SOME INVESTIGATIONS ON COCO-NUT DISEASES, ASSOCIATED WITH SOIL CONDITIONS IN NEW GUINEA.

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PART I.

Introduction.

In a article on the "Diseases of Coco-nuts (*Cocos nucifera*) in New Guinea" (see *New Guinea Agricultural Gazette*, Vol. 3, No. 1, April, 1937), (9), an account of the diseases due to fungi and physiological causes, so far recorded in this Territory, was presented. It was shown that chlorotic deficiency diseases of coco-nut palms which are associated with soil deficiency or soil exhaustion are very important in this country. Affected palms assume a sickly, yellowish-green colour, and the fronds gradually become shorter and fewer until eventually the few remaining fronds present a feathery, unhealthy appearance. The occurrences of this nature were fully described in the article quoted and are easily recognizable as due to soil deficiency. In the final stages tapering stem and general collapse of the bud or cabbage often results, primarily due to soil exhaustion. It is not proposed to deal with incidences of this type in the following discussion.

In the same issue several diseases which may be associated with unfavorable soil conditions and soil deficiency as main factors, together with other contributory causes, such as fungus attack, were described. These may be briefly listed as follows:—Chlorosis, tapering stem, die-back, bud-rot of certain kinds, nut-fall (some kinds), leaf-droop, leaf-break, tip-wither, frond-choke, drought wilt, production of leathery copra, and, finally, an "obscure physiological disease" found in New Ireland.

In describing the latter occurrence at some length (*see* pages 55 to 57 of the volume mentioned), it was stated in the general description that "one main distinguishing characteristic was the "wilting" of the central fronds of young palms in the affected areas".

It is the intention of this present article to publish some more detailed investigations on this "wilting" and "die-back" condition, and, also, to compare it with similar occurrences in other parts of the world. It should be mentioned that the owner of the plantation where this was most in evidence, and other planters in the vicinity, evinced considerable alarm over this disease. They believed, at first, that this condition was new to this Territory and was likely to spread on to adjoining properties, owing to the rapid appearance of the condition and the number of palms affected within a comparatively short time. For this reason, attention was paid to the attempts to solve the underlying causes of this "die-back" disease. The disease was investigated locally, both in the field and in the laboratory, during three separate seasons.

In an article on "The Fall of Mature Palms in New Guinea Plantations" (10), it was made clear that, from a practical stand-point, the study of soil profiles yields much information concerning the suitability of particular areas to coco-nut cultivation, even where chemical data is not available. It was also shown that coco-nuts can flourish and produce normally with a very

restricted root system, providing the surface soil is physically and chemically rich. Where the soils are poor and compacted, root restriction and water-logging will finally lead to deficiency symptoms and soil exhaustion becoming apparent.

In addition to the particular occurrence at Namatanai, some other derangements of the coco-nut palm, associated with unfavorable soil, sub-soil and water table conditions, together with inter-related climatic and nutritional factors, are described. In Part 1 of this article some derangements of young palms at Kokopo, New Britain, and from Bougainville Island also are described.

Description of the "Maturation Wilt" of Young Coco-nut Palms in New Ireland.

The palms on the plantation where this condition was recorded ranged from five to eight years old, and, in most instances, had just commenced to come into bearing. The general condition of the palms, in the areas affected, did not appear so good as in the surrounding areas. The trouble was found only in areas well away from the beach where the palms were planted at the wide spacings of 33 feet and 36 feet on the triangle system. The main area which was affected was situated in a hollow depression and comprised a total of about 600 palms, and numerous palms scattered over this area showed symptoms as described. There were a couple of other widely-separated areas which showed the condition. The plantation has a great proportion of its planted area on slopes exposed to the strong north-west winds. This would aid in the additional loss of water by transpiration (i.e., given off through the leaves), as the north-west season is the dry season on that coast.

