



Circulation Paper No.7/57.

COCONUT RESEARCH INSTITUTE COCONUT RESEARCH BOARD.

The improvement of the Coconut palm
breeding and selection.

by

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INTRODUCTION

Although the coconut industry of Ceylon is of considerable size, comprising the cultivation of several million palms, the yield per acre of nuts and consequently of copra is not generally satisfactory. Where soil and management are both good, yields of 5,000 nuts per acre and above are not uncommon, but the average yield is far below this. There are two main aspects of the yield problem which may be considered under the general heads of agriculture and breeding. It is the special object of this memorandum to consider breeding and selection techniques in some detail, with special reference to the work of this Institute. The agricultural side, which concerns the actual growing of the crop, and involves all the manifold factors of cultivation and management will be considered elsewhere. Briefly it embraces the questions: how should a given soil be handled to give the best economic return to the grower? What consideration should be given to the various systems in vogue of planting, care of palms, use of fertilizers and organic manures, cover crops, ploughing, cultivation, etc.?

Even with all agronomical techniques at a reasonably satisfactory level, it is known that the greater part of the yield comes from a relatively small number of palms. Many palms, in fact do not pay for their keep, so that the breeding of palms with uniformly high yield ranks equally with good agricultural practice.

BREEDING AND SELECTION TECHNIQUES.

The use of Isolated Seed Gardens:

An isolated seed garden has been provided for (Annual Report, C.R.I., 1954, p.9) consisting of 200 acres of forest land, with a 50 chain forest barrier to exclude contamination with foreign pollen. Planting has already been started of selected seedlings from controlled crosses between known high yielding parents. Subsequently natural crossing will be allowed to take place, presumably at random, between all the palms of different ancestries in a random assortment of progenies, in order to provide elite seedlings for dissemination. The assumption was that seedlings obtained in this way would be of the high yielding capacity desired.

That this assumption is not a valid one is shown by experiments conducted at the Institute. Some results of growing seedlings from high yielding mothers subject to natural crossing are now known from an experiment conducted by the Botany Division since 1939, and known as the Latin Square Experiment.

The following Table gives a summary of the results of this experiment ex Annual Report, 1949, P.30:-

SELECTED GROUP A C E		UNSELECTED GROUP B D F		Nuts Copra (lbs.)	
A	SELECTED SEEDLINGS FROM HIGH YIELDING PALMS.	1,431	620
C	SELECTED SEEDLINGS FROM LOW YIELDING PALMS.	1,306	583
E	SELECTED SEEDLINGS FROM HEAP NUTS.	1,284		580	

B	UNSELECTED SEEDLINGS FROM HIGH YIELDERS.	..	7	34
D	UNSELECTED SEEDLINGS FROM LOW YIELDERS.	..	1,116	471
F	UNSELECTED SEEDLINGS FROM NUTS	..	1,111	461
	COMBINED SELECTED A C L	..	1,340	594
	UNSELECTED B D F	..	1,111	467

From these results it is apparent that high yield is not transmitted by a fixed group of offspring from high yielding mother palms exposed to natural crossing. Selected seedlings from high yielding palms are very little better than those from low yielding ones. Also when weaklings are not eliminated in the nursery, seedlings from low yielders (Group D) are even superior to those from high yielders (Group B).

A high yielder may owe its high yield to a variety of causes:

1. An unusually favourable environment.
2. Selection for good vegetative characters in the seedling stage these being correlated with good adult performance.
3. Hybrid vigour due to a favourable combination of genes in the heterozygous or hybrid phase.
4. Genetical superiority in the form of dominant yield genes.

Group A comprises a mixed lot of seedlings from probably all these types of mother after weaklings have been eliminated in the seed bed.

Considering the factors which have made these mothers high yielding, what are the chances of their producing high yielding offspring?

