81.50	97.33
	168	100.00	118.80	120.67	99.74	87.50	105.62
	169	109.25	116.00	110.15	93.82	88.50	102.93
	174	130.50	121.00	120.64	91.64	119.67	108.50
Mean		116.79	117.47	107.27	93.70	84.93	100.80
I/109	141	-	116.67	114.80	100.52	114.56	107.34
	142	122.33	104.14	116.62	101.13	93.57	109.89
	144	110.78	115.50	117.15	104.47	94.82	110.21
	146	-	120.38	99.50	100.10	-	105.48
	148	177.00	-	130.33	93.80	-	126.11
Mean		136.70	116.17	115.68	100.00	100.98	111.81
VIII/158	153	-	114.50	107.17	94.22	98.40	100.44
	155	137.00	128.50	99.17	-	81.00	95.82
	156	-	145.00	95.17	98.00	-	100.05
	159	66.00	113.00	97.17	93.33	75.38	89.79
	160	75.00	-	109.00	91.00	-	96.07
Mean		92.67	125.25	101.54	94.14	84.93	96.43
I/76	126	102.83	112.38	112.50	94.86	110.88	112.51
	128	129.67	125.50	114.00	98.20	-	112.99
	129	177.00	119.60	117.50	96.00	87.75	101.58
	135	101.86	101.82	105.73	94.70	-	102.65
	136	143.33	127.36	111.14	97.29	83.09	111.92
Mean		130.94	117.33	112.17	96.21	93.91	108.33
VIII/143	41	-	119.22	121.71	113.00	112.13	120.73
	49	127.11	139.25	102.14	108.32	105.13	109.66
	50	-	128.00	106.78	113.18	100.65	109.26
	52	157.50	127.80	112.42	126.18	-	124.57
	99	101.00	129.88	112.00	105.50	53.67	106.56
Mean		128.54	128.83	111.01	113.24	100.40	114.16
C.D. (0.05)**							
Sem.		5.59	1.67	1.70	0.941	2.18	1.68

* Mean number of days for sprouting of nuts harvested during the entire period

** CD given in Table 3a.

Table 3a. Critical difference for comparing means of number of days for sprouting of nuts

Family	Month of harvest	Family				
		I/58	I/109	VIII/158	I/76	VIII/143
VIII/23	April	6.64*	6.64	7.04	6.64	6.64
I/58	April	-	6.64	7.04	6.64	6.64
I/109	April	-	-	7.04	6.64	6.64
VIII/158	April	-	-	-	7.04	7.04
I/76	April	-	-	-	-	6.64

* CD for comparing means of family VIII/23 and I/58

VIII/143 followed by I/109 with 111.81 days, VIII/23 with 109.64 days, I/76 with 108.33 days, I/58 with 100.80 days and VIII/158 with 96.43 days. Within families also the progenies varied in respect of the sprouting period. It ranged from 103.43 to 121.07 days in VIII/23, 89.67 to 108.50 days in I/58, 105.48 to 126.11 days in I/109, 89.79 to 100.44 days in VIII/158, 101.58 to 112.99 days in I/76 and 106.56 to 124.57 days in VIII/143. The difference between maximum and minimum number of days taken by the progenies in the family group was least in VIII/158 and highest in I/109.

Month of harvest was also found to influence the sprouting period of nuts. The nuts of progenies of the family VIII/158 harvested in the months of January, March and May took the minimum number of days for sprouting where as the nuts of family VIII/23 harvested in February germinated earlier. In April family I/58 took the minimum number of days. It ranged from 92.67 days in the nuts harvested in January in family VIII/158 to 131.23 days in VIII/23, 114.30 days in VIII/23 to 128.83 days in VIII/143 in the nuts harvested in February, 101.54 days in VIII/158 to 115.68 days in I/109 in the nuts harvested in the month of March, 93.70 days in I/58 to 113.24 days in VIII/143 in the nuts harvested in the month of April and 84.93 days in VIII/158 to 100.98 days in I/109 in nuts harvested in the month of May. However the difference was statistically significant only for the nuts harvested in the month of April.

Another point of interest noticed was that the nuts took less number of days for germination in most of the families as the harvest progressed from the month of January to May. The nuts harvested in the month of May germinated earlier than the nuts harvested in other months.

4. Seedling characters

4.1. Girth at collar

Girth at collar gives an indication of the vigour of seedlings. Data on the mean girth at collar of the seedlings one year after sowing is given in Table 4.1.1 and the corresponding critical differences are given in Tables 4.1a and 4.1b. Highly significant variation in girth was noticed between families. The maximum girth of 9.41 cm was recorded by progenies of VIII/23 and the least girth of 8.60 cm by the progenies of I/76. The mean girth of other families were 9.20 cm in I/58, 8.73 cm in I/109, 8.97 cm in VIII/158 and 8.83 cm in VIII/143. The progenies within each family also showed variations in girth. In the family VIII/23 the progeny mean girth varied from 8.64 to 10.10 cm which was significant at 1% level.

Table 4.1.1. Mean collar girth of F_2 progeny one year after sowing (cm)

Family	F_1 progeny No.	Month of harvest					Mean of 5 months
		January	February	March	April	May	
VIII/23	109	10.36	9.85	9.44	7.97	8.00	8.64
	112	10.30	10.54	9.83	8.94	9.50	9.61
	113	12.90	9.72	10.12	8.93	9.04	9.51
	114	10.90	10.17	10.63	9.14	12.00	10.10
	115	11.14	9.25	9.22	8.76	9.41	9.19
Mean		11.12	9.91	9.85	8.75	9.59	9.41
CD (0.05)*							
Sem.							0.110
I/58	165	-	10.75	9.22	9.35	8.55	9.26
	167	9.60	10.22	9.58	9.72	9.21	9.60
	168	13.00	9.57	9.41	5.85	5.85	9.08
	169	11.13	8.20	9.60	8.98	9.14	9.18
	174	12.00	9.27	9.37	8.52	7.00	8.87
Mean		11.43	9.60	9.38	9.20	7.95	9.20
CD (0.05)*							
Sem.							0.084
I/109	141	-	8.77	9.04	7.81	6.88	7.54
	142	10.50	9.43	9.09	8.33	9.54	9.16
	144	11.62	9.00	8.75	7.47	8.19	8.58
	146	-	9.20	10.37	9.55	-	9.62
	148	8.50	-	7.25	9.44	-	8.76
Mean		10.21	9.10	8.90	8.52	8.20	8.73
CD (0.05)*							
Sem.							0.121
VIII/158	153	-	10.25	9.65	8.49	6.90	8.01
	155	7.00	11.00	9.65	-	9.86	9.74
	156	-	8.00	10.24	8.13	-	8.71
	159	11.90	10.33	10.90	9.61	9.86	10.12
	160	10.90	-	8.18	7.83	-	8.28
Mean		9.93	9.90	8.72	8.52	8.87	8.97
CD (0.05)*							
Sem.							0.161
I/76	126	12.00	8.67	7.80	7.05	6.32	8.27
	128	8.33	8.88	8.38	8.12	-	7.94
	129	10.00	11.00	8.75	9.38	8.50	9.28
	135	13.42	10.45	9.19	9.62	-	9.74
	136	9.67	8.70	7.80	7.87	7.79	7.75
Mean		10.68	9.54	8.38	8.41	7.54	8.60
CD (0.05)*							
Sem.							0.141
VIII/143	41	-	7.23	9.62	8.44	6.66	8.65
	49	9.65	8.87	10.26	10.48	7.17	8.95
	50	-	7.24	9.14	8.33	9.27	8.68
	52	6.25	7.11	9.15	7.99	-	8.13
	99	11.25	8.78	10.38	8.43	11.76	9.76
Mean		9.05	7.85	9.71	8.33	8.72	8.83
CD (0.05)*							
Sem.							0.08
CD (0.05)**							0.931

* Given in table 4.1a. ** Given in Table 4.1b.