Pronounced tip-withering occurred on the centre leaves of the affected palms, and some dying back was also seen on the outer leaves. On the back of the petioles (leaf stalks) of the crown leaves of the palms, pale brown streaks were seen. These sometimes showed up near the tip of the leaf or near the base, but, as a general rule, commenced about two-thirds of the way up from the base. The scattered lesions, although moist in appearance, were quite firm, but later they tended to spread and link up, becoming sunken below the general level of the outer surface of the midrib. Eventually the diseased portions split longitudinally, exposing the fibres after the ground tissues had fallen away, and the unhealthy parts become quite dry and hard.

A cross-section made after drying out had occurred showed a pale, sulphury-yellow layer immediately underneath the sunken tissue; this merged into a brown discolouration extending through the petiole almost to the inner surface. In longitudinal section the discoloured portion showed up as full- reddish-brown streaks. Such rotted portions were seen in some cases to extend below the fibrous tissue at the base of the leaves, but in no case did it appear to kill the palms. A tip-wither of the leaflets which extended from the top of the fronds almost to the base generally occurred concurrently with the stem-rotting mentioned.

Around the edges of the withered sections on the leaflets a distinct halo was noticed in some cases and the "die-back" from the tips was very distinctive. Pale areas with brown margins also appeared in the centre of the leaflets. The above symptoms only showed up on the fronds comprising the crown, while the older leaves were usually not affected.

It appeared that the palms affected were tall, very erect and close-growing, and not an open, robust type. They often presented a frond-choked appearance with the fibrous tissue bound tightly round the bases of the fronds. The only palms affected were those bearing nuts, or flowering before coming into bearing. The nuts from diseased palms showed an unhealthy, yellow colour. Examination of the roots showed no evidence of root disease.

The land prior to planting was under fairly heavy secondary growth and in the past had been used as native gardens. The land is undulating and rises gently from the beach. The soil on the beach and ridges is shallow and overlies coraline limestone. On the slopes and in the depressions the soil was much deeper and, in places, reached a depth of about 4 feet. In the profile the soil on the slopes showed a medium, dark-red, friable loam at the surface, which rapidly merged into a red, or chocolate, rather stiff, clayey sub-soil. A heavy growth of weeds and shrubs was allowed to grow over the area and amongst these Thurston grass, *Paspalum conjugatum,* and Kunai, *Imperata arundinacea,* were seen on the affected areas.

The fungus, *Pestalozzia palmarum,* or grey blight, and the insect, *Brontispa Froggatti,* were scattered widely in the plantation. The diseased palms seemed to be more plentiful where a heavy infestation of white fly, *Aleurodicus destructor,* and other unidentified scales were present. These were more plentiful in the hollows than on the ridges. Microscopical examination of diseased specimens failed to show any strongly parasitic organisms, although it did yield some interesting results.

Detailed investigations by Henderson and the author led to the belief that the condition was local and of physiological origin, so that it appeared likely that the natural soil conditions were at fault. One interesting feature concerning the topography was the presence of several large holes or depressions such as are often seen in country of coral origin. These extended well down into the underlying coral, and in one case a stream of water was running at the bottom of the declivity. It is believed that there is a subterranean passage and a large underground water channel underneath the area where the palms were affected. Here the rain water readily penetrated to the lower layers and was quickly carried away.

It appeared, also, that the roots of the palms showing the upright frond-choked condition had only penetrated the upper and more friable layers of soil while the roots of the stronger palms had penetrated deeper into the sub-soil (*see* diagrams, Figures 1 and 2). Practically all of the affected palms when pushed strongly could be rocked backwards and forwards, showing that the rooting was shallow and that this type of palm had a loose hold on the soil. The root-hold had been further reduced by the doubtful expedient of digging in deeply around the palms, so that many of the surface roots were cut. Whether this was also affected by original shallow planting in the first instance was not known, but appears likely. The appearance of the disease was associated with a pronounced spell of dry weather following on relatively heavy rains. It occurred, however, where the soil was apparently well suited to coco-nuts, although a little heavy in the sub-soil. The rainfall for the months of April, May, June and July, 1936, i.e., preceding the appearance of the disease, was just about half the average for those months at the nearest recording station, but the rainfall was said to be much lower than this at the plantation in question.