Since the coconut (Tall type) is known to be obligatorily cross fertilized, the progeny of any given mother is the result of crossing that mother with an unknown number of fathers of varying genetical make up. Every nut on a tree may in fact have different father. The chances of producing from any given mother a high yielding progeny are thus very low, and if the progenies are mixed, as seems largely to be the present custom, it is likely, and this is borne out by the experimental results, that they would show, little if any improvement over a mixed lot of seedlings from unselected or even low yielding mothers.

The situation, in fact is similar to that known to exist in a number of outbreeding plants, of which the best known one is maize. If in a field of maize, we eliminate all inferior plants and the resulting elite are allowed to intercross freely, the bulked seed from such a field shows practically no advantage in yield over that from an unselected mixed population.

It must not be assumed, however, that all progenies of open pollinated single mother are of the same degree of only average merit. It is well known from the work of the writer that open pollinated cacao trees differ in their power of transmitting high yield to their progenies. Some transmit strongly, probably through the possession of an especially favourable combination of dominant genes, i.e. they are prepotent, while others given progeny no better than average. From preliminary results it appears that this situation also holds good with the coconut. If the progenies of high yielding mothers are identifiable it should be possible within a few years to pick out the 'yield transmitters' and use them for propagation, and for intercrossing with each other.

Use of the Paired Cross Method.

So far I have dealt with the present situation in which planting material is of the ancestry one mother x 'X' fathers, such material being of not more than average value except for the rare 'transmitters'.

It is possible by controlled pollination to make hybrids where both mother and father are known. Such a cross has been designated as 'paired cross', and forms the basis of a new method of tree breeding put forward by the writer several years ago. What happens when a single high yielding female is crossed by a single high yielding male? It is clear from observations on other species that families from such crosses differ markedly from each other. A single human family for example may consist of generally short children, or tall children. They may all be above or below the average in intelligence or physique, or constitution. Each family is vaguely distinguishable by a special association of characters so that the individuals in it resemble each other more than if unrelated.

The writer's experiments were made with maize, which resembles the tall coconut in being a typically cross fertilized species. The results of a large number of paired crosses showed that yielding power fell on a normal frequency curve.

Some of the high yielding paired crosses gave a yield of more than twice the average. The average yield of the combined paired crosses was about the same as that of the unselected material.

Since a proportion of seed from the paired crosses had been retained, it was now possible to make a re-sowing of proved high yielding pairs, and this resulted in an immediate gain of about 30 per cent in yield over the unselected commercial material.

A further cycle of paired crosses between the best of the paired crosses gave a still further increase in yield so that with heavy manuring it reached a level about double that of the original unselected type.

Long Term Possibilities of Coconut Breeding.

It is thus clear that the long term possibilities

of coconut breeding through the use of the paired crosses are immense, though the long juvenile period before adequate data are available is an obstacle to rapid progress. This fact alone makes it all the more necessary to formulate a sound breeding policy for the future based on long term possibilities and in conformity with modern genetical ideas.

Continued use of Genetically Superior Paired Crosses.

Coconuts differ from maize in that once a pair of trees has been established to give uniformly high yielding offspring when crossed, that pair can be subjected to further crossing for the production of seedlings, which after screening for undesirable seedling characters can be used for commercial distribution and trial. The elimination rate is at present as high as 70 per cent. Some paired crosses will give a high percentage of good seedlings, so that the elimination rate may fall to less than 10 per cent.

Isolation of Maternal Transmitters.

If a paired cross is superior it means that one or both parents is prepotent for yield, or that in some way the genetical factors on both sides combine to give good results. If single mothers are crossed with x fathers, the yield of such progenies will also fall on a normal curve with the very rare high transmitters, or prepotents, occupying the upper end of the curve. In other words, given a sufficiently high number of progenies from open pollinated mothers, it should be possible to arrange them in order of yield and pick out mothers which in spite of having been indiscriminately pollinated by miscellaneous males, are sufficiently possessed of dominant yield factors to ensure that their offspring are also high yielding.

Use of Maternal High Yield Transmitters, both as Males and Females.