Table 4.1a. Critical difference for comparing means of collar girth of F_2 progeny

Family	Month of harvest	Family				
		I/58	I/109	VIII/158	I/76	VIII/143
VIII/23	February	1.19*	1.26	1.26	1.19	1.19
	March	0.97	0.97	0.97	0.97	0.97
I/58	February	-	1.26	1.26	1.19	1.19
	March	-	0.97	0.97	0.97	0.97
I/109	February	-	-	1.33	1.26	1.26
	March	-	-	0.97	0.97	0.97
VIII/158	February	-	-	-	1.26	1.26
	March	-	-	-	0.97	0.97
I/76	February	-	-	-	-	1.19
	March	-	-	-	-	0.97

* CD for comparing means of family VIII/23 and I/58

Table 4.1b. Critical difference for collar girth of F_2 progeny within the families

Family	Progeny No.	Progeny number			
VIII/23		112	113	114	115
	109	0.60*	0.67	0.70	0.62
	112	-	0.70	0.73	0.65
	113	-	-	0.79	0.72
	114	-	-	-	0.74
I/109		142	144	146	148
	141	0.71	0.66	0.78	0.132
	142	-	0.62	0.75	1.29
	144	-	-	0.70	1.27
	146	-	-	-	1.40
VIII/158		155	153	156	160
	159	0.97	0.85	0.94	1.07
	155	-	1.01	1.08	1.20
	153	-	-	0.97	1.11
	156	-	-	-	1.17
I/76		126	135	129	136
	128	1.03	0.94	1.03	0.97
	126	-	0.85	0.95	0.88
	135	-	-	0.85	0.78
	129	-	-	-	0.88
VIII/143		41	50	99	52
	49	0.62	0.69	0.80	0.76
	41	-	0.73	0.83	0.79
	50	-	-	0.89	0.84
	99	-	-	-	0.94

* CD for comparing means of progeny No. 109 and 112

In I/58 though it varied from 8.87 to 9.60 cm the difference was not significant. The variations within the progenies of I/109 ranged from 7.54 to 9.62 cm and was significant at 1% level. In the case of VIII/158 it ranged from 8.01 to 10.12 cm which was significant at 1% level. The progenies of I/76 also showed significant difference at 1% level with a range of 7.75 to 9.74 cm. The variation between progenies of VIII/143 ranged from 8.13 to 9.76 cm and was not statistically significant in girth at collar.

In respect of the month of harvest the progenies of I/58 recorded the maximum girth of 11.43 cm and 9.20 cm in the nuts harvested in January and April. In the progenies of VIII/23 it was for the nuts harvested in the month of February, March and May with 9.91, 9.85 and 9.59 cm respectively. The least girth was recorded by the progenies of VIII/143 for the nuts harvested in the months of January, February and April and the progenies of I/76 for the months of March and May. However difference between families was significant only for the months of February and March.

Variations were also observed among seedlings of the same progeny. The mean girth, range, standard deviation, standard error of mean and co-efficient of variation within each progeny tree are presented in Table 4.1.2. The

Table 4.1.2. Mean, range, standard deviation, standard error of mean and co-efficient of variation for seedling girth within each palm

Family	F_1 progeny No.	Mean	Range	S.D.	Sem.	C.V.
VIII/23	109	8.87	4.2-12.2	1.97	0.219	22
	112	9.60	6.0-12.2	1.96	0.241	20
	113	9.61	3.5-13.8	2.00	0.295	21
	114	10.08	6.0-15.3	1.75	0.277	17
	115	9.48	6.0-13.5	2.03	0.260	21
I/58	165	9.30	5.5-11.2	1.36	0.237	15
	167	9.60	5.0-15.0	1.92	0.272	20
	168	9.27	3.0-13.0	1.89	0.334	20
	169	9.17	6.2-13.0	1.49	0.203	16
	174	8.95	6.0-11.5	1.54	0.277	17
I/109	141	7.80	2.3-10.5	1.85	0.285	24
	142	9.16	5.5-11.0	1.32	0.185	14
	144	8.73	3.0-14.0	2.08	0.237	24
	146	9.62	7.5-12.5	1.14	0.193	12
	148	8.76	5.0-10.8	1.83	0.647	21
VIII/158	153	8.40	3.6-11.5	1.91	0.381	23
	155	9.75	7.0-11.5	1.74	0.435	18
	156	8.71	6.0-11.2	1.31	0.309	15
	159	10.12	7.0-13.0	1.57	0.287	16
	160	8.44	6.0-11.0	1.74	0.502	21
I/76	126	8.27	4.3-13.0	2.10	0.361	24
	128	8.39	3.0-11.4	2.01	0.400	24
	129	9.42	4.3-12.2	1.59	0.373	17
	135	9.97	5.0-15.0	1.64	0.221	16
	136	7.90	3.3-13.0	2.01	0.296	25
VIII/143	41	8.73	5.0-11.5	1.87	0.243	21
	49	9.00	3.5-15.0	1.96	0.225	22
	50	8.68	5.3-10.5	1.42	0.218	16
	52	8.09	5.0-11.3	0.84	0.148	10
	99	9.75	4.2-13.5	2.11	0.406	22

co-efficient of variation was taken as an index to indicate the extent of variability of the mean values presented in the table. The maximum co-efficient of variation of 25 was in the tree number 136 of family I/76 and the minimum of 10 was in tree number 52 of family VIII/143.

4.2. Height of seedlings

The height of seedlings was recorded one year after sowing and the data presented in Table 4.2.1.and the corresponding critical differences are given in Tables 4.2a and 4.2b. From the table it can be seen that the seedlings exhibited substantial difference in growth between families and also within family. The mean height was maximum in the family VIII/23 with 104.95 cm followed by I/58 with 94.55 cm, VIII/143 with 90.11 cm, I/109 with 88.90 cm, VIII/158 with 88.17 cm and I/76 with 86.04 cm.

The differences between progenies was found to be significant on statistical analysis in all families except VIII/143. In family VIII/23 the mean height ranged from 92.00 cm in progeny number 109 to 114.25 cm in progeny number 114, while in family I/58 it was 87.00 cm in progeny 168 to 101.00 cm in progeny 141 to 104.57 cm in progeny 146, in family VIII/158 it was 77.54 in progeny 153 to 96.83 in progeny 159, in family I/76 it was 71.71 cm in

Table 4.2.1. Mean height of F_2 progeny one year after sowing (cm)

Family	F_1 progeny No.	Month of harvest					Mean of 5 months
		January	February	March	April	May	
VIII/23	109	118.00	103.81	97.96	86.56	80.30	92.00
	112	119.54	116.44	113.23	99.80	125.70	109.59
	113	134.50	108.01	126.91	98.65	104.13	109.53
	114	117.25	100.75	132.70	92.89	127.00	114.25
	115	115.72	95.55	116.28	93.75	103.15	99.39
Mean		121.00	104.91	117.42	94.33	108.06	104.95
CD (0.05)*							
I/58	165	-	105.80	94.50	98.63	95.65	95.25
	167	90.20	108.67	99.87	104.60	98.88	101.00
	168	126.40	89.50	84.60	92.10	57.00	87.00
	169	100.15	83.00	91.59	95.65	92.80	89.74
	174	98.00	82.75	83.53	78.27	58.17	99.75
Mean		103.69	93.94	90.82	93.86	78.50	94.55
CD (0.05)*							
I/109	141	-	81.33	91.70	76.60	64.68	73.88
	142	103.50	90.07	103.00	83.31	105.41	96.54
	144	106.00	82.85	101.92	74.11	78.65	86.98
	146	-	93.83	104.42	108.71	-	104.57
	148	82.50	-	65.65	89.30	-	82.53
Mean		97.33	86.87	93.31	86.41	82.91	88.90
CD (0.05)*							
VIII/158	153	-	94.25	86.90	80.17	69.31	77.54
	155	44.00	107.00	95.75	-	91.86	92.21
	156	-	85.50	102.20	80.38	-	86.72
	159	103.25	96.33	104.16	95.38	93.50	96.83
	160	89.00	-	94.38	82.50	-	87.54
Mean		78.83	95.77	98.45	84.61	84.89	88.17
CD (0.05)*							
I/76	126	93.30	81.06	78.03	60.00	65.70	75.85
	128	70.17	79.32	80.06	78.65	-	78.84
	129	87.00	101.10	92.00	96.76	84.43	94.30
	135	109.33	85.26	99.16	95.80	-	109.51
	136	84.07	68.83	68.68	67.21	77.74	71.71
Mean		88.78	83.11	83.59	79.68	75.96	86.04
CD (0.05)*							
VIII/143	41	-	63.21	104.11	88.98	64.77	90.38
	49	103.06	83.01	116.19	83.75	69.36	92.54
	50	-	67.67	113.30	84.20	100.06	95.39
	52	49.50	66.20	113.78	72.77	-	80.33
	99	91.00	77.80	111.60	75.94	111.44	91.90
Mean		81.19	71.80	111.80	81.13	86.41	90.11
CD (0.05)*							
CD (0.05)**							13.24
Sem.		3.79	1.82	1.94	2.01	3.94	1.85

* Given in Table 4.2a. ** Given in Table 4.2b.

