RESEARCH WORK ON COCONUT PALMS*

Origin of the Coconut Palm.—It is still always a disputed question in which part of the tropics the coconut palm originated. De Candolle, Beccari, Chiovenda, etc. etc., considered the Indian Archipelago as such, but Cook, Guppy and Hedley thought it to be found in America. The last supposed its spreading over the tropics to be brought about by men, the first thought natural conditions and the structure of the fruit to be sufficient A strong argument of Cook, Guppy, Hedley and De Vries was that it must be considered very improbable that seaborne coconuts could be cast ashore in such a favourable position that they could germinate without the aid of man.

The fact remains however that coconuts are common strand palms on almost every tropical Island and that they were found established when uninhabited Islands were discovered. Another fact which lends support to the original home of the coconut being the Indian Archipelago or Polynesia is the great variety of the coconuts found in the East.

A new fact which supports the view that *Cocos nucifera* is of eastern origin is afforded by the recent discovery of fossil nuts of a *Cocos* in the Pliocene deposits of Mangoni, North Auckland, New Zealand. Though they are small, they show no marked features, except as regards size, to differentiate from the existing genus *Cocos*.

It has also been proved that coconuts cast ashore can germinate and develop without aid of men. In this way coconut palms and coconut groves originated on the Cocos Kerling Islands, on some cays off the coast of Honduras, on the Bay of Cocal (Trinidad), on Krakatau.

All this evidence may be considered to strengthen the view that Polynesian or East Indian Islands are the original home of the coconut palm.

Variation in Coconuts.—From a block containing 471 coconut palms in Malakka, growing under apparently uniform conditions, production has been noted of every tree for a period of 8 years. The following figures show the group frequences, i.e., the number of palms in each group divided according to the average production of fruits per palm per annum.

Group	5	15	25	35	45	55	65	75	85	95	105	115
Number of trees	1	11	34	44	65	88	83	71	35	32	5	2

The coefficient of variability (derived from these figures) of production of an average population of coconut palms (talls) is 34 % of the mean production. 19% of the palms on an average plantation are not profitable. Poor yielding palms remain poor yielders and high yielders are constantly high yielders.

Cost of production of copra in Malaya.—Figures have been collected annually from mature areas from 30 representative estates, all of which are under European management and the area from which the figures are derived is approximately 50,000 acres, over the years 1921-1927 (inclusive).

Average yield of copra per ha.	1,260 kg.	per annum.
,, ,, of nuts ,, ,,	5,475	,, ,,
,, number of nuts per palm	45·6	,, ,,

The palms are still growing; the oldest have only been planted some 28 years. The highest recorded average over a large area (800 acres=320

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ha.) was 90 nuts per tree in 1926, while in the same year the lowest record was 34 nuts; in normal years the highest and lowest records were respectively 75 and 25. Only few estates adopt any regular cultural methods.

Averages concerning cost of production were collected from 16 representative estates during 1927:

Table I.—Cost of Production of Copra in Straits dollars.

	highest	lowest	average
Capital cost per ha.	1625	550	972·50
F.O.B. cost per 100 kg. of copra	11·66	5·58	9·37
Nut picking and collection per 1000 nuts	1·55	0·61	1·18
Husking per 1000 nuts	0·70	0·45	0·53
Splitting per 1000 nuts	0·51	0·28	0·34
Meat extraction per 1000 nuts	0·70	0·18	0·41
Curing per 100 kg. of copra	0·78	0·05	0·53
Cost of bags per 100 kg. of copra	1·12	0·47	no data
Transport to port per 100 kg. of copra	0·63	0·07	no data
Drainage upkeep per ha.	11·35	3·75	6·72
Weeding and cultivation per ha.	65·87	10·50	30·07
General charges per 100 kg. of copra	10·22	2·82	6·22

Dwarf Coconut Palms Experiments.—The three dwarf and closely allied races of the coconut palm are those with ivory-yellow, apricot-red and green fruits respectively. The flowers, as a rule, self pollinate and a high percentage of the resulting fruits breed true to type even when exposed to cross pollination. It is possible to make a fairly accurate separation of the dwarf races from hybrid and tall forms by noting the growth and colour characters of young plants in the nursery.

For the purpose of obtaining additional information fruits of each of the three races were obtained in June 1921 from open pollinated palms in a large plantation, where dwarf forms were mainly grown. The nuts after germinating were planted at Parit Buntar in the State of Perak (Malakka). Six palms of each were planted in December 1921 of which five were selected for the purpose of investigation.