Once a maternal transmitter is identified, it can

be continuously used to provide seedlings for planting. It can also be used (a) in paired crosses, (b) for self fertilization, (c) as male in extensive crosses with high yielding mother palms.

Just as the progeny of a single mother palm may be superior, whatever the nature of the male parent, it is evident that the reverse situation also holds good, namely that once female transmitters are identified, their pollen can be used on pheno-typically high yielding mothers, thus making a very large quantity of good planting material available in a very short time. Indeed this method is the most immediately practical one which can be adopted with our present knowledge.

Analogy between Coconut Breeding and Animal Breeding.

A strong analogy exists between this concept of using pollen of prepotent palms and the current practice of animal breeding where the value of a bull is assessed by the milk yield of a group of his daughters, and by the amount he can raise the mean milk yield of the daughters over that of their dams.

Extension of the Crossing Programme.

When a few transmitters have been identified, and when a few paired crosses have been proved to be superior, the crossing programme can be greatly extended. All known high yielders can gradually be studied and those proved to be non-transmitters can be eliminated as the results of tests become known. Pollen from both members of superior pairs can be tried on a large number of high yielding females.

Use of Dwarf Palms to Speed up Identification of Male Transmitters.

The process of identifying male transmitters can be speeded up by the use of dwarf palms as females. They come into bearing very early, so that using a number of dwarfs as female parents, each bunch can be pollinated by a different high yielding tall male. Since the dwarfs are largely self pollinated and their progeny reasonably homogenous the progenies of single bunches on a palm, each from a different male, can be studied to identify the most prepotent males. Progenies of from 5 to 10 seedlings will be adequate to

make a preliminary and tentative separation. If progenies of 10 are available they should be planted in two groups of five each.

Self Fertilization and its Importance.

So far attention has been concentrated on pair crossing and on prepotency in open pollinated material. It is now necessary to discuss the role of self fertilization. Since the coconut palm, at least in the usual tall type, is a cross fertilized plant, it has almost certainly accumulated by mutation unopposed by selection a large number of deleterious recessives. These would come to light on selfing. Deleterious recessives would also occur in paired crosses, since the parents might be heterozygous for the same recessive gene. By analogy with other outbred species, selfing would be expected to reduce vigour, and loss of vigour in selfed material has been referred to in some Indian work. In Indian Central Coconut Committee 4th Annual Report of 1-4-48 to 31-3-1950, the statement is made: 'It is also noticed that seedlings obtained by self pollination are less vigorous than seedlings obtained by either "crosses" or "naturals". This statement, however, should not be accepted at its face value. Apart from evidence that selfs of some outbred species, e.g. tomatoes, cotton, and cherry, show little if any inbreeding depression, since pure lines of both cotton and tomato are grown commercially, it is likely that different varieties of coconut will respond to selfing in different ways and to different extents. Inbreeding depression does not appear to be important in either the Dwarf or the Maldiva type. It is at least possible that inbred lines of high productivity can be obtained in the coconut, which although perhaps exhibiting slight inbreeding depression may compensate for this by their uniformity in yield and other desirable characters.

With high yielding pure lines, the problem of improved planting material will be largely solved.

Fixing of Prepotency by Selfing.

Once a palm is identified as a transmitter, it is likely that some of its self fertilized offspring will inherit its 'combining' ability. Combining ability has been shown to segregate in maize, so that testing of selfed

progenies which have arrived at the bearing stage with satisfactory yield should be undertaken.

Retention of Weak or Abnormal Selfed Seedlings.

It is customary to discard weak or abnormal seedlings in the seed bed. In selfed families, however, all types should be kept under observation for some time since it is from the rare recessives that valuable novelties may arise.

Use of Old Palms.