Table 4.2a. Critical difference for comparing means of height of F_2 progeny

Family	Month of harvest	Family				
		I/58	I/109	VIII/158	I/76	VIII/143
VIII/23	January	25.76	28.04	28.04	24.28	28.04
	February	12.66	13.43	13.43	12.66	12.66
	March	13.89	13.89	13.89	13.89	13.89
I/58	January	-	29.33	29.33	25.76	29.33
	February	-	13.43	13.43	12.66	12.66
	March	-	13.89	13.89	13.89	13.89
I/109	January	-	-	31.35	28.04	31.35
	February	-	-	14.16	13.43	13.43
	March	-	-	13.89	13.89	13.89
VIII/158	January	-	-	-	28.04	31.35
	February	-	-	-	73.43	13.43
	March	-	-	-	13.89	13.89
I/76	January	-	-	-	-	28.04
	February	-	-	-	-	12.66
	March	-	-	-	-	13.89

* CD for comparing means of family VIII/23 and I/58

Table 4.2b. Critical difference for height of F_2 progeny within the families

Family	Progeny No.	Progeny No.			
VIII/23		112	113	114	115
	109	7.71*	8.59	8.99	7.89
	112	-	8.93	9.32	8.26
	113	-	-	10.06	9.08
	114	-	-	-	9.46
I/58		167	165	174	168
	169	7.54	8.49	8.65	8.57
	167	-	8.61	8.78	8.69
	165	-	-	9.61	9.53
	174	-	-	-	9.68
I/109		142	144	146	148
	141	8.01	7.37	8.80	14.82
	142	-	6.94	8.44	14.61
	144	-	-	7.83	14.28
	146	-	-	-	16.06
VIII/158		155	153	156	160
	159	10.65	9.32	10.26	11.75
	155	-	11.02	11.82	13.14
	153	-	-	10.64	12.09
	156	-	-	-	12.83
I/76		126	135	129	136
	128	33.06	30.27	33.06	31.18
	126	-	27.38	30.44	28.38
	135	-	-	27.38	25.08
	129	-	-	-	28.38

* CD for comparing means of progeny number 109 and 112

progeny 136 to 109.51 cm in progeny 135 and in family VIII/143 it was 80.33 in progeny 52 to 95.39 in progeny 50.

Influence of month of harvest on the height of seedlings was also noticed. The seedlings of family number VIII/23 raised from nuts harvested in all months recorded maximum height and the mean height ranged from 94.33 cm in the seedling raised from April harvest to 121.00 cm in the seedlings of January harvest. Least growth in respect of height was made by the progenies of VIII/158 in the January harvested nuts, VIII/143 in the February harvested nuts and I/76 in the March, April and May harvested nuts. Statistical analysis showed the differences between the parental combinations significant for the months of January, February and March and not significant for other two months of April and May.

Variations were also observed between seedlings of the same progeny. The mean height, range, standard deviation, standard error of mean and co-efficient of variation of seedlings obtained from each seedling from a progeny are presented in Table 4.2.2. The co-efficient of variation was taken as an index to indicate the extent of variability of the mean values presented in the table. The maximum co-efficient of variation of 32 was in progeny

Table 4.2.2. Mean, range, standard deviation, standard error of mean and co-efficient of variation for seedling height within each palm

Family	F_1 Progeny No.	Mean	Range	S.D.	Sem.	C.V.
VIII/23	109	94.35	40.5-126.5	24.54	2.73	26
	112	109.85	54.5-146.5	20.87	2.57	19
	113	110.10	32.0-156.5	25.27	3.73	23
	114	111.15	45.0-150.0	25.51	4.04	23
	115	106.03	48.0-152.0	23.22	2.97	22
I/158	165	97.41	26.5-128.0	22.56	3.93	23
	167	101.09	41.0-144.0	20.44	2.89	20
	168	87.73	27.0-126.5	21.69	3.83	25
	169	90.28	46.0-119.5	17.08	2.32	19
	174	79.75	38.0-109.5	16.42	2.95	21
I/109	141	75.88	26.5-105.5	19.32	2.98	25
	142	98.50	44.0-126.5	18.02	2.52	18
	144	89.63	51.5-130.5	22.79	2.60	25
	146	104.57	87.0-136.0	13.72	2.32	13
	148	82.54	41.0-107.5	19.06	6.73	23
VIII/158	153	79.44	39.0-104.0	16.82	3.36	21
	155	92.22	44.0-125.0	20.26	5.07	22
	156	86.73	42.0-114.5	17.32	4.08	20
	159	96.98	60.0-133.0	17.95	3.28	19
	160	87.99	59.5-107.0	14.31	4.14	16
I/76	126	75.96	41.0-106.0	18.28	3.14	24
	128	78.05	25.0-103.0	19.80	3.96	25
	129	94.29	47.0-128.5	18.93	3.25	20
	135	97.05	40.0-150.0	23.03	3.10	24
	136	69.46	37.0-127.0	21.92	3.23	32
VIII/143	41	91.29	31.0-125.8	24.56	3.20	27
	49	93.15	20.5-150.5	25.78	2.96	28
	50	93.73	44.6-147.0	25.45	3.93	27
	52	84.68	42.0-131.0	26.55	4.63	31
	99	91.90	35.0-137.7	24.97	4.80	27

number 136 of family I/76 and the minimum of 13 was in the progeny number 146 of family I/109. This indicated that the seedlings produced by some of the progenies were more uniform than the seedlings produced by other progenies.

4.3. Total leaf production

The total number of leaves produced by each seedling obtained from different monthly harvests from all the families were recorded one year after sowing of nuts and the mean value presented in table number 4.3.1 and the corresponding critical differences of analysis are given in Table 4.3a.

The families differed between themselves in respect of total leaf production. The maximum mean leaf production of 6.03 was in the family VIII/23 and the minimum of 5.36 was in family VIII/158. The difference between families was found to be significant at 1 per cent level.

Variations were also noticed between the seedlings of the same progeny. The mean number of leaves produced, range, standard deviation, standard error of mean and co-efficient of variation of each progeny tree are presented in Table 4.3.2. The co-efficient of variation is taken as the index to indicate the extent of variability

Table 4.3.1. Mean number of leaves produced by one year old F_2 progeny

Family	F_1 progeny No.	Month of harvest					Mean of 5 months
		January	February	March	April	May	
VIII/23	109	6.40	5.91	5.67	5.00	5.33	5.58
	112	6.29	6.25	5.91	6.04	5.00	6.14
	113	7.50	6.33	5.85	6.15	5.50	6.02
	114	6.50	6.50	6.33	6.00	7.00	6.43
	115	6.78	5.50	5.76	5.50	6.06	6.06
Mean		6.29	6.10	5.90	5.74	5.78	6.03
CD (0.05)*							
I/58	165	-	7.00	5.50	5.63	4.25	5.42
	167	6.20	6.11	5.89	5.70	5.29	5.72
	168	9.00	5.67	6.00	5.32	3.00	5.40
	169	7.25	5.90	6.23	5.29	5.70	5.83
	174	6.50	6.00	5.09	5.00	4.33	5.13
Mean		7.24	6.14	5.74	5.39	4.51	5.50
CD (0.05)*							
I/109	141	-	6.00	6.20	5.25	4.67	5.19
	142	6.67	6.29	5.69	5.63	5.71	5.86
	144	7.22	5.55	5.41	5.37	5.10	5.56
	146	-	5.88	6.17	5.67	-	5.80
	148	4.00	-	5.00	6.40	-	5.7[illegible]
Mean		5.96	5.93	5.69	5.68	5.16	5.63
CD (0.05)*							
VIII/158	153	-	7.00	4.67	4.67	4.50	4.96
	155	3.00	6.50	5.33	-	5.00	5.56
	156	-	5.00	5.80	4.67	-	5.06
	159	6.00	5.33	6.20	5.42	5.13	5.73
	160	6.50	-	5.50	5.17	4.25	5.50
Mean		5.17	5.96	5.50	4.98	4.88	5.36
CD (0.05)*							
I/76	126	7.20	5.75	5.00	4.83	4.60	5.44
	128	5.00	6.60	6.20	5.90	-	5.84
	129	5.00	6.00	5.00	5.74	5.86	5.74
	135	8.17	6.90	5.71	6.20	-	6.29
	136	5.50	4.89	5.67	5.29	4.70	5.09
Mean		6.17	6.03	5.52	5.59	5.05	5.68
CD (0.05)*							
VIII/143	41	-	5.29	6.19	5.42	3.86	5.58
	49	6.25	5.44	5.90	5.37	5.00	5.54
	50	-	4.29	5.33	5.80	6.13	5.60
	52	4.00	4.63	6.00	4.80	-	5.42
	99	6.50	5.60	6.33	5.64	6.60	5.81
Mean		5.58	5.09	5.95	5.42	5.40	5.59
CD (0.05)*							
CD (0.05)							0.414
Sem.		0.281	0.100	0.100	0.100	0.171	0.055

* Given in Table 4.3a.