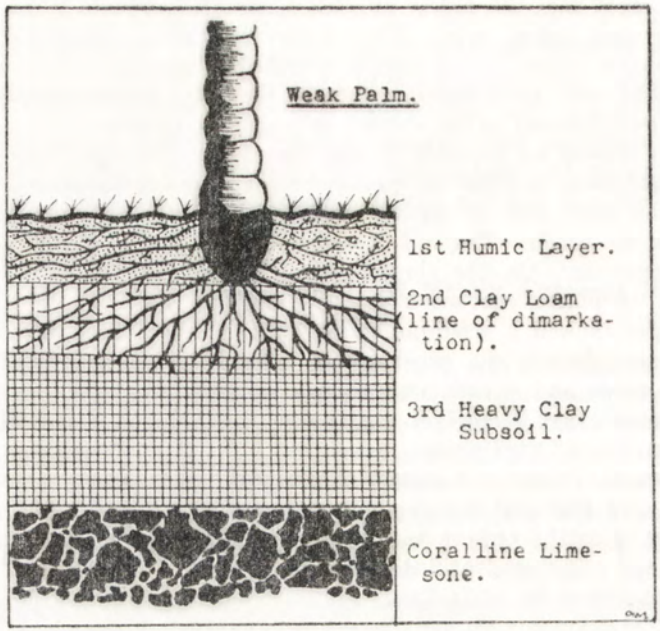


Figure 1.

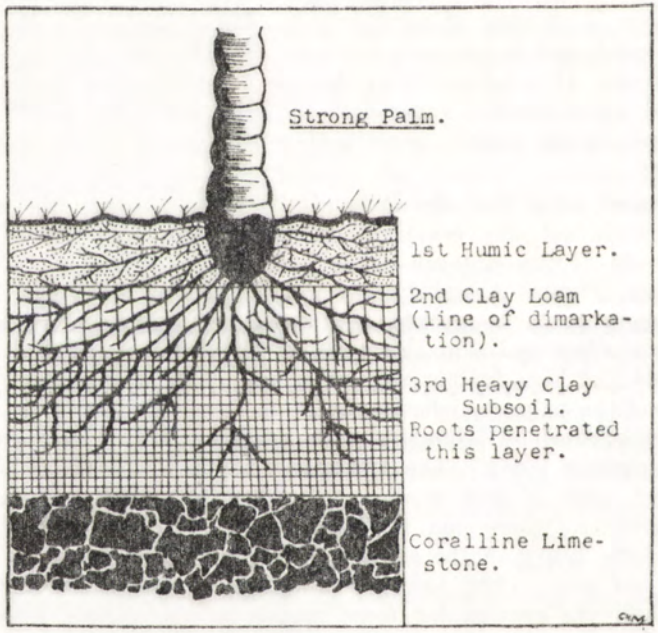


Figure 2.

The malady made an appearance when the palms were coming into bearing, which is a critical period in the life of the palm, when an additional strain is caused by increased water and nutritional requirements. This represents the change-over period from vegetative to productive phase.

During the dry period, shallow-rooting, rather weak palms were not able to obtain sufficient water and plant food to carry on normally, especially where the water could get away so easily. Further, insect attack and probably the effect of weakly-parasitic fungi had some effect when the vitality of these palms was lowered, and this caused some of the withering seen on the central leaves. Thus, there appeared to be a definite relationship between the incidence and severity of the disease and the type of palm.

It is a significant fact that recovery was coincident with the proper cleaning up of the place by cutting down high brush weeds, &c., and more particularly with the incidence of abundant rainfall. The white flies and various scale insects were very much less in evidence after the plantation was cleaned up and the rain occurred, which probably had some effect on the recovery of the palms.

