COCONUTS

PART I. A Literature Summary on the Agronomy and Breeding of the Coconut Palm

PART II. A local, non-statistical survey of methods and problems on Trinidad estates covering the same subjects as above

by

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D.T.A. Report

Submitted in part fulfilment of the requirements for the Diploma in Tropical Agriculture of the Imperial College of Tropical Agriculture, St. Augustine, Trinidad.

1958-1959
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PART I

INTRODUCTION

The aim of this study is to present an up-to-date literature review on the coconut palm covering all aspects from the seedling stage to the production of ripe nuts for harvest, with a large section devoted to pests and diseases. The second section of the project (and a considerably smaller amount of time) has been devoted to a report on the cultural methods employed by the coconut estate managers and coconut peasant farmers of Trinidad, and an outline of the problems of the local industry.

The Coconut Research Institute of Ceylon is engaged in technical investigations on production, diseases and pests and processing, and publishes more or less regular reports of the work being carried out there. In India two coconut research stations are doing technical work on breeding, manuring and cultivation of the coconut palm. A station in Indonesia is doing some work on breeding, manuring, cultivation, diseases and pests, and the Agricultural College of the University of the Philippines has also carried out some technical and agricultural investigations on the coconut. The bulk of new information is provided by these stations, therefore, whilst minor producing countries carry out work on particular local problems. (South Pacific Commission, 1957).

It will be apparent from the ensuing Literature Review that there is a great need for more research on the coconut palm, not only on some of the very pressing disease problems of certain countries, but on the general nutrition and physiology of the plant. The fact that Sampson's (1925) very commendable book is still the
chief reference for a great deal of botanical and physiological information on the coconut palm is witness to the deplorable lack of research in these fields in the last forty years.

It is heartening to know that a new Research Institute with very general terms of reference is to be set up shortly in Jamaica. In addition an FAO team will carry out detailed investigations of a suspected virus disease in the Philippines which may provide some very useful fundamental information on the palm.

A large section of this literature review is devoted to pests and diseases as these have attracted more widespread interest than any other field of research connected with the palm. The reason for this is the wide variety of pests and diseases which exist, and the extreme severity of losses caused by them in different coconut producing countries. A good number of pests are peculiar to a limited area so that they assume very considerable local importance and a great deal of effort may be expended in relatively unimportant copra-producing countries to overcome a formidable threat to the local industry. Examples of this are the correid bug causing early nutfall in the British Solomon Islands, and the Stem Borer, *Melitomina insulare* of the Seychelles.

### Mineral Requirement of the Coconut

Sampson (1958) gives the following figures relating to removal of soil nutrients in the nuts for pails on the Melaka Coast producing 120 nuts/acre. (Table 1).
Soil Conditions in relation to Coconut growth

The coconut palm flourishes on deep "beach" sands with a freely moving water table which does not remain close to the surface, or recede beyond the range of the main roots, for long periods. Sampson (1925) deals extensively with the root structure of the palm and describes its surface feeding habit. Very sandy soils are generally low in organic matter and the major mineral nutrients, so the palm relies on the ground water to supply mineral nutrients. Where coastal sand strips are backed by lagoons, in which a large quantity of organic matter decays, coconuts thrive, because of the movement of the lagoon water towards the beach.

When coconuts are planted on heavy soils root development is restricted by the physical nature of the soil and the rapid saturation in the wet season. Drying out of the surface during the dry season places the palm in conditions of severe water stress. Careful attention to drainage can assist root development, but in many countries the problem of wilt on heavy soils has precluded extensive planting on these soils.

Mineral Requirement of the Coconut

Sampson (1925) quotes the following figures relating to removal of soil nutrients in the nuts for palms on the Malabar Coast producing 128 nuts/annum. (Table 1).
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Loss per annum, gms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>877.4</td>
</tr>
<tr>
<td>Potash $K_2O$</td>
<td>627.1</td>
</tr>
<tr>
<td>Phosphate $P_2O_5$</td>
<td>127.1</td>
</tr>
<tr>
<td>Calcium $CaO$</td>
<td>140.1</td>
</tr>
<tr>
<td>Magnesium $MgO$</td>
<td>112.8</td>
</tr>
</tbody>
</table>

In addition to the above each tree loses approximately 16 fronds per annum, whose ash content is 5%. The average weight of ash per frond is 450 grams, which contains approximately 10% each of K, P, Ca and Mg in the above forms. The high potash requirement of the coconut is most notable. The coconut has a more or less even nutrient requirement throughout the year. Sampson advocated the use of mineral fertilisers on coconuts and recommended even broadcasting among palms as that encourages the spread of roots.

Wijewardene (1954) recommends that fertiliser be applied frequently and in small doses to avoid wasteful leaching losses. He holds the view that localised doses near the trunk base are more effective than broadcast applications. He believes that leaching would be more severe when the fertiliser is broadcast.

Salgado (1956) reports on the 5 x 5 x 5 NPK experiment at the Ceylon Coconut Research Institute, now in its 20th year. Potash continues to be the only fertiliser for which significant differences in yield for different levels of application have been produced. Plots receiving no K fertiliser were first given a small
dressing of K in 1951 and a marked deepening of foliage colour and improvement of growth has resulted. Over 20 years the mean annual differences in lbs. copra per acre are as follows:

\[
\begin{align*}
K1 - Ko & = 512 \text{ lb.} \\
K2 - Ko & = 420 \text{ lb.}
\end{align*}
\]

\[
\left\{ \begin{array}{l}
K1 = 0.75 \text{ lbs. } K_2O \text{ fertiliser per tree/annum} \\
K2 = 1.50 \text{ lb. ditto}
\end{array} \right.
\]

In a 3 x 3 x 3 NPK manurial trial on young palms (7 years old at the time of reporting) a notable response to Phosphate is shown in terms of number of palms in flower and nut yield. (Table 2).

**TABLE 2**

<table>
<thead>
<tr>
<th>Dressing</th>
<th>Palms in flower</th>
<th>Yield of nuts</th>
<th>Leaf number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Po</td>
<td>71</td>
<td>20</td>
<td>9.6</td>
</tr>
<tr>
<td>P1</td>
<td>216</td>
<td>903</td>
<td>11.4</td>
</tr>
<tr>
<td>P2</td>
<td>223</td>
<td>654</td>
<td>11.7</td>
</tr>
</tbody>
</table>

(F1 = ½ lb. SaphosPhosphate/palm. P2 = 1 lb. S.P./palm)

Neither Potash nor Nitrogen produced significant responses for the three indices shown in Table 2.

Halliday and Sylvester (1954) reported, from Phosphate trials on several Ceylon estates that 0.6 lb. P2O5 per tree biennially in one instance where the soil possessed "low reserves of plant food", produced marked yield increases. As a result they recommend 0.6 lb. P2O5/palm every 2 years in sandy loams and clays in Ceylon and slightly heavier dressings on lateritic soils and coarse marine sands. Murray and Lucie-Smith (1952) found in trials on several
estates in Trinidad that only low yielding palms produced significant responses to NPK. These trials were non-statistical but, unlike the Ceylon experiments, nitrogen appeared to be the component responsible for the yield increase of palms in Trinidad.

Coconut types

C.C.R.I. (1956) refers to 5 main types of coconut palm

1. Typica - the tall palm which comes to bear in 5 - 7 years and constitutes the bulk of world plantings. A little observation reveals that within this type several nut forms and palm crown forms are included.

2. Nana - the early bearing dwarf which has recently been used in hybridisation work, and

3. Javanica - a true breeding mutant from Java.

The so-called "Malay Giant" or "Chinese" coconut is a type common in Malaya which produces a very large nut with as much as 18 ozs. green copra per nut. Copeland (1931) describes groups of coconuts in the Philippines, based on average nut size. These correspond roughly (from the description) to the Malay Giant and the 3 Ceylon groups. There are several variations of fruit shape and colour, which are of no interest from the point of view of copra production.