The average period which elapsed from planting to flowering was for the "yellows" 3 years 86 days; the "reds" 3 years 105 days; the "greens" 3 years 263 days. The "greens" however flowered unevenly. Apparently they were not so pure, genetically, as the "yellows" and the "reds".

Spadix production was fairly well distributed throughout the seasons for each year, which, no doubt, was due to the fact that water supply was always ample for the requirements. The number of days between the opening of successive spathes varied for the "yellows" from 10·5-21·1 days; the "reds" from 19·3-24·2 days; the "greens" from 18·7-23·1 days.

The average for a dwarf race is therefore 20 days.

From the time of flowering to February 28th, 1929 the results of flowering and fruits have been as follows:

Table II

Race	No. of palms	Total Spadices	Total of fem. flowers	Total of fruits at 2 months	Total mature fruits. for 1925/26	for 1926/27	for 1927/28	from flowering till March 1929
Yellow	5	344	4672	1822	138	458	549	1553
Red	5	284	3062	1629	119	411	486	1464
Green	5	292	6261	1655	66	338	479	1390

The "greens" had the highest average number of female flowers per spadix (21·4), the "yellows" 13·6; the "reds" 10·6. A high percentage of female flowers fails to set fruit. The percentage of loss of fruit after two months from the time of flowering is very low:

Table III.—The average production per tree (nuts per palm per annum).

	1926/27	1927/28	1928/29	Average
Yellow ...	91·6	109·8	82·2	94·5
Red ...	82·2	97·2	89·6	89·6
Green ...	67·6	94·8	102·4	88·2

The average time from flowering till picking has been for the "yellows" 12·5 months; for the "reds" 13·4 months; for the "greens" 13·1 months.

The flowers are usually self-pollinated owing to the fact that the male and female phases of flowering of each spadix produced by these dwarf palms overlap. Numerous insects, more particularly bees, visit the male flowers to collect pollen and nectar but few appeared to be attracted by the female flowers.

From these 15 trees a number of fruits was collected to germinate in order to see if any appreciable amount of cross-pollination had occurred, as this would be noticeable in their progeny. The germination results of 642 nuts showed that they were apparently true to the type of palm from which they were taken. Twenty-five plants from each palm were planted out from the germinating beds and these are now nearing flowering stage. No characters suggesting hybridisation have been observed:

Table IV.—Analysis of dwarf nuts.

	Average weight in gms. per nut			% Moistue in copra	% oil in copra on dry basis
	Nut	Meat	Copra		
Greens	584	243	143	7·80	65·02
Reds	557	243	139	8·37	65·94
Yellows	511	245	129	7·74	64·78

Dwarf Coconut Palms on Estates.—It was possible to get figures from actual returns from six estates which represent 1,300 acres (520 ha.) of dwarf palms. So it is possible to make a comparison between the Dwarf coconut and the Tall. As the size of the Dwarf is very much smaller than that of the Talls, the number of trees per ha. is very much larger.

Table V.—Production per hectare of dwarf and tall palms.

	Number of palms	Crops in kg. copra per ha.					
	per ha.	4th yr.	5th yr.	6th yr.	7th yr.	8th yr.	From 10th yr.
Dwarf	225	343	928	1128	1386	1752	1950 (estim.)
Talls	100-138	—	75	300	600	900	1309

Table VI.—Comparison of yields of dwarf and tall palms.

	Dwarf	Talls	
Weight in grammes of copra per nut	130	260	
No. of nuts per palm per annum	90	56	(favourable conditions).
Production of copra per ha. per annum in kg.	2530	1900	,,
Production of oil per ha. per annum in kg.	1518	1080	,,

Of the estates included above in the averages of production from dwarfs in the eighth year, production ranged from 1308 kg. copra per ha. (780 kg. of oil) to 2893 kg. copra (1740 kg. of oil).

On most estates the yellow type predominates, being popular on account of its bright appearance. But this type produces a smaller fruit yielding less copra than the "reds" and "greens". The last is undoubtedly the hardiest.

The Dwarfs offer still other advantages over the Talls, e.g., similar growth and fruiting characters; each palm is genetically a high yielder; the palms mature evenly; the production of copra is of a less variable quality.

Oil Content of Malayan Estate Copra.—Reports from London to the Straits said that the oil content of Straits copra was tending to diminish. Figures were quoted to the effect that, while Straits copra formerly contained 66-67 per cent of oil, recent consignments had been found to contain 63-64 per cent only.