The owner of this plantation became very concerned and drastically cut back many palms, in some cases, leaving only the central shoot, which led to the bud-rotting condition present, as this was probably associated with the entrance of secondary fungi and bacteria. Where the palms were cut back judiciously at a later interval and not too many fronds removed they made a good recovery.

Henderson observed that the streaking on the dorsal surface of the petioles (leaf stalks) was intimately connected with rotting tissues at the growing point. In the most seriously affected palms, a bud-rot was said to develop. It is not certain, however, how much of the sporadic bud-rotting which did occur was hastened by the drastic cutting back of the fronds of the affected palms, leading to the entrance and development of secondary organisms. It is most probable that, in some instances, bud-rotting did occur as a direct effect of physiological break-down, aided by secondary fungus and bacterial infection. The appearance of the diseased areas on the leaf stalks suggested physiological collapse of the cells due to faulty nutrition and failure of water supply, if, as it seemed, the fungi or bacteria isolated were not responsible for the longitudinal lesions seen. There were some minute boring larvae (apparently of a small moth or butterfly, but as they did not breed out they were unidentified) confined to some of the dead portions of the diseased streaks, where they were found in small, elongated tunnels, with their frass. Where any tendency of the bud to decay occurred, it was seen that it progressed typically from the leaf stalks inwards, which is apparently the reverse sequence to that found with the majority of bud-rot cases due to the *Phytopthora* fungus.

Where the ground was hoed over, in the dry season, all ground covers were removed, and the surface fibrous roots cut, which further exaggerated the drying out of the surface soil. Many feeding roots were destroyed on the young palms, with an already restricted root system, and this again diminished the water and nutrient supply to palms already suffering from deficiency. Such attempts at controlling the maturation wilt could only increase its effects, as was experienced.

The plantation on which the affection occurred was gradually planted over several years and the palms came into bearing roughly in the same order as the plantings were made.

Records show that the disease has appeared in the affected areas at approximately the same times in the corresponding seasons and in palms of similar age grouping in each of three years to 1937. At stated previously, none of the palms involved was more than eight years old.

The last visit to the plantation in connexion with this investigation was in August, 1937 (after the first description had been published). Then the disease again appeared in a patch of coco-nuts some distance away from the original focus, where the affected palms were also reaching the bearing stage in the dry season.

The owner had, ill-advisedly, cut the fronds so much that it was not possible to get suitable specimens of fronds showing streaking on the petioles for further examination.

Though the condition appeared at roughly the same period of the year, for successive years, as indicated above, it did not reappear later and no trouble was experienced during the year 1938 and up to June, 1939. It will be most interesting to see whether, in future years, it will appear in this plantation, under similar circumstances, in palms coming to the bearing stage. Though there is no sign of the disease at present, there is no guarantee that it will not occur again. The indications are very strong that palms which have passed the critical bearing stage on this property, and have recovered, or escaped the affection, are not liable to show a similar wilt again. The age factor must have an important interaction with other limiting factors present (such as water relationships, the type of soil, sub-soil and climate). As already pointed out, the plantings were made progressively, as time permitted, and in each year the disease occurred it was found in new areas.

Frond Choke.

The affected palms, in most instances, showed the condition of frond choke, which was also described in the article previously mentioned.[9]

In this case the terminal fronds tend to stand very erect and develop poorly. The outside leaves appear closely crowded around the growing point and their bases are held, or bound, together instead of growing free. The following fronds gradually become smaller and smaller as fresh ones appear, while the palm develops a sickly, yellow appearance and appears to lack vigour. As far as can be determined, there are no fungous pests responsible for this disease. It has been suggested that it is aggravated by close planting, unfavorable soil conditions, &c. Again there is a possibility that this is a virus disease, but as the condition is confined to definitely defined areas in many instances, this suggests some physiological derangement.

It appears that certain types of palms, which are very erect growers, are more liable to "frond choke" than others. Where this condition is present, it is wise to improve the cultural conditions, and, also, loosen the overhanging fibrous tissues at the bases of the constricted fronds.