Harland (1958) reproduces an Indian list of geographical races in the coconut, together with some data on the nuts of these different races, and this list is presented in part in Table 5.
### TABLE 5

<table>
<thead>
<tr>
<th>Variety</th>
<th>Weight of Unhusked Nut</th>
<th>Weight of Husked Nut</th>
<th>Weight of Copra per Nut</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Variety <em>Typica</em></td>
<td>1154</td>
<td>454</td>
<td>154</td>
</tr>
<tr>
<td>2 Forma <em>Laccadive</em></td>
<td>1219</td>
<td>510</td>
<td>157</td>
</tr>
<tr>
<td>3 Forma <em>pusilla</em></td>
<td>709</td>
<td>225</td>
<td>60</td>
</tr>
<tr>
<td>4 Forma <em>kappadan</em></td>
<td>1929</td>
<td>332</td>
<td>193</td>
</tr>
<tr>
<td>5 Forma <em>siamea</em></td>
<td>1899</td>
<td>737</td>
<td>221 *</td>
</tr>
<tr>
<td>6 Forma <em>gigantea</em></td>
<td>1786</td>
<td>878</td>
<td>180</td>
</tr>
<tr>
<td>7 Type <em>Adaman-ordinary</em></td>
<td>1701</td>
<td>552</td>
<td>170</td>
</tr>
<tr>
<td>8 Forma <em>Nova-guineana</em></td>
<td>1105</td>
<td>368</td>
<td>215 *</td>
</tr>
<tr>
<td>9 Forma <em>malayensis</em></td>
<td>1162</td>
<td>955</td>
<td>200 *</td>
</tr>
<tr>
<td>10 Forma <em>cochin-chinensis</em></td>
<td>1616</td>
<td>652</td>
<td>140</td>
</tr>
<tr>
<td>11 Forma <em>maldiviana</em></td>
<td>625</td>
<td>317</td>
<td>84</td>
</tr>
<tr>
<td>12 Variety <em>spicata</em></td>
<td>510</td>
<td>285</td>
<td>141</td>
</tr>
</tbody>
</table>

* Outstanding copra yielders

The relationship of these varieties to those listed above is not clear in every case. No. 1 is the *Typica* of the Ceylon work, while No. 9 is probably the Malayan Giant, and No. 11 the Malayan dwarf. Harland points out that further study is required on the relationship of weight of copra per palm to number of nuts and weight of copra per nut. It appears that the coconut exists in a large number of races and crosses of these may exhibit considerable hybrid vigour, with increased copra yields.

The Ceylon Coconut Research Institute has begun some breeding work in the way of controlled crosses of *Typica* and *Nana*...
palms. Kirthisinghe (1951) and Liyanage (1954) report on this work the technique of gathering and storing pollen, pollination and so forth. The nuts from this cross produced palms with the earlier bearing age, and smaller habit, of the Nana variety, combined with a nut size and copra yield more akin to the Typica palm. It appears that considerable scope for type and yield improvement exists, and the amount of hybridisation work will certainly increase in the future.

Harland shows that a great deal of improvement in coconut palm yields can be achieved by careful selection of high yielding parents which are prepotent for yield. As the Typica coconut is normally outbreeding the likelihood of high yielding ability being transferred to progeny is low. This is borne out by some figures from Ceylon in Table 4.

**TABLE 4**

<table>
<thead>
<tr>
<th>Selected Group A.C.E.</th>
<th>Nuts</th>
<th>Copra</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Selected seedlings from high yielding palms</td>
<td>1451</td>
<td>620</td>
</tr>
<tr>
<td>C Selected seedlings from low yielding palms</td>
<td>1506</td>
<td>585</td>
</tr>
<tr>
<td>E Selected seedlings from Heap nuts</td>
<td>1284</td>
<td>580</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unselected Group B.D.F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B Unselected seedlings from high yielding palms</td>
</tr>
<tr>
<td>D Unselected seedlings from low yielding palms</td>
</tr>
<tr>
<td>F Unselected seedlings from Heap nuts</td>
</tr>
</tbody>
</table>

From work on maize Harland found that the yield of progeny of paired high yielding crosses fell on a normal distribution with
an average the same as the yield of unselected material, but some of the crosses produced progeny with a yield of twice the average. Similarly with coconuts, a group of selected palms could be crossed in every combination to see which palms had the best combining ability in relation to nut yield. The best few could then be used to produce improved progeny for planting. Dwarf variety palms are useful for speeding up the process of identifying palms which transmit their high yielding ability, as this variety comes to bear 1 - 4 years earlier than the Typica palm. Once a maternal transmitter is identified it can be used (a) in paired crosses (b) for self-fertilisation (c) as male in extensive crosses with high yielding mother palms.

It is clear from Table 4 that the most immediate improvement in palm yields on a large scale can be achieved by seedling selection. Liyanage (1955) reports on some work on seedlings and nut selection. He failed to demonstrate significant differences in yield of palms from i, selected high yielding mother palms ii. selected high yielding blocks iii. selected low yielding blocks.

However by selecting seedlings on the basis of rapidity of germination and rate of growth, and vigour, the significantly higher yields shown in Table 4 were obtained. Harland questions the value of rapidity of germination as a selection index, and further investigation of that point is necessary. Liyanage also found a significant correlation between time taken to first flowering and the subsequent yield of a palm.
Nursery Care

Palmer (1956) could demonstrate no significant difference in rate of germination between nuts planted upright and those lain on their side in the nursery. No recommendations are made in the literature relating to treatment of young seedlings in the nursery, use of irrigation on fertilisers and so forth, considering the importance which seedling selection has been shown to have, no practices should be allowed which would in any way mask differences in vigour between seedlings.

In relation to planting out, Wijewardene (1954) states that a single post-hole of 12" diameter was a superior planting hole to one 5' x 5' x 5' in which husks were placed. This latter method led to flooding of the hole on clayey loams, and seedlings were often floated off by the husks. Most extensive plantings are done on a triangular system, as for a given plant to plant spacing more palms per acre can be planted than on the square system. Ganarajah (1954) notes that in triangular plantings more full use is made of the soil, and the ground is more effectively shaded, both factors assisting in weed control. Oblong planting, with a greater distance between rows than within rows, is used by peasants in Ceylon to facilitate inter-row cropping.

Cultural Operations on established trees

There is general agreement on the value of some form of ground cover to give extra shade and protect the soil from the sun in the dry season, and to prevent raindrop damage in the wet season. Usually volunteer species will grow profusely and must be
cut often to enable collectors to find drop nuts, and to avoid competition for moisture in times of short supply. Various machines may be used to produce a mulch from volunteer growth, or the herbage may be simply cut and left on the surface. A disc harrow is commonly used in Ceylon to control weed growth and break the soil, while many farmers still use a mouldboard plough. The latter must not penetrate more than about 2" on most soils or it will damage the roots. It has been found in countries where the presence of ants is of importance (because of their relations with other insect pests) that clean weeding forces the ants to nest more on the palms, with the result that the pest concerned may receive more protection and become a worse problem. For instance scale on coconut. The Ceylon Coconut Research Institute (Salgado 1951) recommends various grass and legume species notably *Centrosema pubescens* for planting among the trees, mainly intended to provide suitable forage for grazing cattle. Goonesekera (1954) reports that there are 1 million cattle grazed on the 1 million acres of coconuts in Ceylon. When improved grasses are available the cattle will graze them, but this is seldom the case at present in Ceylon so the young supplies must be protected, otherwise cattle will destroy them. The points for and against grazing cattle under coconuts may be summarised as follows:

**For:**

1. Cattle help to keep the herbage under control.
2. They provide urine and dung of some manorial value.
3. The grass return per acre is increased.
4. The shade of coconuts provides cooler conditions for cattle.
Against:

1. The cattle may destroy young supplies.
2. Cattle tramp the ground, compacting it and will break the edges of drains. (de Silva 1955).
3. Fencing must be provided to confine cattle.
4. They may be injured by falling nuts.

Regarding the disposal of fronds and husks, Sampson (1925) recommends they be burnt to provide readily available minerals. Salgado condemns this practice as being wasteful of organic matter, but the value of husks as a source of organic matter can only be slight. They can possibly provide a breeding-place for pests, though there is no clear proof that pests do breed in husks.

Drainage

Drains have been proven essential in large scale plantings to prevent waterlogging in the wet season, particularly where the soil is at all clayey, which is the case in many Ceylon plantings. The construction of slightly cambered beds with a channel between is a common method. These channels will require considerable labour to keep them clear, particularly if cattle are grazed under the palms. Where gently cambered beds without a channel are used, though drainage will be less rapid, considerably less cost is involved in construction and freer movement of vehicles and implements is facilitated. Regarding fertiliser application, hand application in a circle around the tree (though the benefit of fertilisers is not yet very fully realised by many producers) is the most common method. In Ceylon, where emphasis is placed on obtaining a good stand of grass between the trees, the use of a manure spreader is recommended, although Wijiwardene (1954) points out that fertiliser wastage due to leaching is less when it is placed locally about the tree.
Copeland (1951) compiled a detailed list of insects which attack the coconut palm. These pests could be divided into classes according to the part of the palm on which they feed; thus we have stem, leaf and fruit feeders. Further subdivision into primary and secondary pests can be made, and this is the basis on which the following list has been compiled. Only the economic pests of coconuts are listed below, together with the distribution of each one.

Dumbleton (1954) produced an exhaustive list of the pests of the coconut palm in Oceania and the Pacific Islands, which has provided useful information for the list, and likewise the report of Donawa (1954).