As estate produce is of greater uniformity than that of small cultivators the investigations were limited to the first. A total of 62 determinations showed a moisture content (loss at 100°C) of 6·90 per cent with 4·68 per cent and 9·08 per cent as minimum and maximum. Also 62 determinations showed an oil content (calculated on moisture basis) of 65·61 per cent with 62·29 per cent and 67·27 per cent as minimum and maximum. It is further shown that with an increase of one per cent in moisture content of the copra there is a corresponding decline from 0·6-0·7 per cent in the oil content.

It was not possible to give a reason for the alleged diminution in oil content.

Coconut Cultivation in Ceylon.—As may be known methods of coconut cultivation in Ceylon are practised more scientifically than in Malaya. As a result of this yields are very much higher. Of nine estates the yield of copra per ha. in kg. per annum was respectively: 1890-1890-1969-2047. 2047-2047-2047-2126-2677. As only the Tall palms are planted this may be regarded as the result of better cultivation and manuring. Soil conditions vary from light and to light loam or light clay along the coast; in the undulating country red gravel and light red laterite soils are met with. Plantations vary from 100-400 ha. Planting distances vary from 25 by 25 feet to 27 by 27 feet.

The general practice by intensive cultivation is to plough and harrow alternate rows every two years. On a sandy soil excessive cultivation in such soils in a dry district has resulted in a marked falling off in yield of copra per palm.

It is generally recognised that more satisfactory returns can be obtained by periodical application of artificial manures. The general practice is to apply from 6-7 kg. per palm of a complete mixture every two years, but under the present system of manuring alternate rows every other year, each palm actually receives half the above quantity each year. These mixtures contain organic fertilisers (e.g., bonemeal, fish meal, groundnut meal) as well as inorganic. They aways contain some form of potash manure.

On the Manuring Trial Grounds results were as follows:

Table VII.—Fertiliser trials.

	Yield per ha.			
	1925	1926	1927	1928
Nuts ...	6395	4600	8595	10760
Copra ...	1685	1897	2315	2803

The highest estate yield from trees of 35-45 years was 85 nuts (Tall type) per palm per annum. A high yielding estate (13,965 nuts per ha. per annum over an area of 500 ha.) has adopted a system of manuring to apply 9 kg. of a complete mixture per palm every alternate year.

To prepare a good quality of copra, it is essential that only ripe nuts should be harvested. After picking, the nuts are collected in small heaps of 3,000 to 4,000 nuts where they remain for a period of 3 to 4 weeks in dry weather, which may be extended to 5 weeks during wet weather. It is said that by doing this the oil content of the copra is improved.

Iron Sulphate as a Fertiliser.—According to information from M. Bodin very remarkable results have been obtained by applying iron sulphate to coconut palms on the Tuamotu islands. The soil consists almost exclusively of coral debris. Every three years 250 to 300 grammes of pure iron sulphate are used per palm. On the island of Pukapuka yields have increased from 350 to 2000 kg. per ha. (average planting distance 8 by 8 m.). The trees, first yellow coloured and with small leaves, turn dark-green within a year and normal leaves are formed. On Pukapuka the use of iron sulphate for this purpose was 5000 kg. in 1927.

Disease of Coconut Palms.—In Malayan Tall coconut plantations a feature known locally as "Bud-Rot" due to lightning strike is common. In a typical case, a group, usually not more than about 10-12 trees, is affected: two or three of the central trees may be killed outright, the surrounding trees show symptoms of varying intensity, which to some extent support the suggestions of lightning strike. The lightning damage affecting only a small group of trees was not considered to be serious, but during the last four years, large compact blocks of mature palms have been suddenly affected and in such cases the suggested explanation appears inadequate.

As a result of a thorough investigation *Marasmus palmivorous* (Sharples) may be indicated as the cause of the disease.

Dwarf coconuts and African oil palms however are very much more susceptible than Tall coconuts. The only methods that can be adopted are the usual sanitation methods: to clean away vegetable debris between the bases of the leaves and to decrease atmospheric humidity in the places where the fungus is growing strongly; green leaves showing the fungus prominently must be cut off even if ripe fruits have to be sacrificed.

Recent contributions to coconut diseases lead the writer to think that confusion may again arise unless the present situation is clearly defined. In several contributions the question of palm diseases seems to have been given undue prominence. In many cases it is obvious that the improvement of bad cultural conditions (drainage and aeration of the soil) is of greater importance than the question of the cause and prevention of specific diseases.