It would be useful to record the total nuts produced by high yielding individuals during the greater part of their life histories. In particular, palms should be sought which are yielding under a low level of nutrition, e.g. in the no manure plots at the Institute. Palms may react differently and individually to the environment. They may show differences in such characters as ability to tolerate nutrients deficiencies, drought resistance, seasonal or uniform bearing, resistance to factors causing senescence, etc. Many palms on which yield records have been kept are now old, and by the time their prepotency status has been established their crop will have been so much reduced that they are of little value as a source of nuts for seedling production. Nevertheless once established as prepotent, aged and declining palms can still be used as a source of pollen to the end of their lives. The rate of decline of such trees should be arrested by special manurial treatment. Preservation of pollen is an important aspect of breeding work and it should not be difficult to devise means of keeping pollen in a viable condition, using controlled temperature and humidity for long periods. In this way a 'pollen bank' of valuable material can be maintained and palms used long after they are dead. Finally the analysis for several years of potash and phosphorus content of nut water of single palms to an advanced age would be of great interest.

Selection in the Seed Bed.

From what has been said it will be realised that although all the techniques are now available for producing a continuous flow of guaranteed high yielders, the out put of planting material be very slow for some time. When once started, progress will be rapid, especially if pollen from

proved transmitters is used on a large scale. At the present time, a careful selection of seedlings in the nursery for vigour and rapid germination is more important than breeding.

Dr. D.V.Liyanaige at this Institute (Annual Report, C.R.I. for 1953, p. 23) has shown very clearly the great value of seedling selection in the nursery. The salient results are given in the Table below.

TABLE

Average yield per acre according to seedling selection.

<u>Material.</u>	<u>Nuts.</u>	<u>Difference</u>	<u>Copra lb.</u>	<u>Difference</u>
Selected seedlings	2,646		1,273	
Unselected seedlings	2,358	288	1,136	137
Critical difference.	142 nuts	(P - 0.05)		
	127 lb. copra	(P - 0.05)		

The difference in favour of the selected seedlings is about 12 percent, bearing in mind that the unselected group comprises all types of seedlings ranging from good to bad.

To quote Dr. D.V.Liyanaige 'The most important factor contributing to increased yields is a vigorous selection of seedlings'. He seems also to have obtained evidence that the period taken for germination is an important factor. He states 'Period taken for germination of seed nuts appears to have a profound influence on the performance of the palms. When seed nuts germinate early they give rise to palms that flower in a shorter period and are also more productive than those that arise from late germinations'. Whether early germination necessarily means ultimate higher yield, should be studied in more detail. Having noted a general correlation between seedling characters and adult behaviour the next step is to study the incidence of wastage in single palm progenies, whether open pollinated, selfs or paired crosses. The wastage of seedlings in the process of screening for vigour, is at present large and it is clear that this wastage could be greatly reduced, if not largely eliminated, by the selection of parents giving inferior offspring. A survey of existing nursery material from paired crosses confirms this theory. Some progenies are uniformly and definitely bad.

Others are comparatively good and at the same time very vigorous. Parents of bad progenies are being eliminated from further study.

This established correlation between seedling characters and adult behaviour, is the most important means known to us at present of providing superior planting material. It must, however be borne in mind that selection at the seedling stage involved the possible destruction of rare but superior types, since not all superiority can be detected in the seedling stage, and in particular slow growing palms carrying valuable genes may be eliminated. Nevertheless the search for correlations between the characters of the seedling and those of the adult should be undertaken in great detail, especially from the point of view of physiology.

Rejuvenation of Old Palms.

The coconut palm is potentially immortal. That is, it will continue growing in height indefinitely, up to the point at which further growth in height becomes impossible for mechanical reasons. It is clear however that adventitious roots can be induced to grow from any part of the trunk, perhaps almost to the crown. By the use of the air layering method, in which a large bag of some moisture retaining substances is placed round the stem some 10 feet below the crown, and kept moist, roots will be developed. At an appropriate time the palm can be lowered to the ground, the stem gradually cut below the new root system and the palm transplanted. It is thus important to perfect the rejuvenation technique by a sufficient number of preliminary experiments.

Possibilities of Vegetative Reproduction.