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Stem Attackers</strong></td>
<td></td>
</tr>
<tr>
<td>Oryctes rhinoceros and other Oryctes spp.</td>
<td>India to the Philippines, Palau, Fiji, Samoa. Attacks the crown of the palms.</td>
</tr>
<tr>
<td>Strataegus spp.</td>
<td>American tropics and the Caribbean Islands</td>
</tr>
<tr>
<td>Melitomma insulare</td>
<td>Madagascar and the Seychelles</td>
</tr>
<tr>
<td><strong>2. Leaf Attackers</strong></td>
<td></td>
</tr>
<tr>
<td>Artona catoxantha</td>
<td>Indonesia, Malaya, Burma, Western New Guinea.</td>
</tr>
<tr>
<td>Levuana iridescens</td>
<td>Fiji.</td>
</tr>
<tr>
<td>Brassolis sophorae</td>
<td>Trinidad and tropical South America.</td>
</tr>
<tr>
<td>Nephantis serinopa</td>
<td>India and Ceylon.</td>
</tr>
<tr>
<td>Brontispa longissima</td>
<td>Solomon Islands and other Melanesian Islands. Australia, New Guinea, New Caledonia, New Hebrides.</td>
</tr>
</tbody>
</table>

contd/-
Only pests of considerable economic importance are dealt with in detail in the following text. Clearly many insects may be recorded on a plant, feeding on the foliage or damaging it in some way, without those insects being of very much significance as a pest on that plant. A notable feature of the insect pests of the coconut is the geographical localisation of even the more important ones. For instance Oryctes rhinoceros, and Rhyncophorus ferrugineus (neither of which occur in the New World or many parts of the South Pacific) are the most widespread pests, but their further spread is relatively simple to control. The fact that many important coconut areas are islands, sufficiently isolated from the nearest land masses to have a fairly peculiar insect population, is of great significance from the point of view of pest control. Examples will be dealt with for which biological control was very successful after a pest from one area was accidentally introduced into another area. When the predators of Aspidiotus destructor were taken from Trinidad to the new outbreaks of that pest in Fiji, they
obtained very effective control, due in large measure to the absence of certain insect species which reduce their effectiveness as a control of scale in Trinidad.

Because many coconut areas are remote islands the amount of commercial traffic touching them is small and quite simple precautions are effective in preventing the introduction of new insect pests.

**Hymenopterous Pests**

I. *Artona catoxantha*. Occurs in Malaya, Sumatra, Java, Borneo, Western New Guinea and Burma. (C.I.E. Map No. 55). The caterpillars of the Zygaenid moth swarm on the foliage and may damage it enough to reduce the nut yield almost to zero, but they seldom cause palms to die. Gater (1926) noted that in Indonesia the parasite *Ptychomyia remot a* achieves only partial control of *Artona*, being itself parasitised by several other species of insects.

II. *Levuana iridescens*. Occurs as a pest only in Fiji. The introduction of *Ptychomyia remot a* from Malaya to Fiji achieved very effective control, in the absence of the enemies of *Ptychomyia* (Tothill et al. 1950). The large number of overlapping broods of *Levuana* made possible a rapid build-up of the introduced parasite, thus effecting control very rapidly indeed.

III. *Brassolis sophorae*. Occurs in the New World, notably on the mainland of South America. It has been reported occasionally in the Southern Caribbean islands too. Periodic deficiency in parasitism (Cleare and Squire 1954) permits sporadic outbreaks, when the caterpillars consume large amounts of foliage and can strip a
tree sufficiently to cause its death. Clean cultivation among the palms has been found to keep the incidence of this pest down in British Guiana.

IV. *Nephantis serinopa*. Occurs in India and Ceylon and is the only important Lepidopterous pest in those countries, where it is called the Black headed coconut caterpillar. Jayaratnam (1941) points out that the pest is indigenous to the Eastern Coast of Ceylon but is unnoticed as a pest there as it is parasitised by *Trichospilus pupivora*. The larvae of *Nephantis* feed on palm leaves and build silken tunnels. A heavy infestation can defoliate a palm. Nirula (1952) achieved effective control with a 0.1% D.D.T. spray.

Correid Bugs and Early Nutfall

I. *Pseudothertantus wayi*. Occurs in East Africa on the coastal parts of Kenya and Tanganyika and the islands of Zanzibar, Pemba and Mafia. The damage this bug causes is described by Way (1955) as "gumming disease and premature nutfall". The older nymphs and adults insert the proboscis into young nuts, of up to 14 weeks of age, and while feeding inject a substance which causes abscission of the nut. One bug can make 200 insertions in its lifetime so that even very light infestations may produce serious nut losses. Way found that heavy bearing palms lost a higher proportion of their crop, probably because a larger build-up of bugs occurred. An ant, *Fheidole* sp. was found to encourage *P. wayi* by driving away from palms another ant, *Decophylla* sp. which can keep the correid population under control. A third ant, *Anoplolepis* sp. had a similar effect to *Fheidole* sp. in relation to *P. wayi*; but leaving a rough vegetative cover in *Anoplolepis* populated areas discouraged this
ant and led to reduced incidence of early nut-fall.

II. *Amblypelta cocophaga* (China). Occurs in the British Solomon Islands on Malaita, Guadalcanal, Nggela, San Cristobal and some islands in the Western District (Brown 1957). Though early nut-fall was recorded first in 1911 in this island group, it was not till 1956 that Lever (1956) established *A. cocophaga* to be the cause. Early nut fall has become a serious threat to the coconut industry particularly on Guadalcanal where the largest plantings are established. Phillips (1956) reports on the relationship between *A. cocophaga* and certain species of ants. *Pheidole megacephala* was found to be present in nutfall areas, while *Oecophylla smaragdina* inhabited good-bearing palms. Another species, *Anoplolepis longipes* was also found associated with good bearing (or absence of nutfall) but was not quite as effective as *O. smaragdina* in bringing about the disappearance of *A. cocophaga* from palms.

On Malaita, *Iridomyrmex myrmecoidae* was found inhabiting nutfall palms. Marked changes in the incidence of nutfall, which were brought about by changes in the ant species distribution, followed the U.S. Army occupation of B.S.I. Tests showed that the insecticide used in Guadalcanal in the weekly anti-mosquito aerial sprayings was more lethal to *Pheidole* sp. than to *Oecophylla* sp.

Because an economic means of killing the bug by direct spraying does not exist (it being uneconomic to spray the coconut crown, and in addition Brown (1957) noted the existence of a reservoir of infestation of the bug on several species of forest trees in the jungle), efforts have been concentrated on finding a way to modify the ant population in such a way as to eradicate correid bugs from plantings. Various spraying experiments have been tried to
encourage *Decophylla* and *Anoplolepis*, thus ousting the other ants from palms, and according to Brown (1956) some success has been achieved with a build-up of *Anoplolepis*. It does not however, hold out any hope of an early control of *A. coccophaga* being achieved in these islands.

**Scale Insects**

*Aspidiotus destructor*. Occurs in Trinidad and the rest of the West Indies except Jamaica, and is present in almost all other coconut lands of any importance. Taylor (1935), who was largely responsible for the biological control of this scale in Fiji, deals with its life history in detail. The eggs hatch beneath the scale of the female and larvae wander in search of a suitable site to insert their rostrum and become sedentary. The male has a pale reddish scale while the female is yellowish in colour. *A. destructor* has been reported on a very large number of other plants, notably bananas, *Piper* spp. and *Barringtonia* spp. in Fiji. The scale feeds mainly on the under sides of leaves of the coconut palm causing premature yellowing and death, hence reducing nut yields. The following is a brief account of the very successful control programme in Fiji.

*Aspidiotus destructor* was first noticed in Fiji in 1917 and by 1927 had become a very serious pest, widespread throughout the more important coconut areas in the Fiji group. Spread from one tree to the next, and from one area to another, takes place on birds, large insects and infested foliage and nuts. The limited powers of locomotion of the scale larvae permit unassisted spread only on the foliage of an infested tree. There was a
notably higher incidence of scale in the wetter parts of Fiji and in dense coconut groves protected from strong wind.

Predators of coconut scale were introduced from Java and Trinidad, and it was one of the coccinellid beetles from Trinidad which very effectively arrested the further spread of the scale and finally reduced its occurrence to an insignificant level. Taylor lists the reasons for the success of the coccinellid Cryptognantha nodiceps in controlling scale as follows:

1. *C. nodiceps* breeds continuously throughout the year.
2. Its natural enemies (which modify its activity considerably in Trinidad) are absent from Fiji.
3. Its larvae are extremely voracious and eat only the scale if possible.
4. The coccinellid has a long adult life and the female lays many eggs. The third or even fourth generation has been produced before the original individuals die, so a very big population is built up.
5. It can disperse widely in search of food.
6. It can survive even if scale has been reduced to a very low level as alternative food is available in Fiji.