Table 4.3a. Critical difference for total leaves produced by F_2 progeny within the families

Family	Progeny No.	Progeny number			
VIII/23		112	113	114	115
	109	0.37	0.41	0.43	0.38
	112	-	0.43	0.44	0.39
	113	-	-	0.48	0.43
	114	-	-	-	0.45
I/109		142	144	146	148
	141	0.45	0.41	0.49	0.83
	142	-	0.39	0.47	0.82
	144	-	-	0.44	0.80
	146	-	-	-	0.85
VIII/158		155	153	156	160
	159	0.56	0.49	0.54	0.62
	155	-	0.58	0.63	0.69
	153	-	-	0.56	0.64
	156	-	-	-	0.68
I/76		126	135	129	136
	128	0.65	0.59	0.65	0.62
	126	-	0.54	0.60	0.56
	135	-	-	0.54	0.49
	129	-	-	-	0.56

* CD for comparing means of progeny No.109 and 112

Table 4.3.2. Mean, range, standard deviation, standard error of mean and co-efficient of variation for total leaf production within each palm

Family	F_1 progeny No.	Mean	Range	S.D.	Sem.	C.V.
VIII/23	109	5.58	3-8	.20	0.133	22
	112	6.02	4-8	.93	0.114	15
	113	6.03	4-8	.26	0.186	21
	114	6.27	4-8	.56	0.089	9
	115	5.92	3-8	.23	0.157	21
I/58	165	5.50	3-8	.15	0.1999	21
	167	5.72	3-9	1.29	0.182	22
	168	5.43	2-8	1.29	0.228	24
	169	5.85	3-8	1.15	0.156	20
	174	5.13	3-7	0.89	0.159	17
I/109	141	5.34	3-7	1.11	0.171	21
	142	5.82	4-9	1.02	0.143	18
	144	5.59	3-8	1.21	0.138	22
	146	5.80	4-8	0.93	0.158	16
	148	5.75	4-7	1.17	0.412	20
VIII/158	153	4.80	3-9	1.06	0.212	22
	155	5.19	4-7	0.81	0.204	16
	156	5.00	4-6	0.64	0.151	13
	159	5.50	4-8	0.94	0.172	17
	160	5.50	4-7	0.80	0.230	14
I/76	126	5.41	4-9	1.33	0.228	25
	128	6.03	4-8	1.31	0.263	22
	129	5.74	4-8	0.96	0.165	17
	135	6.29	4-9	1.24	0.168	20
	136	4.99	2-8	1.36	0.201	27
VIII/143	41	5.64	2-8	1.29	0.168	23
	49	5.58	3-7	1.15	0.132	21
	50	5.57	3-8	1.08	0.167	19
	52	5.43	3-8	1.28	0.222	23
	99	5.81	3-9	1.39	0.267	24

of the mean values presented in the table. Co-efficient of variation was maximum (27) in the case of progeny number 136 of family I/76 and minimum (9) in the case of progeny number 114 of VIII/23.

Between progenies of same family also difference was noticed in respect of total leaf production. The mean leaf production ranged from 5.58 to 6.43 in family VIII/23, 5.13 to 5.83 in family I/58, 5.19 to 5.86 in family I/109, 4.96 to 5.73 in family VIII/158, 5.09 to 6.29 in family I/76 and 5.42 to 5.81 in family VIII/143. Statistical analysis showed the difference to be significant between progenies of families VIII/23, I/109, VIII/158 and I/76 and not significant in families I/58 and VIII/143.

The influence of month of harvest on total leaf production in seedlings was found to be not significant in the nuts harvested in any of the months.

4.4. Leaf splitting

Early splitting of leaves in the seedling is considered to be an indication of seedlings vigour. The days taken for first splitting of leaf were recorded in respect of the seedlings under study and the mean values are presented in Table 4.4.

Table 4.4. Leaf splitting in one year old F_2 progeny

Family	F_1 progeny No.	Total seedling	Days taken for first splitting (mean)	Rank of leaf splitted first (mean)	Splitting percentage of total progeny
VIII/23	109	79	321.25	5.63	50.63
	112	64	320.45	5.60	60.61
	113	46	314.72	5.92	54.35
	114	42	306.05	5.95	48.78
	115	63	322.26	5.91	37.70
Mean					50.34
I/58	165	33	326.32	5.37	59.38
	167	50	324.53	5.82	34.00
	168	32	337.56	5.78	29.03
	169	54	329.69	5.77	24.07
	174	31	350.00	5.75	25.80
Mean					33.00
I/109	141	42	340.60	6.00	12.20
	142	52	335.06	5.94	35.29
	144	76	330.56	5.72	23.68
	146	35	333.75	6.00	22.86
	148	8	353.00	6.00	50.00
Mean					24.82
VIII/158	153	25	339.78	5.33	36.00
	155	16	324.75	5.75	16.00
	156	18	346.50	5.50	33.33
	159	30	335.63	5.56	53.33
	160	12	365.00	6.00	13.33
Mean					36.64
I/76	126	35	330.50	5.75	11.76
	128	24	351.86	5.27	30.43
	129	34	327.93	5.53	44.12
	135	54	339.57	6.37	55.56
	136	47	347.00		20.00
Mean					33.50
VIII/143	41	59	342.00	6.20	48.83
	49	76	337.40	5.95	26.82
	50	42	342.33	6.50	46.15
	52	33	361.00	6.75	12.12
	99	27	318.40	5.30	37.04
Mean					30.80

The mean number of days taken for first splitting ranged from 306.05 in progeny number 114 of family VIII/23 to 365 days in progeny number 160 of VIII/158. Wide variation was noticed in the number of seedlings with split leaves one year after sowing among the different progenies of families. While 60.61% of the seedlings of tree number 112 of family VIII/23 showed splitting of leaves in one year, the minimum percentage of 11.76 was observed in the progeny number 126 of family I/76.

5. Distribution of seedlings based on vigour

The seedlings were grouped into vigorous, medium and poor based on collar girth, height and total number of leaves one year after sowing. The criteria used for this grouping were: Vigorous-collar girth above 10 cm, height above 100 cm and total number of leaves above 5; Medium - collar girth between 7.5 and 10.00 cm, height between 70 and 100 cm and total number of leaves 4 to 5; Poor - girth below 7.5 cm, height below 70 cm and total number of leaves below 4. The percentage of seedlings coming under different groups in all F_1 progenies along with their mean yield are presented in Table 5 (Plate I).

In respect of the mean values of the progenies of each family, VIII/23 produced the maximum number of vigorous seedlings. The percentage of vigorous, medium and

Table 5. Distribution of seedlings based on vigour

Family	F_1 progeny No.	Mean* yield of nuts	Total seedlings	Vigorous seedlings (%)	Medium seedlings (%)	Poor seedlings (%)
VIII/23	109	88.82	79	45.56	32.92	21.52
	112	94.82	64	57.82	34.37	7.81
	113	72.27	46	54.36	34.78	10.86
	114	72.73	42	69.06	23.80	7.14
	115	98.73	63	55.33	28.57	15.88
Mean				55.10	31.30	13.60
I/58	165	56.82	33	48.48	39.40	12.12
	167	71.09	50	58.00	30.00	12.00
	168	45.91	32	34.38	46.87	18.75
	169	70.18	54	35.18	50.00	14.82
	174	29.82	31	16.12	58.06	25.80
Mean				40.00	44.00	16.00
I/109	141	55.09	42	14.28	38.09	47.63
	142	76.64	52	42.30	46.15	11.55
	144	77.55	76	27.64	46.05	26.31
	146	66.27	35	57.14	42.86	-
	148	29.50	8	25.00	50.00	25.00
Mean				33.33	44.14	22.53
VIII/158	153	38.18	25	12.00	56.00	32.00
	155	71.18	16	31.25	50.00	18.75
	156	53.73	18	22.22	66.66	11.12
	159	72.81	30	53.34	36.66	10.00
	160	31.91	12	25.00	50.00	25.00
Mean				30.70	50.49	18.81
I/76	126	44.73	35	28.57	28.57	42.86
	128	62.36	24	20.84	54.16	25.00
	129	65.45	34	32.36	55.88	11.76
	135	83.55	54	55.56	29.62	14.82
	136	99.36	47	12.76	44.68	42.56
Mean				31.95	40.73	27.32
VIII/143	41	82.91	59	44.09	35.62	20.29
	49	87.36	76	35.52	44.73	19.75
	50	98.73	42	38.09	40.47	21.53
	52	36.27	33	21.22	39.39	39.39
	99	47.55	27	51.85	37.04	11.11
Mean				37.98	40.08	21.94

* Average over ten years

Table 6.1. Petiole colour of grand parents and F_1 progenies

Family	Female parent	Male parent	F_1 progeny No.	F_1 progenies
VIII/23	Green	Green	109	Light green
			112	Light green
			113	Light green
			114	Light green
			115	Light green
I/58	Light green	Green	165	Light green
			167	Light green
			168	Light green
			169	Light green
			174	Light green
I/109	Green	Green	141	Light green
			142	Dark green
			144	Light green
			146	Light green
			148	Light green
VIII/158	Light green	Green	153	Light green
			155	Light green
			156	Light green
			159	Light green
			160	Light green
I/76	Yellowish green	Green	126	Light green
			128	Light green
			129	Light green
			135	Light green
			136	Light green
VIII/143	Light green	Green	41	Light green
			49	Light bronze
			50	Light green
			52	Light green
			99	Light green

PLATE I. Distribution of seedlings based on vigour

1. Vigorous

2. Medium

3. Poor

poor seedlings in this family were 55.10, 31.30 and 13.60 respectively. The minimum of 30.70 percentage of vigorous seedlings were produced by VIII/158. Between the progenies, the percentage of vigorous seedlings varied from 45.56 to 69.06 in VIII/23, 16.12 to 58.00 in I/58, 14.28 to 57.14 in I/109, 12.00 to 53.34 in VIII/158, 12.76 to 55.56 in I/76 and 21.22 to 51.85 in VIII/143. Out of five progenies in each family the number which produced more than 50 per cent vigorous seedlings was four in VIII/23 and one each in I/58, I/109, VIII/58, I/76 and VIII/143. It was of interest to note that the progenies which gave high yield have also produced maximum percentage of vigorous seedlings where as poor yielders have produced only low percentage of vigorous seedlings.