One of the most important problems confronting the breeder is an answer to the question : can the coconut be reproduced vegetatively? It is fully appreciated by growers of rubber, cacao and tea that the uniformly high yield for given environments of vegetatively reproduced material, i.e. from cuttings, buds or grafts represents the greatest contribution that science has so far made to these industries. Some plants, e.g. the date palm, have the power of producing from the base suckers which can be used as propagating material. The best varieties of date

palm are propagated in this way, and the clones have been named. Although the possibility of vegetative reproduction is at present remote, there are indications that the problem is worth while following up.

Twins and their Importance.

The occurrence of 'twins' apparently always 'identical' is by no means infrequent in the coconut and triplets have also been recorded by Dr. Liyanage at this Institute. Twins are a special case of polyembryony,--the production of a large number of usually identical embryos in a single seed, such as occurs in some types of mangoes and citrus.

Twins are valuable both in physiological and breeding work. Pairs of twins can be used for a partial solution of the most difficult question facing the breeder, the separation of the effects of heredity and environment. Thus if both members of a pair were high yielding, it is evident that heredity is playing a considerable part in determining yielding power, and such palms would be more useful for breeding than if the results of a single palm only were available. Study of twins would also help to provide knowledge of the nutritional requirements of the coconut in different soils, or under artificial conditions. It is unnecessary to labour the point here, but reference may be made to the use of twins in cattle for the solution of many problems of feeding and managements.

Polyembryony.

The question of polyembryony is mentioned by Narayana and John (1949, 'Varieties and forms of the coconut', Madras Agricultural Journal, 36:1)

They state: 'This is the phenomenon of a single coconut producing more than one seedling. The number may be from two to four'. These authors make no reference to the existence of identical twins; nor do they appear to appreciate the importance of twins or polyembryony for physiological and breeding studies.

The genetical basis of twinning, if indeed it is genetically controlled, is not known. If inherited, the tendency could be increased by selection.

Vivipary.

An approach to the question of vegetative multiplication is provided by the phenomenon of vivipary. This is referred by Narayana and John (loc cit.) and Patel (1938). 'Here the young female flowers, instead of developing into normal nuts grow into bulbils or small seedlings, which however when planted in the ground failed to establish themselves'. Although now regarded as merely a curiosity, vivipary would be of the greatest use in both physiological and breeding work, provided the bulbils could be rooted. This does not seem to be an insuperable problem if modern horticultural techniques are employed. What is required is that crosses should be made between the viviparous type and various normals in the hope of producing palms which show only a partial development of vivipary, simultaneously permitting vegetative multiplication and high yield.

The Suckering Habit.

'This' say Narayana and John' is a rare instance of a coconut tree producing suckers like a plantain'. When separated from the parent tree and planted in the field the sucker gave rise to a normal tree. We are not told whether the sucker in turn produced other suckers. The genetical basis and suckering is not known. The suckering habit has also been found in Ceylon and it may not be uncommon.

Both suckering and vivipary may be due to heterozygous dominants. In this case the character could be transmitted to large numbers of offspring.

Possible Induction of Adventitious Buds.

In some plants it is possible to induce the formation of buds from the surface of a cut stem by hormone treatment.

The experiment should be tried of cutting a palm to a height of say 3 feet from the ground, plastering the cut surface with heteroauxin and covering with polythene. It is remotely possible that buds may develop from the surface, in which case the first step would be to root the palm 10 feet from the crown, transfer it elsewhere, and then try to induce buds to form on the 2 foot stump.

Possible Induction of buds from Leaf Petiole.

In some plants, a leaf will root when placed in a suitable medium but will not normally form a bud. If however, the petiole is wounded, an adventitious bud may be formed on the cut surface. This experiment is now being tried.

The use of Haploids.