Little is known of the severity of scale damage in other coconut lands, and it does not appear to be a major threat anywhere. It is, however, the type of insect pest whose importance is very easily underestimated, so more serious attempts to reduce its incidence should be made in other countries.
Coleoptera

I. Oryctes rhinoceros. The "Rhinoceros beetle" of Asia and the Pacific area. It occurs in India, Ceylon, Burma, Indochina, Malaya, Pakistan, Philippines, Fiji, Palau and several other small Pacific islands. (C.I.E. No. 54). Contrary to early reports Oryctes does not occur in East Africa, Zanzibar, Mauritius or the Seychelles though other unimportant members of the same genus occur in these countries (Gressitt 1955).

C. Ambrose Wickremansuriya (1955) describes the damage done by the Rhinoceros beetle in Ceylon as follows: "ragged appearance of mature leaves as if cut about with scissors, irregular apertures towards the leaf base, holes in the stem just below the crown, and partly damaged inflorescences". The beetle attacks the "cabbage" of palms to obtain the sap, but only rarely causes outright death of the palm. The damage done by Oryctes leaves the tissues open to attack by the Palm Weevil, Rhynocorphorus ferruginas, and the fungus Phytophthora palmivora, which may both kill the palm. The beetle attacks young palms most commonly, and in Ceylon the dwarf palm is very susceptible to attack. Breeding occurs in compost, farmyard manure, dead palm wood and in the wood of certain jungle palms. Gressitt reports on the tremendous build-up of Rhinoceros beetle on Palau in the wood of palms killed by war. Control has been obtained in Palau by cleaning up all the dead wood and introducing Pachylister chinensis, a predator from Western Samoa. In Ceylon one method of control, by inoculating compost traps with the fungus Metarrhizium anisophae which kills the larvae of the beetle, was not very effective. Painting the leaf bases with Mason's mixture, a tarlike repellent, protects palms quite
effectively in Ceylon. Wickremansuriya is of the opinion that an undiscovered predator prevents the build-up of a really serious infestation. Oryctes was accidentally introduced into Fiji in 1955, and O'Connor (1955) reports that eradication attempts were unsuccessful. Control of further serious spread has been achieved using compost traps 15" square and 24" deep filled with a 9:1 mixture of sawdust and coconut meal soaked in B.H.C. The same mixture placed in the axils of leaves provides protection from the beetle for several months. Some Histerids were introduced from Trinidad to Fiji in 1954 in an attempt at biological control which was unsuccessful. Fiji Department of Agriculture Annual Report (1957) states that the beetle continues to spread and the search for a suitable parasite is being extended.

2. *Strataegus* spp. The "Rhinoceros Beetle" of the New World. Members of this genus are widely distributed over South and Central America and the West Indies (Donawa 1954). Planck (1953) notes that *S. quadriforeatus* caused severe damage to seedlings in Porto Rico in the 1950s following a build-up in palms damaged by the hurricanes of 1928 and 1932. The beetle enters young seedlings at or below ground level and works up to the growing point inside the outer leaves. It destroys the growing point by chewing it, thus killing the young tree. The use of fine-mesh wire-netting (\(\frac{1}{2}\)") around young trees was the only effective protection found in Porto Rico. In Trinidad some estates claim that planting nuts on end provides protection against Rhinoceros beetle (*S. anachoreta*) as the stem arises vertically and is not close to the ground in the nursery. It is held, in the case where nuts are planted on their side, that the shoot
commonly emerges almost horizontally and curves upwards after emerging and the beetle can enter the stem more easily at the point of curving. Soaking nuts in dieldrin before germination, and pouring dieldrin around the base of young supplies in the field is the common method of protection used in Trinidad. Other species of the genus are *S. aloëus* in British Guiana and Brazil, and *S. titanus* in Jamaica. Plant sanitation, to reduce the breeding places of the beetle, is important in obtaining control.

5. *Rhyncophorus ferrugineus*. The Red Palm Weevil occurs in all coconut countries in South East Asia but most of the Pacific Islands are free of this pest. It is the most serious world pest of the coconut palm and no means of eradicating it from established areas exists at present. It is chiefly secondary in its attack, and enters small wounds in the stem, or wounds from Rhinoceros beetle damage, in the crown.

Salgado (1952) notes that the weevil breeds profusely in decaying palm crowns. Nirula (1952) reported that 1 part of Pyrethrin and 10 parts Piperonyl Butoxide sprayed at 1% strength on infested palms provides an effective control in India. When the weevil is well established in the stem of a palm the only effective control is to cut off the riddled wood and paint tar on the clean surface beneath.

4. *Rhyncophorus palmarum* - occurs in tropical America and the West Indies. It is called the "Gru-gru Weevil" in Trinidad and is quite a serious secondary pest. Attack is similar
to that a R. ferrugineus, and scorched palms, affected by burning debris near to them, are very susceptible to attack. Hygiene methods and scrupulous avoidance of injury to palms are the control measures employed. The weevil was suspected as an agent in the spread of "Red Ring" worms but the disease spreads in areas where the weevil is absent in Trinidad.

5. *Promecotheca reichei* - occurs in Fiji, Tonga and Samoa where it is called the "leaf mining beetle". It is indigenous and was unimportant as a pest in Fiji until a mite was introduced to control another pest. The mite disturbed the relationship between a natural predator and *P. reichei*, so that the latter became a serious pest on coconuts. Taylor (1937) reports that the introduction of a further parasite of *P. reichei* has brought it under control. Other *Promecotheca* spp. attack coconuts in Oceania and the Far East.

6. *Melitomma insulare* - occurs in the Seychelles and Madagascar where it is a very serious pest. The larva of the beetle attacks the base of the palm and tunnels vertically in the in the sappy central tissue. A relationship generally exists between the beetle and a bacterium which enters the tunnels made by *M. insulare* in the tissue, and produces a fluid on which the beetle feeds. The base of infested trunks has a dark appearance, and if seen early it is possible to arrest the insect by cutting away the outer tissue and painting the exposed tunnels with para-dichlorobenzene. *M. insulare* attacks mainly young trees less than 7 years old. The progressive hardening of the stem-base with age appears to make it resistant to attack. Outbreaks are worst where large
numbers of supplies occur together and where drainage is poor. Planting only on deep coral sands and staggered supplying are recommended, to avoid attack.

7. *Brontispa frogatti* has recently been shown to be indistinguishable from *B. longissima*, Gestro. It occurs in British Solomon Islands and New Caledonia. B.S.I.R. (1957) states that this small beetle which may severely damage young palms, can be readily controlled by spraying every 6 weeks with dieldrin, chlordane or D.D.T.
DISEASES

A geographical localisation of particular diseases of the coconut palm exists, rather similar to the state of affairs relating to the pests. The picture is less clear in relation to diseases however as in a number of different countries palms die from diseases with which a pathogenic agent has not yet been associated. The tendency has been to attribute such losses to adverse physical and chemical soil conditions. Recently certain characteristics of the "Unknown Disease" of Jamaica, and "Bronze Leaf Wilt" of the Southern Caribbean and West Africa have cast suspicion on the idea that no pathogenic agent is involved. Two diseases of coconuts in the East - "Kadang-Kadang" of the Philippines, and "Root Disease" of India, have long been regarded as being primarily physiological or nutritional, because no pathogen could be isolated; but intensive and thorough research is needed to clarify the position. Up till the present only two lethal pathogenic agents, *Aphelencoides cocophaga*, which causes the "Red Ring" disease of Trinidad, and *Phytophthora palmivora* which causes "Bud Rot" have been isolated. A number of fungi attack the stem or foliage of the coconut palm but their spread can be arrested, before serious damage is incurred, by removing the affected parts and providing some fungicidal protection.

Far less precise information, regarding the incidence of diseases, is available than for insects, and the literature is distinctly vague concerning the world distribution of certain fungi. Only the more important fungi, according to Briton-Jones...
(1940), are included in the following Review. A far more lengthy list of fungi, which have been recorded damaging coconut palms, exists. Dumbleton (1954 a) presents a list of parasitic organisms for the Pacific area which includes one virus, one bacterium and seventeen fungi.