The palms naturally tend to grow very upright where they are closely planted, and there is a dense canopy of closely intergrown fronds. This type of growth is also a common feature of replanted palms, growing under much older and taller palms, and it is an indication of light and, possibly, root competition. These

latter occurrences of palms showing upright growing fronds are similar in effect, but not due, to the same causes as where "frond choke" is met in areas of poorly vigorous palms of approximately the same age and development.

Presence of Necrotic Deficiency Spotting.

It was seen when visiting the plantation that the palm fronds in the whole affected area showed a yellowish or bronzed appearance. On closer examination, it was found that the coco-nut fronds in these areas were suffering from what appeared to be a "deficiency spotting" all over the leaflets (leaf pinnules) at the time the physiological wilt occurred.

The coco-nut leaves showed countless small brown or yellowish-brown spots. These abundant spots were close together and were usually rounded and surprisingly regular in outline. Their appearance suggested some form of "necrosis", as no organisms were found associated with the numerous small brownish spots present. Where *Pestalozzia* was found, the spots were large, more irregular and coalesced, thus presenting an altogether different appearance.

Some fronds showing deficiency spotting and derived from the affected area, at Namatanai, were collected and sent to England for examination and comment.

The report[1] by Professor Ashby (February, 1938) on the spotted coco-nut leaflets sent to him was as follows:—

The small spots appeared to be free from a fruiting fungus, but the large spots bore numerous pustules of *Pestalozzia* (or *Pestalotia*) *palmarum*, Cke., a fungus of very wide distribution on coco-nuts. Its parasitism on healthy leaves has not been proved; it is probably only able to infect leaves which are in ill health, due to some other cause. The very abundant, small spots are suggestive of the "Cadang Cadang" disease in the Philippines, mentioned in my previous letter.

At the present time, when a disease is thought to be of a physiological nature, one tends to think either of a virus or a soil deficiency, especially in some minor element (e.g., boron, manganese and zinc), especially if soil and subsoil conditions appear to be satisfactory in other respects, and there has been no very abnormal preceding weather.

We are still much in the dark about the change in the nutrient requirements of the coco-nut as it comes into bearing. It is likely to be one of the investigations in progress at the Coco-nut Research Station, Ceylon. A chemical analysis of the soil would bring out any deficiency in the available amount of one or other of the major essential elements (potash, phosphoric acid and lime). Volcanic soils, in particular, are liable to be deficient in availability of one or other of those elements for some crop-plants. In the annual report for 1936 of the East Malling Research Station, there are a number of interesting papers by Roach[23-24] and others, on injecting fruit trees, including leaves, with mineral substances for the detection of deficiencies. These methods might give interesting data if tried on the coco-nut.

It might be explained here that steps had already been taken to have the soils analysed as suggested in this report. The author had previously conducted injection experiments with coco-nuts on a plantation near Kokopo with twelve different substances and some interesting results were obtained with several of the substances used.

These preliminary tests on soil-deficiency problems are largely the sphere of a soil chemist, and only where they have any bearing on the nature of the disease in New Ireland are they discussed here.

To illustrate the possible effects of rare metal deficiency, such as boron, the symptoms described by Denniss, in *Science Progress*, 1937,[7] are given—

The most reliable diagnostic symptoms of boron deficiency in higher plants is *death* of the apical point of the stem. This is generally followed by stimulation in the growth of lateral buds, resulting in the formation of side shoots, which in turn die back at the

tip. Leaves of affected plants are commonly slightly thickened, often tend to curl and may become slightly chlorotic. Frequently, the petioles (leaf stalks) are noticeably brittle, and, in many cases, the plants fail to bloom or to set fruit.

He goes on to describe the histological symptoms, which include lack of full normal development, especially in the roots. Although the effects of boron have not yet been observed in coco-nuts, this description gives a good idea of what is not unlikely to happen here where rare metal deficiencies occur. Experiments already carried out have shown that iron compounds and such elements as copper sulphate, $CuSO_4$ (bluestone), in weak solution, do have a stimulating effect on chlorotic palms in this country.