6. Distribution of seedlings based on colour of petiole

The petiole colour variations in the grand parents and their progenies (F_1) are furnished in Table 6.1 and the number of seedlings (F_2) in each progeny falling under different colour groups are furnished in Table 6.2 and Plate II and III. Green is the predominant colour of the grand parents both female and male. In the F_1 progenies also the pre-dominant colour is green. But in the (F_2) progenies there was a clear segregation of petiole colour into green and bronze in a majority of the progenies.

Table 6.2. Distribution of seedlings based on the colour of petiole

Family	F_1 progeny No.	Total seedling	Green	Bronze	Yellow	Orange
VIII/23	109	79	52	27	-	-
	112	64	24	40	-	-
	113	46	18	28	-	-
	114	42	15	27	-	-
	115	63	18	44	-	-
I/58	165	33	26	7	-	-
	167	50	35	15	-	-
	168	32	24	8	-	-
	169	54	43	11	-	-
	174	31	21	10	-	-
I/109	141	42	34	8	-	-
	142	52	44	8	-	-
	144	76	63	13	-	-
	146	35	26	9	-	-
	148	8	7	1	-	-
VIII/158	153	25	15	10	-	-
	155	16	12	4	-	-
	156	18	15	13	-	-
	159	30	24	6	-	-
	160	12	5	3	2	3
I/76	126	35	35	-	-	-
	128	24	23	1	-	-
	129	34	21	13	-	-
	135	54	45	9	-	-
	136	47	36	11	-	-
VIII/143	41	59	-	45	9	5
	49	76	20	48	4	4
	50	42	7	23	7	5
	52	33	-	27	4	2
	99	27	13	14	-	-

PLATE II. F_2 progeny segregation for petiole colour

1. Green
2. Orange
3. Bronze
4. Yellow

PLATE III. Leaves showing various petiole colours

1. Green

2. Bronze

3. Yellow

4. Orange

In the F_2 progenies of VIII/143 some of the seedlings with yellow and orange petioler colour was also noticed. The green dwarfs were reported to be stable for green colour and therefore the colour variations noticed in the present study might be due to the heterozygous nature of the tall female parent used in the mating.

7. Chlorophyll content of seedlings

Chlorophyll 'a', 'b', 'a/b' and 'a+b' contents of the leaves of the F_2 progenies of the March harvested nuts were estimated and the mean values are presented in Table 7. The total chlorophyll content was highest in the progenies of grand parent VIII/23 (mean 2.87). Variations in chlorophyll content was noticed both between families and within families. Variations from 2.30 to 3.66 in the progenies of grand parent VIII/23, 2.50 to 3.46 in I/58, 1.91 to 3.29 in I/109, 1.56 to 3.08 in VIII/158, 2.38 to 3.02 in I/76 and 2.45 to 2.80 in VIII/143 were also noticed.

8. Correlation studies

Simple linear correlation co-efficients were worked out between nut characters and seedling characters and the value is presented in Tables 8.1 and 8.2. The nut characters (polar circumference, equitorial circumference, weight and

Table 7. Mean chlorophyll a, b, a/b ratio and a+b content in F_2 progeny (mg/g)

Family	F_1 progeny No.	Chlorophyll content			
		a	b	a/b	a+b
VIII/23	109	1.15	1.15	1.00	2.30
	112	1.34	1.27	1.05	2.61
	113	1.38	1.31	1.05	2.69
	114	1.60	1.52	1.05	3.12
	115	1.37	1.29	1.06	3.66
Mean		1.36	1.30	1.04	2.87
I/58	165	1.30	1.20	1.08	2.50
	167	1.47	1.36	1.08	2.83
	168	1.62	1.84	0.88	3.46
	169	1.49	1.30	1.14	2.79
	174	1.39	1.25	1.11	2.64
Mean		1.45	1.39	1.05	2.84
I/109	141	1.51	1.33	1.13	2.84
	142	1.62	1.67	0.97	3.29
	144	1.28	1.35	0.94	2.63
	146	1.28	1.37	0.93	2.65
	148	0.996	0.909	1.09	1.91
Mean		1.33	1.32	1.01	2.66
VIII/158	153	1.11	1.02	1.08	2.13
	155	1.20	1.15	1.04	2.35
	156	1.33	1.23	1.08	2.56
	159	1.58	1.50	1.05	3.08
	160	0.768	0.788	0.97	1.56
Mean		1.19	1.13	1.04	2.33
I/76	126	1.32	1.27	1.03	2.59
	128	1.49	1.52	0.98	3.01
	129	1.29	1.34	0.96	2.63
	135	1.46	1.40	1.04	2.86
	136	1.17	1.21	0.96	2.38
Mean		1.34	1.34	0.99	2.69
VIII/143	41	1.27	1.32	0.96	2.59
	49	1.21	1.44	0.84	2.65
	50	1.43	1.37	1.04	2.80
	52	1.42	1.31	1.08	2.73
	99	1.23	1.22	1.00	2.45
Mean		1.31	1.33	0.98	2.64

Table 8.1. Simple linear correlation co-efficients between nut characters and seedling characters

Nut characters	Seedling characters		
	Girth	Height	Total leaf production
Polar circumference	0.393*	0.100	-0.116
Equitorial circumference	0.472**	0.302	0.044
Weight	0.436*	0.210	-0.081
Volume	0.533**	0.297	0.046
Days taken for germination	-0.429*	-0.276	-0.261

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

Table 8.2. Simple linear correlation co-efficient matrix of seedling characters

Seedling character	Height	Total leaf production
Girth at collar	0.844**	0.676**
Total leaf production	0.732**	-

** Significant at 1% level

volume) showed significant correlation with girth of the seedlings while no such correlation was noticed with the height and total number of leaves produced. However girth of seedlings had significant correlation with height and total number of leaves produced. The number of days taken for germination had a significant negative correlation with the girth of the seedlings, whereas correlation with height and total leaf production though negative was not found to be significant.

Discussion

D I S C U S S I O N

The selection of parents from a population for further propagation from an outbreeding material like coconut is dependent on the performance of parent and its progency in controlled matings. The extent of genetic variation in the seedlings obtained from open pollinated seednuts of hybrid palms also need to be studied in the context of large scale planting of hybrid palms and the possibility of utilising these palms for seednut collections. Such an analysis would also permit the identification of high yielding genotypes with superior transmission of their traits to their progeny and the pattern og genetic variation which will enable a breeder to know the magnitude of genetic variation available for selection and the breeding procedure to be adopted. In a crop like coconut with large generation interval the relationship of seedling characters with adult plant performance, will help elimination of inferior genotypes at an early stage. The West Coast Tall variety grown extensively in Kerala and other coconut growing areas of India is locally adapted and is highly heterozygous and show considerable genetic variation for yield in the same location. In the present study an attempt has been made to analyse the genetic variations of yield of nuts and other characters associated with productivity in certain T x D hybrids and other mother palms. The 6 grand parents were West Coast Tall palms grown at the Central Plantation Crops Research Institute, Kasaragode. They were used as female parents in controlled matings with dwarf green palms and the resultant tall x dwarf palms (F_1) were grown at the Coconut Research Station, Nileshwar. Open pollinated seednuts were collected from 5 palms each of the 6 parental combinations for study of the seedling characters.

1. Performance of Tall x Dwarf (F_1) palms

The grand parent palm VIII/23 recorded the maximum mean yield of 119.40 nuts/annum followed by I/58 with 111.20 nuts, VIII/143 with 110.70 nuts, I/76 with 109.30 nuts, I/109 with 94.50 nuts and VIII/158 with 74.30 nuts. An analysis of the yield data of their progenies (F_1 palms) revealed that the mean yield of all the progenies of VIII/23 was highest with 85.47 nuts followed by I/76 (71.09 nuts), VIII/143 (70.56 nuts), I/109 (61.20 nuts), I/58 (54.76 nuts) and VIII/158 (53.56 nuts). The better yield performance of the parent palms compared to the hybrid progenies is attributable to the more favourable environment of the former. The performance of coconut palms at the Central Plantation Crops Research Institute in general was better than at the