Physiological Diseases

1. Bronze Leaf Wilt. Occurs in Trinidad where large areas of palms died out in the 1920s, showing the characteristic wilt symptoms. The oldest leaves begin to go yellow and finally brown, successively, until only a few of the youngest leaves remain green. All the nuts are shed by this time. Eventually the remaining leaves brown off and the palm dies. In Trinidad these symptoms occurred only in palms on certain kinds of soil, and the disease presented no systematic pattern of spread, which suggested that no parasitic organism was involved. The work of Hardy (1925 - 1955) at I.C.T.A. led him to conclude that a restriction of root development, due to certain soil factors, was responsible for severe water shortage in the dry season. This led to death of the tree from severe physiological stress. He defined three types of wilt soils as follows (Bain - 1957).

i. Surface soil close textured overlying a subsoil which is impervious to water. (Rapid waterlogging in wet season, quick drying in dry season).

ii. Soil and subsoil open-textured and free draining. Poor moisture supply in dry weather. (No water table in the dry season).

iii. Friable surface soil but intolerant subsoil with a marl layer or other impedance to root development.
Similar wilt symptoms followed by death have been noted in India, Ceylon and East and West Africa according to Briton-Jones (1940). Leather (1958) in a report on "Cape St. Paul Disease" of Ghana notes the close similarity of symptoms and soil conditions to those connected with wilt in Trinidad. Martyn (1955) states, in relation to "awka" disease in Southern Nigeria that it throws new light on Bronze Leaf Wilt, as apparently the same disease occurs on deep friable soils there, and there have been two distinct epidemics in that area. However the position of Bronze Leaf Wilt in the West Indies in relation to the soil types of which it occurs and the lack of epidemic tendencies, is reasonably clear and it is rather confusing the issue to assume that "awka" disease is exactly the same disease. Considerable research is needed, on the water and mineral uptake, and general behaviour of the coconut on different soils, before the position can be clarified fully.

II. Unknown Disease. Occurs in Jamaica where it was first reported before 1900; it was for many years regarded as being the same as Bronze Leaf Wilt of Trinidad. Nutraan and Roberts (1955) note that it now occurs in the Cayman Islands, Haiti, Bahamas and possibly also Cuba. Leach (1946) describes the symptoms and explodes the idea of any similarity in cause to Bronze Leaf Wilt. The outer leaves go yellow, then brown, all nuts are shed and finally the leaves dry up; the young spathes are blighted, unilaterally at first. The leaves drop but fall from the palm without hanging against the stem. Whole plantations on excellent coconut soils have been destroyed. Sometimes the manner of spread suggests a pathogenic agent, while in other areas no sign of progressive spread can be seen at all. Martyn (1949) believed that some patho-
gen was involved, but admitted that placement of soil from around diseased palms close to the roots of healthy palms failed to produce disease symptoms. Nutman advances strong evidence that some pathogenic agent is involved. They noted that sodden patches develop in the heart leaves and at first no organism can be isolated, though presently saprophytic fungi invade the leaves. Sterile necrotic roots have occasionally been found; and in the cells of leaves, double, and sometimes multiple, nuclei occur. They suggest that a virus is the cause, but could not carry out transmission tests. The Malayan Dwarf palm has been notably free from infection in Jamaica, and these authors suggest using it to develop a commercial palm resistant to the virus of Unknown Disease, or "Lethal Yellowing" as they call it.

III. Kadang-Kadang. Occurs in the Philippines, and according to one report (FAO 1957), is one of the most serious diseases affecting the coconut industry, and causes an annual loss of over £50 million sterling. The disease was first noted in the Bicol provinces in 1928 and has since spread to Masbate, Saman and several small islands in that region. Estimates indicate that up to 1955 five million trees had been destroyed by the disease. Celino (1947) summarises the symptoms as follows: yellowing of the leaves (and falling off in nut production) which slowly progresses with the leaves becoming smaller, so that it may be four to six years before the tree dies. A pathogenic agent, possibly a virus, is indicated, as the leaves develop distinct water soaked lesions and the spread of the disease is from definite foci. Nutritional trials carried out on seedlings (Escritor 1955/56) gave no positive indication that the disease is a simple nutritional effect. This same report noted that the soil in Kadang-Kadang areas always showed a high nematode
FAO has recently agreed to provide a team to investigate the disease and attempt to determine its cause, with a view to devising control measures.

IV. Root Disease. Occurs in the Travancore-Cochin area of India and was first reported in 1882. The progression of the disease resembles "Kadang-Kadang" quite closely. By 1930 losses were very heavy and in 1937 an Investigation Scheme was undertaken. Menon and Nair (1951/52) describe the symptoms as follows: outer whorl of leaves goes yellow and leaflets begin to dry up from the tips; the yearly production of leaves is reduced so the number of leaves in the crown becomes smaller; the nuts are shed, and later developing spathes are smaller and weaker, eventually failing to open altogether; finally the palm is exhausted and the heart of the crown dries up. If improved cultivation is carried out the symptoms are masked and the palm may survive much longer. This led to the idea that a nutritional deficiency was involved, as all soils where the disease was most common showed a paucity of essential nutrients. Also the outer and middle leaves of diseased palms were lower in potassium than those of healthy plants. At the present time detailed nutritional studies are being carried out to discover whether a certain mineral deficiency predisposes the roots of the palms to invasion by facultative soil fungi. Menon and Nair suggest three points which favour a virus hypothesis however.

1. Nature of the leaf chlorosis, and the necrosis of roots.
2. The manner of growth stunting.
3. The masking of symptoms during periods when good growth conditions prevail.
As yet the hypothesis has not been thoroughly tested experimentally, but the recent indications of virus infection in Jamaica's "Unknown Disease" lend strength to the idea.

V. Pencil Point - the morphological effect of drought and malnutrition over an extended period. Briton-Jones deals with it in detail.

Bacterial Diseases

Briton-Jones (1940) discounts the idea that bacterial organisms are responsible for any diseases in the coconut. Nowell (1925) believed that bacterial bud-rot occurred but it seems certain that a secondary bacterial invasion of the crown, following death due to Bronze Leaf Wilt or other causes, was all that he observed.

Fungal Diseases

I. Bud Rot. Was first reported in Cuba in 1870 and is known to occur in all coconut countries including many of the Pacific Islands (Dumbleton 1954 a). The fungus Phytophthora palmivora is the causative organism and infects the tissue of the growing point of the palm. The first sign of infection is withering of the heart leaf followed by those around it. Then the older leaves wither and die, the oldest first. Briton-Jones (1940) states that the disease occurs in either wet or dry season in Trinidad and he recommends burning of palms which die of bud rot. The disease only becomes epidemic after severe hurricane damage and Martyn (1955) is of the opinion that the fungus can only gain entry to damaged tissue. Certainly attempts at artificial infection with the fungus
have never succeeded on healthy tissue. Certain insects, for example the rhinoceros beetles (Oryctes spp. and Strategus spp.) may be important in predisposing palms to Bud Rot infection. As a prophylactic measure the Ceylon Coconut Research Institute recommend spraying all palms surrounding an infected one with Perenox at two-weekly intervals until the infected palm is removed.

II. Stem Bleeding Disease. (Ceratostomella paradoxae).
According to Briton-Jones (1940) this occurs in all the major coconut countries, and Dumbleton (1954 a) notes that, in the South Pacific Commission area, it occurs in Australia, New Guinea and New Hebrides. Goonewardene (1955) describes the symptoms as follows: a red fluid emerges from the affected part of the stem, which, when cut, appears rotted, yellow or black in colour. The fungus enters at points of injury and may extend several feet up the stem. The usual control is to cut away the affected tissue and paint the surface with tar, sump-oil or some fungicidal paste. The disease is generally associated with damp, poorly drained, soil conditions. Thus good drainage, and care with cultivation implements to avoid injury to palms, can prevent the occurrence of stem-bleeding disease altogether.

III. Grey Blight (Pestalozzia palmarum and Diplodia spp.).
These fungi have been reported attacking the leaves of palms in Jamaica and Ceylon, but Briton-Jones (1940) regards their presence as purely secondary, being dependent on the palm receiving a severe physiological check due to mineral deficiency or other causes.

IV. Thread Blight (Corticum penicillatum). Occurs in the Pacific area in situations of very high humidity (Briton-Jones 1940),
(Dumbleton 1954 a). The fungal mycelium runs along the midrib of leaves and ramifies over the surface of leaflets, thus killing them. Affected leaves fall early. The disease is not of very great economic significance and no control measures are worthwhile at present.

V. Leaf Disease. Occurs in India and is described by Menon and Nair (1951/52) as follows: Blackening and shrivelling of distal ends of leaflets, reddish brown spots on tender leaves and midribs, affected parts snap off in the dry weather. Hardening of leaves with maturity arrests the progress of the disease. Mainly palms under 25 years old are affected, palms are seldom killed outright, but the disease causes a reduction in nut yield.

Several fungi were found associated with the affected parts and the following three fungi produced Leaf Disease symptoms when inoculated onto healthy tissue. Helminthosporium spp., Gloeosporium spp. and Gleocladium spp. Infection is most severe during the monsoon season. No control measures have been devised yet.

Martyn mentions numerous other fungal diseases of minor local importance which affect the foliage or the nuts of the coconut palm, but none merits any mention in this report.

Nematode Diseases

As already mentioned the nematode count of Kadang-Kadang soils is above average, but no positive evidence of nematodes in the diseased trees has been produced. A disease affecting young palms in the West Indies and whose cause was a mystery for many years,
was finally shown by Nowell (1925) to be due to a nematode entering the stem of the young palms and causing death quite rapidly.