It might be pointed out that sulphate of iron (ferrous sulphate, $FeSO_4$, $7H_2O$) has been used rather widely as a manure by one company on several plantations in the pumice belt near Rabaul, with good effect on the appearance and vigour of the palms. It does change the chlorotic appearance of the palms and causes their fronds to assume a more normal, healthy, green colour. It has been claimed that this quick effect is because the iron-sulphate assists in liberating certain plant foods in the soil[3] (i.e., purely due to catalysis). Its direct effect has, however, been indicated where the author carried out injection experiments with dilute solutions of the iron sulphate. The effect of iron was further confirmed where solid ferric citrate, $C_6H_5O_7$ (Fe_3) was injected into the chlorotic palms and gradually restored their colour. The direct tonic effect of ferric and other iron compounds on fruit trees and other plants, when applied in proper strength solutions, has also been amply demonstrated in other countries. When applied to the soil, it is almost certain that liberation of plant foods as well as the direct effect would occur.

Cadang Cadang Disease.

The Director of the Imperial Mycological Institute wrote as follows, which led us to make inquiries along the lines suggested:—

In the *Philippines Agriculturist*, vol. 26, No. 4, September, 1937, there is a short article by G. O. Ocfemia,[19] entitled "The Probable Nature of Cadang Cadang Disease of the Coco-nut." The symptoms described are suggestive of the "physiological disease" in New Ireland. Ocfemia, who has done some valuable work on virus diseases [bunchy top of Abaca (*Musa textilis*) and Fiji disease of sugar-cane], believes that the symptoms of the Cadang Cadang disease point to a virus causation.

Ocfemia, in reply to a letter from the present writer, stated that no further work had been carried out to determine the causal nature of the disease in question.

A condensed review of Ocfemia's article[19] is given from the *Review of Applied Mycology*, p. 108, February, 1938—

Coco-nuts on San Miguel Island (Philippines) were observed, in 1931, to be affected by a disease known locally as "Cadang Cadang" or growth failure and involving 25 per centum of the palms in some parts of the affected estate. The leaves were yellow and chlorotic, developing numerous yellowish, translucent spots, which turned orange-yellow. From a distance the crown of the affected trees appeared yellowish green. The pinnae were narrow and tended to bend over or break in the middle. The leaves gradually became smaller than those of the same age on healthy trees, and the blades of the pinnae of the middle leaves dried out, the leaves dropping prematurely. Infected plants were stunted and produced small, short leaves, closely bunched at the end of the trunk. The leaf-dwarfing was followed by gradual tapering of the trunk which finally appeared as a bare, pointed pole. As soon as the pinnae turned yellow, no further fruits were formed, though spathes were sometimes abundantly produced. The racemes (refers to flowers and flower stalks) dried out, but remained on the tree. No organism was found, but the characteristics of the disease are considered to indicate that a virus may be responsible.

It will be seen that there are several features in common with the disease from New Ireland, as, for example, the spotting and frond choking or bunching of the leaves. Nevertheless, the age factor and periodic appearance of the disease in palms which were coming to the bearing stage, and their subsequent recovery as well as absence of the marked tapering stem effects are points of difference which must be noted. It must be conceded also that physiological drought, manurial and rare metal deficiencies may induce similar symptoms to those described.

The occurrences in New Guinea as recorded in palms coming to maturity are closely related to those described by Dr. Jack,[15] and could be termed a "maturation wilt". There is little doubt in the present author's mind that the causes are closely related to those causing bronze wilt and other forms of coco-nut wilt.

Micro-Organisms associated with the Disease in New Ireland.

Plate and slope cultures of the organisms present in all parts of the affected palms were made. *Botryo-diplodia* spores associated with sickle-shaped spores of *Fusarium* spp. were seen. On all the cultures made, a very short bacteria was present which formed whitish colonies, later turning pink in the agar. This bacteria formed a slime (zooglœa) and did not infect the wounded leaves of very young palms.