Coconut Research Station, Nileshwar. A comparison of the yield of parent and progenies would reveal the stability of superiority of high yielding palms even in a poor environment. While selection in superior environment will be desirable, selection of high yielding palms even in an unfavourable environment is still practicable. Several workers have reported that selection of high yielding parents in controlled pollination ensures high yielding progenies (Rockwood, 1953; Liyanage, 1958; Menon and Pandalai, 1960; Liyanage and Sakai, 1960; Nambiar and Nambiar, 1970; Kannan and Nambiar, 1979). However, Harlan (1957) was of the opinion that all high yielders need not necessarily transmit their high yielding capacity to their progenies. Differences among progenies of the same grand parent was noticed in respect of setting percentage, nut yield and copra content per nut. In the progenies of VIII/23 which ranked first in yield, three progenies gave an yield of above 80 nuts and two progenies between 61 to 80 nuts while in the progenies of VIII/158 which ranked last in yield two progenies gave less than 40 nuts one between 41 and 60 nuts and two between 61 and 80 nuts. So also the grand parent tree VIII/143 which gave a mean yield of 110.70 nuts produced, two progenies yielding 47.55 and 36.27 nuts while the remaining three progenies gave as high a yield as 87.36, 82.91 and 98.73 nuts. Copra content also varied considerably among progenies of the same grand parent tree. It ranged from 128.33 to 156.67 gm in the progenies of VIII/23, 86.67 to 203.33 gm in I/58, 85.00 to 138.33 gm in I/109, 91.67 to 185.00 gm in VIII/158, 65.00 to 120.00 gm in I/76 and 78.33 to 118.33 gm in VIII/143. Setting percentage was another character in which variation was noticed among the progenies. The differential performance of the progenies of the same parent as observed in the present study had also been reported by Bavappa et al. (1977). Genetic variation in F_1 families of West Coast Tall x dwarf green palms for 13 vegetative characters and yield components were studied by them and they suggested that by proper choice among tall and dwarf parents efficient exploitation of hybrid vigour could be effected. Since the West Coast Tall variety is highly heterozygous showing considerable genetic variability, the variations between the progenies of the same mother palm with respect to shape, size and colour of nuts, quantity of copra per nut, number of nuts per palm and vegetative characters, can naturally be expected.

2. Weight and size of nuts of F_1 progenies

As in the case of nut yield the F_1 progenies differed significantly in respect of nut characters. The progenies of VIII/158 which gave the least mean yield per tree produced heavy nuts where as VIII/23 which yielded maximum number of nuts produced small size nuts. There was a negative relationship between yield and size of nuts. This variability was also noticed among the progenies of same grand parents. It Is attributable to substantial additive variability present in the parent palms.

3. Number of days taken for germination

Progenies of the same grand parent varied among themselves in respect of the number of days taken for sprouting of their nuts. In two out of six families, nuts of progenies which gave the maximum yield germinated early. The progeny tree number 115 of the family VIII/23 which recorded the maximum yield of 98.73 nuts germinated in 103.43 days which is the minimum for the family group. In the family VIII/158 the progeny tree number 159 which yielded maximum (72.81 nuts) took the minimum number of days (89.79) for germination. The progeny tree number 50 of family VIII/143 which recorded the maximum yield of 98.73 nuts and the progeny tree number 167 of family I/58 with a maximum yield of 71.09 nuts were second best in respect of the least number of days taken for germination.

In respect of the other two families also the highest yielding palms took comparatively lesser number of days for germination. Number of days taken for germination of seednuts had been reported to have a prefound influence on the subsequent growth and performance of the palms and give an indication of the potential earliness of the seedlings. Seednuts which sprouted early gave rise to palms which flowered in a shorter period and were more productive than those sprouted later (Jack and Sands, 1929; Liyanage, 1955; Charles, 1959). In the present study the progenies of the same grand parent have shown considerable difference in respect of number of days taken for sprouting. This is an indication of the variability existing in the F_1 progenies of the same grand parent in their capacity for production of early bearing and high yielding F_2 palms.

4. Seedling characters

The three easily measurable characters of seedlings ie. girth at collar, height and total number of leaves produced help in assessing the vigour of seedlings. The difference in respect of all the three characters was significant between families and also among the progenies of same family. Taking the family mean as a whole the progenies of VIII/23 which recorded the highest nut yield, produced seedlings having the maximum girth, height and number of leaves. The next best was I/58 which ranked second in yield. The progenies within the same family also showed variations among themselves in respect of the above three characters. The difference of girth at collar was significant at 1 per cent level among the progenies of the grand parents VIII/23, I/109, VIII/158 and I/76 and not significant in I/58 and VIII/143. In respect of height of seedlings thedifference was significant among the progenies of all families except VIII/143 and in the case of total number of leaves produced the difference was significant among the progenies of all families except I/58 and VIII/143. Seedlings obtained from the same F_1 progeny also showed variations in respect of girth at collar, height and number of leaves produced. The co-efficient of variation among the seedlings of different progenies ranged from 17 to 22 in the progenies of grand paren. VIII/23, 15 to 20 in the progenies of I/58, 12 to 24 in the progenies of I/109, 15 to 23 in the progenies of VIII/158, 16 to 25 in the progenies of I/76 and 10 to 22 in the progenies of VIII/143. The same was more or less the case in respect of height and total number of leaves produced. The co-efficient of variation among the seedlings of some progenies were low while in some others it was high showing thereby that all the seedlings produced by the same F_1 plant were not uniform in respect of their vigour. Some of the palms were capable of producing more number of vigorous seedlings than the others. In Table 5 the distribution of seedlings based on vigour has been furnished. Taking the family as a whole the maximum percentage of 55.10 vigorous seedlings was produced by the progenies of VIII/23 followed by I/58 with 40.00 per cent, VIII/143 with 37.98 per cent, I/109 with 33.33 per cent, I/76 with 31.95 per cent and VIII/158 with 30.70 per cent. This confirms the assumption that high yielding palms are capable of giving more number of vigorous seedlings which is an indication of the early and high yielding character of the palm.

An analysis of the vigour of the seedlings produced by each hybrid progeny also showed variations in respect of the percentage production of vigorous, medium and poor seedlings. According to the criteria fixed for seedling selection the vigorous and medium seedlings can be used for planting and the poor seedlings will have to be rejected from the nursery. Out of five palms the number of palms which produced more than 20 per cent poor seedlings was one each of VIII/23 and I/58, two of VIII/158 and three each of I/76, VIII/143 and I/109. It was also noticed that production of vigorous seedlings was not dependent on the yield of the T x D progenies. In the case of VIII/23 the two comparatively poor yielding palms ie. progeny numbers 113 and 114 produced less number of poor seedlings. The reverse was also true. The progeny number 136 of family I/76 which gave the maximum yield had produced the maximum percentage of poor seedlings.

A number of workers have reported that the vigour of seedlings in the nursery based on girth at collar, height and number of leaves produced was related to early bearing and high yield subsequently (Patel, 1958; Nambiar and Nair, 1963; Satyabalan <u>et al</u>. 1964 and Namboothiri <u>et al</u>. 1975). However, Ninan and Pankajakshan (1961) did not find the existence of any relationship between the yield of the parent and the progeny characters like girth and number of leaves.

From these results it could be reasonably assumed that while the high yielding palms could transmit their high yielding traits in controlled matings to their progenies, the hybrid progenies under open pollination need not necessarily transmit the same traits to their off springs. If the seedling characters could be taken as a criteria for their future performance, the capacity of the hybrid palms for production of high yielding progenies under open pollination would likely to be independent of the yield of the hybrid palms.

Nambiar (1971) from a study of F_2 progenies of open pollinated tall x dwarf found that over 90 per cent of the progenies didnot exhibit precocity as in the case of tall x dwarf hybrids. Wide range of variation was noticed in respect of height of palm, weight of nut and copra content in the progenies of the same parent. This according to him, indicate the unsuitability of open pollinated tall x dwarf seednut for propagation. Kannan (1976) also reported about the differential behaviour of the F_2 progenies of the same parent. Joseph (1959) on the other hand from a study of the F_1 and F_2 progenies of tall x dwarf reported that F_2 was significantly superior to F_1 despite the fact that there were a few seemingly dwarfish segregants in the F_2. However, he had suggested rigorous selection of F_2 progenies for obtaining quality planting material.

5. Prepotency of grand parents and F_1 progenies

In the context of the unreliability of the possible transmission of high yielding trait by the hybrid palms to their open pollinated progenies it would be worthwhile to examine as to how far the criteria of prepotency could be applicable in the present study. The term prepotency was used by Harland (1957) to describe palms that were able to transmit the high yielding character to their progenies inspite of having been indiscriminately pollinated by miscellaneous parents. Progeny test could be used as a method for identification of prepotent palms. It might take 20 or more years to get reliable progeny data if the yield characters have to be studied. But in view of the findings (Patel, 1937) that seedling characters like girth and number of leaves are positively and significantly correlated with the adult palm's performance, a study of the seedling characters might give indications of the existence of prepotency in the parent palms. In the present study yield data of five F_1 progenies each of six high yielding grand parents were studied. Considering the fact that the F_1 progenies were grown in a comparatively poor environment a mean yield of 60 nuts and above per annum can be considered as fairly high yield. On this basis all five progenies of the grand parent VIII/23, two out of five progenies of I/58, three progenies of I/109, two progenies of VIII/158, two progenies of I/76 and three progenies of VIII/143 are high yielders. Even though the number of population under study is comparatively small it can reasonably be indicated that the grand parent VIII/23 is prepotent.