**Red Ring (Aphelenrocoides cocophilus).** Occurs in Trinidad, Barbados, St. Vincent, Grenada, Panama, Honduras, Venezuela and British Guiana. Briton-Jones (1940) describes the disease as follows: conspicuous yellowing and wilting of the outer leaves, which finally become bronzed and collapse to be succeeded rapidly by the younger leaves. The stem in cross section shows a conspicuous red ring of lysed tissue caused by the presence of the worms of *A. cocophilus*. Most commonly trees between four and ten years of age are attacked, though occasionally older trees become infected. Recovery has never been recorded. The disease has caused very severe losses in Trinidad where extensive replanting is taking place. The pattern of spread within estates is the typical haphazard distribution of a nematode, which is carried mainly on soil contaminating vehicle wheels, labourers' boots and so forth.

Moist, poorly drained soils appear to favour the worm, because generally Red Ring incidence is heavier on such soils. A research programme has been undertaken in Trinidad to study the relationship of the worm to the palm, the mode of infection and so forth, with a view to devising control measures. Nematocides like Nemagon do not appear an economic means of eradicating the worm, though there is a need for trials to be done to elucidate the behaviour of such materials in tropical soils.
Establishment of Coconut Plantings

The acreage of coconuts is being continually expanded in Ceylon on virgin lands and the sites of cultivation of other plantation crops. Ganarajah (1955) lists the following conditions necessary on a planting site:

(i) The soil must be of at least average fertility and not liable to water-logging.

(ii) The rainfall must be between 50 and 80 inches and well distributed.

(iii) The elevation must be below 1500 ft., above this yields are reduced and nuts are small.

(iv) The land should not be too steep or rocky. There should be no impermeable hard pan of clay, rock or conglomerate close to the surface."

Sampson (1955) discusses the choice of site for coconuts in relation to drainage, slope, inherent fertility and existing vegetation. It seems advisable to cultivate the site thoroughly before commencing to plant seedlings, in order to obtain control of any weed species which could otherwise become troublesome later.

By far the most important part of coconut planting in the next 10 years will be replanting in old stands of palms. Extensive coconut planting was done shortly before the turn of the century and these palms are now reaching the end of their economic life. Furthermore, expansion of the coconut industry to meet the increasing world demand for vegetable oils must be considered with caution in
view of the superior productivity of the oil palm. Whereas a highly productive coconut estate in Trinidad or Ceylon will produce 1200 lbs. of edible oil per acre per annum, a plantation of "Deli" oil palms (*Elaeis guineensis*) in Malaya may produce over 5000 lbs. of oil per acre per annum. Hence the expansion of coconut plantings in terms of world acreage seems unlikely. Expansion of peasant plantings will of course continue in countries like Ceylon and the islands of Oceania where the coconut is very intimately bound up with the way of life of these peoples.

The coconut palm possesses a wider range, in terms of latitudes within which it is grown, than the oil palm. This is bound up to some extent with the natural association of the coconut with sea-shores. The modifying effect of proximity to the sea in reducing wide temperature fluctuations allows the range of coconuts to exceed 20° North and South of the equator. The greater part of areas which could be further exploited with commercial plantings of coconuts are well within the above limits however, and are also, generally speaking, quite suited to the culture of oil palm. Already oil palm has been grown experimentally with some success in the territory of Papua and New Guinea (Private Communication). The palm kernels were exported to Australia for extraction. If an expansion of plantation oil crops ever occurs in the area of Oceania this writer feels that it will be with *Elaeis guineensis* and not *Cocos nucifera*.
PART II

TRINIDAD SURVEY

General Statistics relating to Coconuts in Trinidad and Tobago.
(Central Stats. Off. 1956).

Total Acreage - 41,824. 3,096,000 trees with 559,000 more trees in subsidiary plantings, in gardens, etc. A total of 4,951 holdings with coconut plantings.

Table 1

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<th>Size of Holding</th>
<th>No.</th>
<th>Acreage</th>
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<tr>
<td>1000 acres</td>
<td>18</td>
<td>11,357</td>
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Method employed in the present study

The aim of this non-statistical survey was to gain first hand knowledge of all aspects of coconut production in Trinidad from the seedling to the mature nut stage. This type of study has been undertaken before (Palmer 1956) and was aimed mainly at making the author thoroughly familiar with coconut production under local conditions. All information has been gathered in Trinidad only. The method employed was simply to interview the managers of different selected estates, and the peasant proprietors on small holdings, and to observe in the field any features of particular interest. In some cases managers produced records for perusal but generally, accurate, reliable information relating to soil and rainfall, for
example, was not forthcoming. In all 11 estates were visited, having a total acreage of about 10,000 and peasant or small scale producers whose size of holding varied from 6 - 35 acres.

The main plantings of coconuts in Trinidad are in the Cedros area, along the coastal sand from Manzanilla to Guayaguayare, and from Matura along the coast to Toco, and in the Toco area. These are the areas which were visited in the course of this study. Other plantings of small extent exist around Blanchisseuse, at Golden Grove (near Piarco) and along the Churchill-Roosevelt Highway about 5 miles from Port of Spain. There are scattered plantings along the main road to San Fernando also.

Environment of Coconut plantings

Average rainfall ranges from 60 to 100 inches. The majority of plantings are on coastal sands and sandy soils contiguous with them. The end of Cedros peninsula consists of a deep sand and apart from some areas of swamp is planted entirely to coconuts. In the Mayaro area most plantings are on the flat sands but do extend to the heavier undulating land behind; invariably yields were reported to be poorer on the heavy land. In situations where fresh-water swamp adjoined the coastal sands, providing a constant supply of water containing nutrients from decayed organic matter, the coconut palms were healthiest and required least management to keep them bearing well. When the rainfall is below average over an extended period, so, the water level in the swamps is low, trees suffer notably from wilt and nut yields are reduced markedly. Such is the case from the period 1957 - 1959 in Trinidad.
Age of Plantings and General Features

A very great variation of tree age exists between estates. On estates unaffected by the hurricane of 1955 extensive plantings aged around 80 years exist. Hurricane damaged areas have most trees around 25 years of age now, at the stage of full bearing. Generally the old plantings are being systematically supplied and many more old palms would have been removed but for the very acute losses of supplies dying from Red Ring. The old trees, though bearing only very few nuts in many cases, are at least yielding some return and are retained until supplies come successfully into bearing.

Younger plantings aged less than 50 years are on the triangular system, at 50' spacing on sand. Older plantings are usually on the square, at 28' or so, and often supplying is being done on the same system to avoid inconvenience in mechanical operations while the old trees are still there. On the estates considerable attention is given to drainage to avoid flooding in the wet season. A very elaborate system is used on heavy land with every row of trees on a graded bed with a trench between each to remove surplus water. In one case a very marked increase in general vigour and in yield, obtained when such grading was carried out. In two cases the incidence of bleeding stem disease was greatly reduced by drainage, and on most estates the incidence of Red Ring was believed to be higher where drainage was poor.

Interplanting

Quite a variety of crops are planted among coconuts in Trinidad though generally on a small scale. Several estates have
a few acres of limes interplanted and a small banana planting was present on another estate. Peasant farmers naturally had food crop trees, like breadfruit and oranges and grapefruit and cassavas among the palms. One peasant grew pineapples among his palms leaving a 4' square area free around the base of each palm. He claimed that he did not fertilise the pineapples (all palms received 1 lb. Sulphate of Ammonia per annum) yet the trees with pineapples around them yielded more nuts than the rest. A possible explanation is that the area under pineapples was clean weeded all the year while the rest of the holding was cutlassed only once a year.

Establishment of grasses

The general problem in Trinidad is the relatively severe dry season, and a wide variability in total annual rainfall. One estate in the Cedros area, where the average annual rainfall is 55" over the last 50 years, has recorded 59" and 81" in two separate years within the last ten. Clearly there will be little moisture in the soil during much of the dry season, and any cultural practice which will intensify this shortage does not bear consideration. It was notable therefore that only those estates particularly well favoured by the tidal flow of underground water had given any serious consideration to establishing grass and cover crops between the palms. Trinidad lags far behind countries like Ceylon in this regard, as there has been a movement for many years in Ceylon to diversify coconut holdings by establishing improved grass and legume species to provide grazing for cattle. One important reason for the lag is that nuts are collected as drop nuts in Trinidad and that the collectors work most efficiently where the undergrowth is kept short. Another factor is that estates are geared to nut
production only and are generally making good economic returns without investing capital in what appears, with existing standards of management on estates, to be a rather unsound enterprise.