A species of eelworm was found, associated with the diseased tissue of the leaf stalks, but only a very few colonies were seen. Specimens were prepared and sent to the Imperial Bureau of Parasitology, where Dr. Goodey identified the species as *Cephalobus rigidus*, which is a non-parasitic, saprophagous species of eelworm, commonly occurring in soil, on herbage and in decaying organic matter, and hence was not the cause of the petiole lesions.

Professor Ashby, in referring to the symptoms described (*New Guinea Agricultural Gazette*, vol. 3, No. 1, p. 55), said that "it is possible that the saprogenous *Cephalobus rigidus* might have followed a parasitic nematode. He suggested that "it might be desirable to examine the internal tissues of leaf stalks of leaves younger than those showing external symptoms (dark, depressed streaks and withering)". No parasitic species were, however, isolated after a long and careful search.

Simmonds[27] in 1925 described a form of "bud-rot" possibly due to nematode worms, from Fiji, but, unfortunately, they were apparently not identified. He recorded that "on one occasion a palm was found in Fiji, showing certain symptoms of 'bud-rot', but differing from the typical form in that the central leaf had not wilted and fallen over. Nematode worms were found to be present in vast numbers and were traced from a spot on one of the leaves to the central bud. They seemed in this instance to be the actual causal organisms". It is a pity that it was not determined whether this was a parasitic, or saprophytic species, as the latter would only feed on tissues killed from other causes.

Professor Ashby, Director of the Imperial Mycological Institute,[1] kindly investigated a number of slides, specimens stored in spirit, and cultures forwarded to him.

The following organisms were identified:—

What appeared to be *Aerobacter aerogenes* (Esch.) Cast. Chalm.=(*Bacterium aerogenes* Esch.); a slime-forming, non-motile, non-sporing rod, producing acid and gas clot in litmus milk. This is a bacterium of wide distribution in soil and

decaying plant tissue, but is not known to be pathogenic. There was another motile, rod-shaped bacteria (not identified) present, but the *Aerobacter* was the organism which turned up on platings.

Regarding the slide preparations, two scrapings from a nut showed the large septate, brown, striate pycnospores of *Botryo-diplodia theobromae* Pat. about 23-30 x 12-14 microns in size. The fungus is of world-wide distribution in the tropics on a great variety of crop-plants. It is a saprophyte or semi-parasitic entering through wounds, or through lesions caused by other fungi and capable of spreading rapidly in ripe fruits, or debilitated tissues. "Leaf-break" in Ceylon and elsewhere has been attributed to it.

In one scraping from a nut in which the pycnospores of *B. theobromæ* were present and in a scraping from a petiole which was made from a specimen in spirit, a hyphomycetous (*Fungi imperfecti*) fungus occurred with small, hyaline, elliptic conidia, on branched conidiophores. It could not be identified from the slide preparations, but might be recognizable in culture. A preparation from "sulphur-yellow tissue" showed 0-1 septate microconidia probably of a *Fusarium* spp., but no *chlamydospores* were detected.

In another slide (fungus and bacteria from a midrib, unsterilized culture) a fungus was present, in which the cells had separated into "Oidia"; it is probably a species of *Oospora*. Other slides contained bacteria, some being spore-forming. The specimens in spirit do not show anything characteristic of a known disease.

This definite statement by Professor Ashby that the isolated organisms were almost certainly not responsible for the primary trouble was very helpful in turning our attention from any organisms to the climate and soil conditions, where the affected palms were growing.

Nature of the Disease.

The scattered nature of the trouble and its sporadic appearance seemed to discount the fear that an infectious disease was present. It also appeared unlikely that if the disease were infectious to any degree, it would confine itself to palms at a certain stage of development, on a particular plantation.

Even in the earliest reports to the owner, it was stated that, "although fungi and other organisms were present, it was extremely doubtful whether any particular fungi were primarily responsible for the condition". This was borne out by the later investigations. It is well known that weakly, parasitic fungi, also insects, and other organisms have a much greater injurious effect on palms of poor vigour than on normal, healthy palms.