With respect to the F_2 progenies the total number of seedlings studied is fairly large enough to draw valid conclusions. Vigour of seedlings expressed in terms of girth at collar, total leaf production and height have been taken as indications of the future performance of the palms. The percentage of seedlings falling in the vigorous, medium and poor groups are furnished in Table 5. Kannan and Nambiar (1979) after a study of the adult palm performance of vigorous, intermediate and poor seedlings have reported no significant difference in nut or copra yield between vigorous and intermediate seedlings. They also found those seedlings superior to poor seedlings in the early growth and yield. Therefore, the vigorous and medium seedlings can reasonably be considered high yielders. In the absence of precise experimental data, palms giving more than 80 per cent of vigorous and medium seedlings can be taken as prepotents. On the basis of this assumption four progenies of grand parent VIII/23 (tree numbers 112, 113, 114 and 115) four of I/58 (Tree numbers 165, 167, 168, 169) two of I/109 (Tree numbers 142, 146) three of VIII/158 (Tree numbers 155, 156, 159) two of I/76 (Tree numbers 129, 135) and two of VIII/143 (Tree numbers 49 and 99) can be assumed as prepotents.

It will be of interest to correlate the yield of these palms with the percentage recovery of seedlings obtained from them which are likely to give high yields. In the progenies of grand parent VIII/23 the tree number 109 which ranked third in yield with a mean nut yield of 88.82 nuts was not found to be prepotent where as tree numbers 113 and 114 with an annual yield of 72.27 and 72.73 nuts respectively were prepotents. In I/58 except the lowest yielding tree number 174 which gave an yield of only 29.82 nuts, all others including tree numbers 165 and 168 with an annual yield of 56.82 and 45.91 nuts were prepotents. In I/109 the highest yielding tree number 144 with an annual yield of 77.55 nuts was not prepotent. In VIII/158 the tree numbers 155, 156 and 159 with an annual yield of 71.18, 53.73 and 72.81 nuts were prepotents where as the other two trees which gave lowest yields of 38.18 and 31.91 nuts were not prepotents. In I/76 the tree number 136 which gave a maximum mean yield of 99.36 nuts failed to give sufficiently large number of high yielding seedlings and hence is not a prepotent palm. In the case of VIII/143 also the tree number 58 which gave maximum mean yield of 98.73 nuts was found to be not prepotent whereas the tree number 99 with a mean yield of 47.55 nuts was a prepotent palm.

This confirms the earlier finding that in respect of the T x D hybrids the high yielding palms need not necessarily give high yielding progenies under open pollinated condition.

6. Petiole colour

The petiole colour variations of the progenies give an indication of the pattern of segregation of palms in different generations. In the grand parents the petiole colour was predominantly green. The pollen parent was green dwarf which had dark green petiole. Except for one progeny of VIII/143 all other hybrid progenies were light green in colour. This progeny tree number 49 of VIII/143 turned out to be light bronze. In the F_2 seedlings there was clear segregation for colour into green, bronze, yellow and orange. The green dwarfs are reported to be stable for green colour and therefore the colour variations noticed in the present study might be due to the heterozygous nature of the tall female parent used in the mating. The relationship between the colour characteristics of the palms and yield attributes have not been studied. It is worthwhile to study this aspect to know whether based on the seedlings colour, also, the future performance of the palms could be predicted.

7. Influence of month of harvest on the seednut and seedling characters

Seednuts for the present study were obtained over a period of 5 months from January to May. The influence of month of harvest on the seednut and seedling characters was also studied. The maximum number of nuts were harvested during the month of March and April from all palms. These two months accounted for 57.23 per cent of the total nuts obtained during the five month period from the progenies of VIII/23, 63.13 per cent from the progenies of I/58, 64.70 per cent from the progenies of I/109, 62.30 per cent from the progenies of I/158, 56.14 per cent from the progenies of I/76 and 65.95 per cent from the progenies of VIII/143. This is in conformity with the findings of Patel (1938).

The pattern of variation in nut characters was not found to be uniform. The variation in nut characters during the different months may be due to environmental factors rather than genetic factors.

The number of days taken for sprouting and the percentage of sprouting were not found to be influenced by the month of harvest substantially during the 5 month period, under study. However, it was noticed that the seednuts took less number of days for germination in most of the families as the harvest progressed from the month of January to May. George (1964) had reported that the seednuts collected during February, March and April recorded the highest percentage of germination. Time taken for germination was also less during the same period.

8. Chlorophyll content of seedlings

Variations were noticed in chlorophyll 'a', 'b' and total chlorophyll of the leaves of the seedlings (F_2) of the different hybrid progenies. Distinct differentiation between the cultivars and the hybrids in chlorophyll content had been reported by Mathew and Ramdasan (1974). They found high yielding types having higher quantities of chlorophyll content on area basis than in low yielding types. It is of interest to examine the quantity of chlorophyll content in the leaves of seedlings of prepotent palms selected earlier on the basis of seedling vigour. The seedlings of four F_1 palms of grand parent VIII/23 identified as prepotents have higher quantity of total chlorophyll content compared to the one which is not prepotent. In the progenies of grand parent VIII/158 the three palms identified as prepotents have highest quantities of total chlorophyll content compared to the other two palms. With slight variations this holds good in the case of other palms also. It can therefore be stated with a fair amount of precision, that seedlings which are potential high yielders can be identified from the nursery itself on the basis of the quantity of chlorophyll content in their leaves.

9. Correlation studies

Vigour of the seedling is assessed by the girth at collar, height and total number of leaves produced by the seedling. The present study showed that early germinated nuts produced seedlings having more collar girth. Girth of the seedlings is highly correlated with height and total leaf production. Therefore, early germination may be an indication of seedling vigour. Patel (1938) obtained similar results. He observed after a detailed study that early germinated nuts produced seedlings having a faster rate of leaf production while nuts germinated later produced seedlings having a slow rate of leaf production. Liyanage (1955) reported that seednuts sprouted earlier gave rise to palms that flower in a shorter period and more productive than those sprouted later.

Summary

SUMMARY

Thirty T x D (F_1) palms obtained from six West Coast Tall palms by controlled matings with green dwarf palms and the seedlings obtained from their open pollinated seednuts (F_2) were the materials for the present study. The West Coast Tall palms stand at the Central Plantation Crops Research Institute, Kasaragode and the T x D palms are at the Coconut Research Station, Nileshwar. The seedlings were raised at the Instructional Farm, College of Horticulture, Kerala Agricultural University, Vellanikkara. The studies were conducted during the year 1979-80.

2. The main objective of the study was to assess the extent of variability in the seedling progenies obtained from open pollinated seednuts (F_2) of T x D palms. It was also intended to study the performance of T x D progenies (F_1) derived from six West Coast Tall parents. The effectiveness of selection of high yielding mother palms for obtaining high yielding progenies in the West Coast Tall and T x D palms was investigated based on yield performance and seedling characters. The effect of season of harvest on the nut yield, nut size and seedling characters was ascertained. The feasibility of utilising the chlorophyll content of leaf as an index of seedling vigour was another aspect of study.

3. The utility of selection of high yielding West Coast Tall palms in controlled matings for production of T x D hybrids has been brought out from the present studies. A comparison of the nut yield of the parents and their T x D progenies showed the stability of superiority of high yielding palms. Even under poor environment this stability of superiority of the high yielding character has been maintained.

4. The behaviour of seedlings obtained from the open pollinated seedlings of T x D hybrids is found to be different. The adult performance of the progenies could not be studied as it requires a number of years for the seedlings to come to bearing. Therefore, conclusions have been arrived at from the study of seedling characters. Several workers have reported that the vigour of seedling such as girth at collar, total leaf production and height as indicative of the future performance of the adult palm. The percentage of vigorous, medium and poor seedlings produced by each (F_1) progeny was found to be independent of the productivity of the palm. Low yielding progenies like tree numbers 113 and 114 of grand parent VIII/23 have produced larger percentage of vigorous and medium seedlings while high yielding progenies like tree number 136 of grand parent I/76 have produced maximum number of poor seedlings. Therefore,

collection of seednuts from high yielding T x D progenies for further propagation should be resorted to with great caution.

5. Number of days taken for sprouting of nuts is an indication of early bearing and high yield. In the present study progenies of the same parent have shown considerable difference in respect of the number of days taken for germination. This is an indication of the variability existing in the T x D palms in their capacity for production of early bearing and high yielding F_2 progenies.

6. Colour segregation was noticed in the petioles of (F_2) seedlings. The petiolar colour of the grand parents and the (F_1) progenies were green while in the F_2 progenies green, bronze, orange and yellow petiole colours were noticed. Though the colour of petiole has not been related with the future performance of the palm, it is a clear indication of the variability existing in the progenies.

7. An attempt has been made in the present study to identify prepotent palms in T x D. Four progenies each of grand parents VIII/23 and I/58, two progenies each of VIII/158, VIII/143 and I/109 have been identified as prepotents on the basis of seedling performance. This finding will help in

the propagation of high yielding palms by collecting seed-nuts from these prepotent palms for raising seedlings.