The one case where serious attempts had been made to find improved species to provide cattle feed, and devise a satisfactory system of management, was that of an estate of young trees, replanted after the 1951 hurricane. Several species of grass are being tried on this estate under a soilage system of management, but as yet no plan for extensive grass production is planned. Species under trial include Pangola grass (*Digitaria decumbens*), Dallis grass (*Paspalum dilatatum*), Sudan grass (*Sorghum sudanense*), and Guatemala grass (*Tripsacum laxum*). Points worth noting in relation to such trials are:

I. The difficulty of picking up nuts from the ground when a thick sward is established.

II. The need for a greater nutrient supply, to be met by increased fertiliser dressings. The problem of discovering the most economic rate of fertiliser dressing on grass plots between rows of palms would require a carefully planned statistical experiment of the type done by a specialised research establishment. It is unlikely that any helpful information of this sort would be available for a long time as the whole question of stock and pasture management under tropical conditions is very much in the experimental stage.

Several Trinidad estates run small flocks of one hundred or so sheep, but very little effort is made to manage the flocks, the managers being content to trust to luck that a few animals
will be available for sale each year. The risk of loss due to larceny is quite high, and disease losses are very high too, so few managers see any point in spending money on an enterprise which can easily come to nothing. Generally one or two boys are employed as shepherds, and they simply confine the sheep on to the estate, and see that none are stolen in daylight. In the evening the flock is brought to the estate buildings and penned for the night. Mating is completely haphazard and the choice of rams (one estate has tried four different breeds in ten years) is quite empirical. The frequent changes referred to above were because none of the breeds tried, which included Persian black-head and Wiltshire, gave "satisfactory" results. In other words lambing percentages were low, and the few surviving offspring failed to fatten. It was clear, however, that the system of management was at fault, as ewes dropped lambs at any time of the year, and received no special pre-parturition management; parasites attacked the navel of young lambs causing many fatalities, and worm infestation of the survivors was high. Until a trained sheepman is employed to control the mating of sheep and carry out prophylactic measures against diseases and parasites no estate in Trinidad will run a profitable flock. In the opinion of the author sheep are the obvious answer to livestock on estates, as experience shows they do not damage supplies, or compact the soil to an undesirable extent. Sheep are capable of grazing on much shorter herbage growth than cattle, so that the ground cover may be able to provide adequate picking for sheep while being kept short enough not to conceal any drop nuts.

Very little selection is done on germinated seedlings, only the obviously poor and weak ones being discarded, which reduces...
Supplying. Nursery and field practice

The use of a nursery for producing supplies for the field is fairly general in Trinidad, although several of the peasants interviewed plant nuts at stake in the field, or transplant sprout nuts which have germinated where they fell. The general practice in nurseries is as follows:

Nuts are placed on their side (or on end where Rhinoceros beetle is a problem), about half submerged in the soil. The nursery is usually sited in clean sand close to the beach, and kept well weeded. The nuts are spaced up to 12" apart. Planting time varied a good deal, from early in the wet season to very near the end of the wet season. It is fairly general to water the seedlings during the dry season to prevent wilting and it prevents the formation of really long roots sent down early in search of moisture.

Nuts are generally taken from selected mother trees, selected for general appearance, vigour and shape of the crown. As most estates gather nuts as drop nuts no accurate recording of the yield of particular palms is possible, but the size of the bunches on a tree and the bunch number gives a good indication of yield. From nuts gathered thus, all misshapen ones are discarded, the general index of good shape being a plump, fairly short nut. A nut type called the "St. Vincent" is known to give better copra yields per thousand than the "standard" Trinidad nut, and many estates aim at this plump type in selecting nuts for the nursery.

Very little selection is done on germinated seedlings, only the obviously poor and weak ones being discarded, which seldom
amounts to more than 5%. When presented with the results of the Ceylon experiments, which showed that heavy seedling selection on heap nuts achieved greater yield increases than the use of nuts from selected high yielding blocks of palms, most managers were sceptical. They argued that earliness of germination can be of little value to them in selecting seedlings because the nuts planted in the nursery on an estate are at varying stages of maturity, so that the germination rate would vary accordingly. Clearly a short storage period before planting nuts would iron out these differences. Seedling selection in Trinidad therefore leaves much to be desired, and there is little likelihood of the average genetic yielding ability of supply palms being at all above that of existing plantings under the present system.

During the course of this study the author was unable to see an example of the planting out methods used in Trinidad, but the general practice was outlined by estate managers. They use as small a hole as possible on sandy soil and place the supplies in with untrimmed roots, at a depth so the nut is 1 - 2” below the soil surface. In clayey soil a large, 3' x 5' x 3' hole is dug, up to a month before supplying and weathering is allowed to take place. When the seedling is put in place the hole is filled with compost material mixed with the clay to provide a more open soil for the roots to penetrate. The more progressive estates use a balanced N.P.K. fertiliser on their supplies up to bearing age. For example on one estate a granulated compound, 12:10:28 is put on the supplies at 1 lb. in the first year up to 4 lb. in the fourth year to give the palm a good start. After that no fertiliser is used at all.
On several estates N.P.K. is applied only in the first year, and no further fertiliser is used till the palms begin to bear. The author feels that much more should be done to encourage the use of more fertiliser before the palm reaches bearing age, to ensure a vigorous extensive root system and a large trunk girth on the young trees.

Breeding in Trinidad

Most of the coconut palms of Trinidad are of the "standard" or "Typica" type; tall, coming to bear at 5 - 6 years of age at the earliest, and growing to 100 feet in height by about 80 years of age. Several types can be distinguished within this large group, based either on nut shape, as for example the more plump nut of the "St. Vincent" type, or crown conformation, as for example the lax-crowned Venezuelan type.

Several years ago two different groups were introduced from Malaya the Giant, and the Dwarf. The Malayan Giant yields up to 650 lbs. dry copra per 1000 nuts (compared with the usual 500 - 350 lbs./100 nuts of the standard type), so it is being hybridised with the local type to provide nuts for the nursery. One estate obtains all its planting nuts from a block of Malayan Giant mother palms situated within a field of standard palms. No data are available comparing the yield of progeny from the cross between Malayan Giant and Standard with the yield of a pure Malayan Giant progeny. It is obvious that nuts from the Giant mother trees mentioned above would be of both types, and it would not be possible to know whether the male parent, of a particular nut, was of the Giant or Standard type. It is very necessary that some controlled experimenting be carried out to clarify the nature
of differences which must exist between pure and hybrid types.

The author feels that crosses of Malayan Giant pollen onto standard mother palms, and of standard pollen onto Malayan Giant mother palms, carried out under controlled conditions, need to be done in Trinidad. This sort of work is beyond the scope of single estates but could be carried out without much difficulty by the staff of the Department of Agriculture, using the crossing technique employed in Ceylon.

Fertiliser Practice

From 0 to 5 lbs. of fertiliser per tree per annum is applied on different estates. Sulphate of Ammonia is the main constituent of fertiliser mixtures of 25:9:6, and 5:1:1 and similar NPK proportions. It is difficult to understand the difference in attitude between managers using no fertiliser and those who consider it quite economic to apply as much as 5 lbs./tree/annum. Notably it is in older plantings, on difficult terrain, where the general standard of field cultivation and drainage is poor that the use of fertilisers is considered unprofitable. Only one peasant farmer used fertiliser, Sulphate of Ammonia at 1 lb./tree/annum. Other peasants said they would use fertiliser if medium term money loans were available to finance it. Fertiliser is applied by hand in a ring about 6 feet from the base of the tree in all cases, but one estate will shortly use a mechanical spreader to distribute the fertiliser evenly over the surface of the soil.

There is some difference in opinion in the literature regarding the method of application of fertiliser. The author feels that mechanical spreading is more satisfactory as it is less
labour-consuming and encourages wider ramification of the palm roots. Use of a mechanical spreader would enable split doses to be applied, for instance, twice a year, which would be far more satisfactory than the biennial dose applied on a number of estates.

Yields exists.

A very wide range of yields, from around 3000 nuts per acre on the poorer estates up to 5,250 nuts/acre on the best estate visited. It was very difficult to ascertain any figure for yield of nuts per acre from peasant farmers but on one holding 2000 nuts/acre seemed to be the yield, estimated from the weight of copra sold in one year. High nut yield on the estates generally went with high yield of copra per 1000 nuts. One estate has an average, over several years, of 450 lbs. of copra per 1000 nuts (copra at 8% moisture content), while on estates on heavier land and where little fertiliser is used, 300-550 lbs. copra /1000 nuts is common. A 'St. Vincent' type nut has been shown to give better yields/1000 nuts than the standard type, while the "Malayan Giant" and some of its hybrids yield up to 650 lbs. dry copra per 1000 nuts. This nut is not popular with the crackers because of its weight and the difficulty experienced in cracking it with a cutlass.