A haploid is a plant which develops from an ovule without fertilization. It is usually characterized by weak and spindly growth and by sterility which may be absolute on both male and female sides, or in some instances it may be partly fertile on both or one side. Such plants contain only one set of chromosomes with their contained genes. By the use of colchicine and other methods the chromosome complement can be doubled and complete fertility restored. A doubled haploid will show by its degree of vigour how long continued inbreeding will affect vigour in an open pollinated plant such as the coconut. When self pollinated a doubled haploid will breed true. If prepotent for yield, all the pollen will be of the same standard for crossing. If high yielding itself it will give uniform progeny in this respect. If doubled haploids can be obtained in the coconut it may be immediately possible to fix high yield on one operation and obviate the dreary process of many years of selection and selfing. The methodology of haploid induction is now fairly well known. Haploids occur sometimes as one member of a pair of twins, though whether this occurs in the coconut is not yet known. Other methods comprise (a) use of X rayed pollen, (b) use of oil pollen, (c) use of pollen of another species, usually in the same genus. It will thus be clear that work on haploids should form a most important long term project.

Varietal Differences in Geographical Races.

IMPORTANT DATA ON SOME VARIETAL CHARACTERS
OF GEOGRAPHICAL FORMS OF THE COCONUT ARE
GIVEN BY NARAYANA AND JOHN (loc.cit.)
AND PRESENTED BELOW.

Variety or Form.	Weight of unhusked nuts. Grms.	Weight of husked nuts. Grams.	Percentage	Weight of copra per nut. Grms.	Percentage of copra per husked nut.
1. Variety typica.	1,134	454	40.0	159	35.0
2. Forma laccadive.	1,219	510	41.8	157	31.8
3. Forma pusilla.	709	225	31.7	60	26.7
4. Forma kappadan.	1,929	193	10.0	332	--
5. Forma siamea.	1,899	737	38.8	221	30.0
6. Forma gigantea.	1,786	878	49.2	180	20.5
7. Type Andaman ordinary	1,701	552	32.5	170	30.8
8. Forma nova-guineana	1,105	368	33.3	213	57.9
9. Forma cochin-chinensis	1,162	652	56.1	140	21.5
0. Forma malayensis.	1,616	935	57.9	200	21.4
1. Forma maldiviana.	623	317	50.9	84	26.5
2. Variety spicata.	510	283	55.5	141	49.8

Size of Nut in Selection.

Selection for more number of nuts involves the danger of increasing number and decreasing size (or weight of copra per nut). As the nut becomes large the number becomes smaller, though the correlation is not absolute.

Correlations of Importance in Selection.

From data given by Narayana and John (loc.cit.) presented below, it is possible to calculate certain correlations of interest to the breeder.

These correlations are as follows:

Weight of Unhusked Nut and Weight of Husked Nut.

$r = 0.8605.$

Varieties with heavy unhusked nuts also have heavy husked nuts.

Weight of Unhusked Nut and Percentage Husked Nut.

$r = -0.1224.$

Here there is no association between these two characters. The proportion of husked to unhusked weight is not materially different from one variety to another.

Weight of Unhusked Nut and Weight of Copra per Nut.

$$r = 0.7475$$

Varieties with heavy unhusked nuts also have a higher weight of copra per nut.

Weight of Unhusked Nut and Percentage of Copra per Husked Nut

$$r = - 0.3861.$$

This value suggests that to some extent that in varieties with heavy unhusked nuts the weight of copra decreases relative to the husked nut weight.

Weight of Husked Nut and Weight of Copra per Nut.

$$r = 0.6369.$$

Varieties with heavy husked nuts also have a higher weight of copra per nut.

Weight of Husked Nut and Percentage of Copra per Husked Nut.

$$r = 0.5608.$$

This correlation value suggests that in varieties which have a higher husked nut weight, the weight of copra relative to the weight of husked nut decreases.

Comments on the above Correlations.

The most important of the above correlations is that between weight of the husked nut and weight of copra per nut. Although as stated above the correlation between these two characters is high and positive, reference to the data reveals interesting differences between the varieties.