8. Seasonal variations were noticed on yield, size and weight of nuts.

9. The influence of month of harvest on the number of days for sprouting was not found to be significant for the five month period of study. However there was a gradual reduction in the number of days taken for sprouting as the harvest progressed from January to May.

10. The total chlorophyll content in the leaves of vigorous seedlings which are potential high yielders are found to be high. This would help in the identification of high yielding palms from the nursery itself.

11. Early germinated nuts produced seedlings having more collar girth and as such greater vigour.

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Appendices

APPENDIX I

Weather data for the period from February 1979 to June 1980

Month	Temperature (°C)		Relative humidity (%)		Total rain-fall (mm)	Number of rainy days per month
	Maximum	Minimum	Maximum	Minimum		
1979						
January	34.1	18.6	96	38	Nil	Nil
February	34.8	21.6	96	37	22.0	4
March	36.7	22.3	96	38	3.2	1
April	40.1	21.3	95	33	46.5	4
May	35.7	21.8	97	52	155.1	10
June	35.1	22.0	97	53	722.7	22
July	31.1	21.0	98	68	729.8	28
August	31.4	21.6	97	65	426.6	19
September	32.8	22.6	98	67	208.7	18
October	33.4	22.0	95	45	127.3	16
November	32.9	22.2	96	61	317.4	18
December	32.2	19.4	95	45	Nil	Nil
1980						
January	33.5	18.3	93	30	Nil	Nil
February	37.5	18.3	95	26	0.4	1
March	39.4	21.1	94	28	1.8	1
April	38.1	21.6	97	36	135.3	7
May	35.6	22.7	94	50	126.8	11
June	32.5	21.3	97	66	596.2	24

The observations were collected from the B-class observatory at Mannuthy.

APPENDIX II

Analysis of variance for weight of unhusked nuts per palm from January to May 1979

Month of harvest	Total	Treatment		Error	
	DF	MS	DF	MS	DF
January	22	84983.67*	5	24844.14	17
February	27	136854.95**	5	23748.68	22
March	29	108444.08**	5	17668.31	24
April	28	43396.12	5	1949.06	23
May	22	99535.15*	5	32002.89	17
Total nuts	29	83360.00**	5	15962.50	24

* Significant at 5% level

** Significant at 1% level

APPENDIX III

Analysis of variance for volume of unhusked nuts per palm from January to May 1979

Month of harvest	Total	Treatment		Error	
	DF	MS	DF	MS	DF
January	22	1503608.41*	5	514535.51	17
February	27	2210522.04**	5	266225.17	22
March	29	1260966.49*	5	260391.74	24
April	28	667383.70*	5	193355.68	23
May	22	1018119.81*	5	293394.73	17
Total nuts	29	1002000.00**	5	205000.00	24

* Significant at 5% level

** Significant at 1% level

APPENDIX IV

Analysis of variance for polar circumference of unhusked nuts per palm from January to May 1979

Month of harvest	Total	Treatment		Error	
	DF	MS	DF	MS	DF
January	22	61.64	5	31.67	17
February	27	90.86**	5	11.14	22
March	29	78.13**	5	10.60	24
April	28	49.93**	5	11.55	23
May	22	48.05*	5	15.70	17
Total nuts	24	69.33**	5	10.70	24

* Significant at 5% level

** Significant at 1% level

APPENDIX V

Analysis of variance for equitorial circumference of unhusked nuts per palm from January to May 1979

Month of harvest	Total	Treatment		Error	
	DF	MS	DF	MS	DF
January	22	90.76**	5	18.24	17
February	27	107.16**	5	17.97	22
March	29	79.80**	5	17.42	24
April	28	40.90**	5	15.87	23
May	22	48.04*	5	15.67	17
Total nuts	29	69.49**	5	10.62	24

* Significant at 5% level

** Significant at 1% level

APPENDIX VI

Analysis of variance for number of days taken for sprouting of nuts harvested from January to May 1979

Month of harvest	Total	Treatment		Error	
	DF	MS	DF	MS	DF
January	22	840.09	5	718.57	17
February	27	157.59	5	77.87	22
March	29	117.06	5	87.11	24
April	28	257.07**	5	25.75	23
May	22	109.98	5	109.09	17
Total nuts	29	194.53	5	84.78	24

** Significant at 1% level

APPENDIX VII

Analysis of variance for collar girth of F_2 progeny one year after sowing

Month of harvest	Total	Treatment		Error	
	DF	MS	DF	MS	DF
January	22	2.61	5	3.43	17
February	27	2.95*	5	0.82	22
March	29	1.65*	5	0.55	24
April	28	0.49	5	0.52	23
May	22	2.21	5	2.67	17
Total seedling	29	@2.71**	5	@0.50	23

* Significant at 5% level

** Significant at 1% level

@ Adjusted

APPENDIX VIII

Analysis of variance for collar girth of F_2 progeny within the families

Family	Total	Treatment		Error	
	DF	MS	DF	MS	DF
VIII/23	293	17.56**	4	3.45	289
I/58	199	2.91	4	2.76	195
I/109	212	24.61**	4	3.04	208
VIII/158	100	19.46**	4	2.58	96
I/76	193	33.20**	4	3.96	189
VIII/143	236	10.68*	4	3.36	232

* Significant at 5% level

** Significant at 1% level

APPENDIX IX

Analysis of variance for height of F_2 progeny one year after sowing

Month of harvest	Total	Treatment		Error	
	DF	MS	DF	MS	DF
January	22	1027.47*	5	331.15	17
February	27	655.82**	5	93.19	22
March	29	839.81**	5	113.24	24
April	28	193.28	5	116.94	23
May	22	601.17	5	356.30	17
Total seedling	29	@656.70**	5	102.85	23

* Significant at 5% level

** Significant at 1% level

@ Adjusted

APPENDIX X

Analysis of variance for height of F_2 progeny within the families

Family	Total	Treatment		Error	
	DF	MS	DF	MS	DF
VIII/23	293	5119.72**	4	563.21	289
I/58	199	2517.38**	4	384.02	195
I/109	212	5401.11**	4	384.45	208
VIII/158	100	1342.89**	4	308.30	96
I/76	193	12241.17*	4	4099.98	189
VIII/143	236	1194.31	4	644.59	232

* Significant at 5% level

** Significant at 1% level

APPENDIX XI

Analysis of variance for number of leaves produced by one year old F_2 progeny

Month of harvest	Total	Treatment		Error	
	DF	MS	DF	MS	DF
January	22	2.00	5	1.81	17
February	27	0.77	5	0.39	22
March	29	0.18	5	0.21	24
April	23	1.88	5	0.18	23
May	22	0.90	5	0.77	17
Total seedling	29	@0.64**	5	@0.10	23

** Significant at 1% level

@ Adjusted

APPENDIX XII

Analysis of variance for number of leaves produced by F_2 progeny within the families

Family	Total	Treatment		Error	
	DF	MS	DF	MS	DF
VIII/23	293	5.65**	4	1.28	289
I/58	199	3.11	4	1.36	195
I/109	212	3.07*	4	1.21	208
VIII/158	100	2.68*	4	0.86	96
I/76	193	9.83**	4	1.57	189
VIII/143	236	0.60	4	1.49	232

* Significant at 5% level

** Significant at 1% level

VARIABILITY STUDIES IN THE SEEDLING PROGENIES OF T_xD COCONUT (*Cocos nucifera* Linn.) HYBRIDS

BY

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ABSTRACT OF A THESIS
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1981

A B S T R A C T

A study was conducted at the Instructional Farm, Vellanikkara, during 1979-80 with the objective of assessing the extent of variability in the seedling progenies obtained from open pollinated seednuts of Tall x Dwarf (F_1) palms. Seednuts were collected from 30 Tall x Dwarf F_1 palms belonging to six family groups and the experiment was laid out in completely randomised design with family groups as treatment and progeny as replication.

The present investigation emphasised the utility of selection of high yielding West Coast Tall palms in controlled mating for the production of Tall x Dwarf hybrids and showed the stability of superiority of Tall x Dwarf hybrids even under poor environmental conditions.

The percentage of vigorous, medium and poor seedlings produced by each (F_1) progeny was found to be independent of the productivity of the palm under open pollinated condition. Therefore, collection of seednuts from high yielding T x D progenies for further propagation should be resorted with great caution. Progenies of the same parent have shown considerable difference in respect of the number of days taken for germination giving an indication of the

variability existing in the T x D palms, in their capacity for production of early bearing and high yielding F_2 progeny. The petiolar colour of the grand parents and F_1 progenies were green, while the F_2 progenies showed segregation with green, bronze, orange and yellow colour.

Four progenies each of grand parents VIII/23 and I/58, and two progenies each of VIII/158, I/76, VIII/143 and I/109 have been identified as prepotents on the basis of seedling performance.

Seasonal variations were noticed on yield, size and weight of nuts. The total chlorophyll content in the leaves of the vigorous seedlings which were potential high yielders were found to be high. Early germinated nut produced seedlings having more collar girth and as su greater vigour.