Mechanisation exists on the estates visited. The most important aspect of cultivation is weed control between the trees, and the breaking up of fronds and other trash material. A heavy roller with 4 blades...
attached is very effective in killing weeds, and at the same time forming a mulch by disturbing the surface soil and mixing the vegetative material into it. On heavy land this implement fails to disturb the surface and is quite unsatisfactory where slopes are involved. Cutlassing by hand is resorted to in these cases, or, if the slopes are not too difficult, a mower with horizontally rotating blades or chains driven by power take-off. Some estates have disc-cultivators with scalloped discs, but in at least one instance they were found to penetrate rather deep and damage tree roots. A rotary-hoe type implement had been tried on one estate but it was found to form a hard pan and so interfere with drainage.

Whatever the method, weeding was carried out at least twice a year, and three times in several cases. All the peasant farmers weeded by cutlassing, and did not disturb the soil at all. Several of them cutlassed only once a year, and weed growth was quite rank and the general appearance of trees very poor.

Pests and Diseases

There are several insect pests encountered more or less throughout the island, but each one causes noticeable damage only in restricted areas.

I. Rhinoceros beetle (Strataegus anachoreta) is a serious menace to seedlings in the Cedros area. Efforts are made to avoid damage by planting nuts vertically in the nursery and by applying dieldrin around the young seedlings in the field for the first three or four years. The removal of dead tree trunks from the estate deprives the beetle of a breeding ground, but they can multiply on certain trees in the jungle so eradication seems impossible.
II. "Gru-gru" Palm Weevil (Rhyncophorus palmarum) is widespread in Trinidad but is not present in high concentration anywhere. The idea that it spreads the infection of Red Ring worms has been discounted recently. It is a secondary pest and may attack where Rhinoceros Beetle has previously damaged a palm.

III. Bearded Weevil (Rhina barbirostris) is well known in the Cedros and Mayaro areas. It is a secondary pest which attacks especially trees scorched by fire. Control is by avoiding the burning of trash near to palms.

IV. Shot-hole Borer (Xyleborus perforans) is known in the Cedros area but damages palm trunks only rarely.

V. Coconut Scale Insect (Aspidiotus destructor) is perhaps the most important pest of coconuts on the island at present. It occurs in all the main estate areas but is worst on Southern Cocal and Northern Mayaro. The scale never reaches really serious densities owing to the presence of natural predators, e.g. Cryptognantha spp. (a ladybird), but it is a cause of serious yield losses and strenuous efforts are being made to prevent its slow but steady spread. Certain ants, e.g. Astecta chartifex protect the scale, to a certain extent, from its predators; so control takes the form of eradicating these ants with Chlordane spraying, and general tree hygiene. One estate uses a high pressure Myers sprayer to spray 10 gallons of 1% Chlordane on the leaves of more seriously affected trees. On several estates a picker cleans up the crown once a year, removing ants' nests and old leaves still adhering to the crown, and spraying with a small sprayer while up the palm. This, like the high pressure spraying, is expensive, and owing to the difficulty of finding climbers will-
ing to submit to the discomfort of working on ant-infested palms, the scale is still spreading slowly where this method is in use.

VI. Coconut Butterfly (*Brassolis sophorae*) is known around Cedros but is not a serious pest there.

VII. Giant grass-hopper (*Tripodacris dux*) has been a little troublesome at Cedros in the past but has not been seen in recent years.

**Diseases**

Red Ring (*Aphelenocides cocophilus*) is the most serious disease and seriously threatens the future of the Trinidad industry because of the high proportion of supplies destroyed by it. On one estate only is the disease not present and the number of annual supplies on that estate is very small indeed. The disease has been known in Trinidad since before 1920 but has become far more serious in the last 10 years or so due perhaps to the presence of a larger number of the more susceptible young trees resulting from the general increase in supplying in ageing plantings. Many estates in Mayaro area, right through to Toco, lose up to 50% of all supplies planted, generally just as the young trees come to bearing age. Often whole fields will be destroyed while in other cases just odd trees die. Without exception managers noted that it was on the more poorly drained fields that Red Ring was worst, but no parts of their estates seemed completely free from attack. In support of this idea one manager produced some figures for tree mortality due to Red Ring between 1925 and 1952, when drainage trenches were dug in 1925. The soil is a medium clay on this estate.
Unfortunately no figures exist for the rate of supplying during that time, but a dramatic fall-off in deaths occurs after 1925. A research team is working on Red Ring in Trinidad at the present time and it is hoped to elucidate the status of the worms in the soil, which may lead to some means of control.

Bleeding-stem Disease (Ceratostomella paradoxa) is prevalent in plantings on heavy soils poorly drained. One estate on the clay soils east of Cedros has a team of 2 men working continuously on "bleeding-stem" control, through the wet season. More care with picking carts and cultivation implements and cutlasses in avoiding injury to tree stems would reduce the occurrence of this disease considerably. Control on estates is carried out by removing the affected part of the stem with a cutlass and tarring the clean surface beneath. Two peasant farmers claim to kill the fungus by piling debris around the base of the stem and lighting it, thus scorching the fungus-infected portion of the stem. This seems to be rather drastic and could weaken the palm and make it susceptible to bearded weevil attack.
Pencil Point. Many palms exhibited the symptoms of this physiological disease on clayey, poorly drained soils where little or no fertiliser is used. Very few nuts were borne on such palms, and it was mainly on peasant holdings that they were observed. The recent two successive dry seasons has caused some pencil point on heavy land on several estates too.

Bud Rot. Most estate managers admitted to losing an occasional tree due to bud rot, while evidence of its ravages on peasant holdings was clearly visible in the form of crownless stems.

Bronze Leaf Wilt. On many estates the trees suffer from some form of wilt for part of the dry season, but the author could get no indication of the number of fatalities following the typical Bronze Leaf Wilt symptoms. None of the estates visited were on the really serious "Wilt Soils" as outlined by Bain (1954), but it is probably true that on poorly managed heavy land in the Mayaro and Cedros areas some losses are caused by Bronze Leaf Wilt.

Big Bud. This form of nutritional starvation in which the leaves become successively smaller and the tree ceases to bear was noted on a poorly managed peasant holding at Cedros. Such trees may be observed in abandoned plantings elsewhere in Trinidad.

Lightning Damage. One estate manager recalled losing 80 trees in one lightning strike several years ago, and small losses of up to 12 trees occur quite frequently. Generally a tree struck appears to be suffering from wilt, at first, going brown on the outer fronds, but it will probably be dead within a few weeks.
Estate Organisation in Trinidad.

A block of buildings as centrally placed as possible contains the administrative office, drying apparatus and machinery and stock yards for an estate. The plantings are divided into fields, generally of 50 acres or less, which serve as units for all the cultural and collecting operations. Access to individual fields by road is essential to facilitate rapid passage of tractors and implements for carrying out cultural operations and for transporting nuts. Frequent inspection of fields for diseases or pests is made easier also.

The degree of mechanisation determines to some extent the size of the labour force on an estate. Cultural operations involving cultivation of the soil are always done by tractor drawn implements in Trinidad. Weed control on flat land is usually obtained with a tractor drawn roller mulching machine, which can cover 5 acres or more per day, while the area close to the base of a palm is slashed. On steep cambered beds and slopes cutlassing is done. Four man-days are necessary to cutlass one acre. Hand operations in the field are almost invariably done by task. Fertiliser spreading is generally done by hand in Trinidad, requiring 1½ man days/acre. A permanent labour force of semi-skilled men is needed for the following work, however.

i. attending to drying plant, either mechanical or sun drier.

ii. tractor driving, for cultural operations and transport.

iii. attending the nursery and supplying seedlings in the field.
iv. Recording of tasks, production of individual fields, and consignment of produce to market. (Overseers).

v. Attending any livestock.

The following is the labour force on a 700 acre estate which produces about 5000 nuts/acre/annum.

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collecting carts (4)</td>
<td>8</td>
</tr>
<tr>
<td>Tractors and trailers (2)</td>
<td>4</td>
</tr>
<tr>
<td>Cracking gangs (6)</td>
<td>18</td>
</tr>
<tr>
<td>Slashing gang</td>
<td>12</td>
</tr>
<tr>
<td>Overseers</td>
<td>4</td>
</tr>
<tr>
<td>Climbers</td>
<td>1</td>
</tr>
<tr>
<td>Stock attendants</td>
<td>4</td>
</tr>
<tr>
<td>Maintenance staff</td>
<td>9</td>
</tr>
<tr>
<td>Other jobs, including nursery, disease control, etc.</td>
<td>8</td>
</tr>
<tr>
<td>Manager</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>69</strong></td>
</tr>
</tbody>
</table>

N.B. This estate has a herd of 47 water buffalo.

Many of the people employed are housed on the estate.

More casual jobs like slashing are commonly done by hired labour from a neighbouring village because of the seasonal variation in the need for slashers.
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ACKNOWLEDGEMENTS

The author is grateful to Mr. W.J. Badcock for criticisms and suggestions during the survey and the preparation of the manuscript. Also the author is indebted to all those coconut men, on estates and peasant holdings, who were so ready to provide the information which makes up this report.