Comparing Nos. 1 and 8, we see that the weight of the unhusked nut is not significantly different. The weight of the husked nut for No. 1 is 454 grams, while that in No. 8 is considerably less, 368 grams. That means that these two varieties differ in the percentage of husked nut 40.0 per cent as against 33.3 per cent.

When we come to weight of copra per nut, No.8 is superior, being 213 grams as against 159 grams for No.1. This is reflected in a greatly increased percentage of copra per husked nut in No.9-57.9 per cent as against 35 per cent in No.1.

What matters therefore, is not the magnitude of the correlation coefficient, but the extent to which varieties deviate from the linear relationship. A high weight of copra per nut in a husked nut of medium size is probably the best combination to go for, although our present knowledge does not enable us to say what the optimum values of these characters should be. Further detailed studies are necessary on the high yielding palms which have been recorded, especially on the relationship of weight of copra per palm to number of nuts and weight of copra per nut.

Hybridization between Forms and Varieties.

In outbreeding plants such as maize and in many forest trees crosses between races from different localities have often increased productivity through hybrid vigour. The coconut exists in a large number of races scattered throughout a wide area, and it is important that crosses be made between them. Such crosses as the large form Kappadan by pusilla--the form with a large number of small nuts, would be of great interest, since the weight of the hybrid nut might follow the geometrical mean pattern all possible combinations, however, should be tried.

Hybridization between Tall and Dwarf.

Trials of crosses of this type have been made in several parts of the world.

Although the dwarf coconut has many disadvantages compared with the tall type it has some advantages. It is earlier maturing, easier to pick, cultivate and manure and replace. Its breeding system--predominantly that of an inbreeder with an occasional out cross leads to a considerable degree of uniformity in the off-spring--much greater in fact than that in the progeny of tall parents. The hybrid of Dwarf x Tall seems to be of great merit, being intermediate in most characters, early maturity, great

vigour, etc. It seems likely that the use of controlled hybrids, (paired crosses) of dwarf x tall may find extensive use in commercial practice. The production on a large scale of hybrids will provide an opportunity of assessing prepotency in highly yielding tall. It is likely that some crosses between prepotent tall and selected dwarfs will give relatively uniform and highly productive hybrid, and it is further likely that prepotency may be a fixed property of some dwarfs..

The possibility of new and valuable types in the second generation of dwarf x tall and in the hybrid crossed back to selected dwarfs and tall must be kept in mind.

Suggestions for Experimental Work.

In making suggestions for experimental work I do not wish to convey the impression of advocating a complicated programme of long range research without much reference to the immediate future. All the experimental work so far suggested, and summarized below, has an important practical aim in view, and is designed to shorten the time taken for breeding more efficient palms and to increase the efficiency of the breeding process.

1. Identification of prepotent high yielders by comparison of a large number of open pollinated progenies.
2. Identification of prepotents by crossing high yielders by a group of selected dwarfs.
3. Study of a large number of paired crosses in progenies of sufficient size.
4. Study of progenies from high yielders, dwarfs, geographical type crossed with pollen of proved transmitters, thus increasing the number of paired crosses for detailed observation.
5. Study of crosses between geographical for possible utilization of hybrid vigour.

6. Study of selfed progenies, with special reference to inbreeding depression and rate recessives of possible value.
7. Search for haploids. Methods of doubling the chromosome number of haploids.
8. Study of twins, triplets, polyembryony, suckering and vivipary with reference to genetic basis and possible uses for vegetative reproduction.
9. Study of seedling physiology in order to make seedling selection more efficient.
10. Correlation of seedling characters with adult characters of values.
11. Use of twins, triplets and suckers for nutritional and physiological study.
12. Study of the relationship of weight of copra per palm to number of nut, nut weight and weight of copra per nut, with the object of determining optimum values for selection.
13. Study of possible methods of vegetative regeneration, i.e. hormone treatment of cut stumps, petiole wounding etc.
14. Study of methods of rejuvenating old palms by air layering.

25th January, 1957.

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