It appeared most likely from the investigations already outlined that the derangements displayed by the palms at Namatanai were almost undoubtedly of a physiological nature.

The necessity for soil analyses and for investigating any particular soil, water-table, climatic, or environmental conditions, likely to lead to upset of the nutritional functions of palms coming to the bearing stage, was also clearly indicated. It was obvious that any deficiency of the soil, especially in major nutrients, would greatly exaggerate any unfavorable environmental factors present.

The analyses carried out at the Waite Institute indicated a certain amount of potash deficiency in the soils where the affected palms were growing. Where the water and nutrient supply to the young palms was reduced by unfavorable soil

and water relationships, the availability of the potash to the palm would be still more lessened at the period of greatest demand. Where there is insufficient lime present, as was the case with the surface layer here, the potash would be given up still more slowly.

Particulars of Soil Samples.

The coco-nut palms which grow in the Namatanai district of New Ireland appear to flourish generally, although there are a few very old plantations in this area to indicate how they will fare when they reach an advanced age. The indications are, however, that they will last as long as in most districts here, despite the apparent shallow depth of soil, before coral is reached, in some places. The soils on the plantation under investigation are undoubtedly of a residual nature, being for most part derived, *in situ*, from uplifted coral. In some areas there is possible admixture of some top soil washed down from the high hills behind, but the soils are mainly of coralline derivation.

Profiles from three situations in the one plantation were submitted for analysis. In the "X" series, the hole was sunk on a fairly raised area, away from the foreshore, where the underlying coral was met closer to the surface.

In the "Y" series, the soil samples were taken from a spot lower down in a depression. In this position, the red, underlying sub-soil was deep and a hole had to be sunk several feet before any coral was reached.

The single sample "1Z" represents a different type of sub-soil which was met about 100 yards nearer the foothills than the position where the "X" series was obtained. This was more yellowish in colour, although the texture appeared much the same as the other sub-soils submitted.

The appearance of the affected palms and the accompanying symptoms, soil conditions, &c., have previously been described, as mentioned elsewhere.[9]

Report on Soil Samples from New Guinea.

(New Ireland District.)

*By J. S. Hosking.**

2. Soils from a privately owned plantation, Namatanai sub-district, New Ireland.

Two profiles and a further sub-soil sample from a privately-owned coco-nut plantation situated in the Namatanai sub-district on the island of New Ireland have been examined and the results are appended.

The two profiles from this coco-nut plantation are similar, and consist of red-brown extremely heavy clays throughout their whole depth. In the surface layers, which are darkened by organic matter, the clay contents are 62 and 79

* Of the Division of Soils, Council for Scientific and Industrial Research, located at the Waite Institute, South Australia.

per centum respectively and the content rises to about 90 per centum in the sub-soils. In profile "X" the clay sub-soil overlies a layer of soil, admixed with nearly 70 per centum of the parent coralline limestone. In the sub-soil "Z3" the colour is yellow to yellow-brown and the clay content also about 90 per centum. A coarse sand, fine sand, silt ratio, approximating to 1 : 3 : 6 for all the samples, indicates an essentially similar origin for the materials at all three profiles. The somewhat lower clay contents of the surface horizons show that some eluviation has taken place in both profiles.

Although the mechanical analyses of the soils (*see* Table 2) would appear to class the soils as heavy clays, their physical properties indicate that in the field they would act as much lighter soils in a similar manner to the red loams of eastern Australia.

The soils are acid in the surface and in the absence of limestone close to the surface, increase in acidity with depth. In the limestone layer, however, the soils become distinctly alkaline.

They are well supplied with both nitrogen and phosphoric acid, but potash is low throughout the profiles. The low values for potash, considering the high content of clay, show a further similarity to certain of the Australian red loams.

TABLE 2.—MECHANICAL ANALYSES AND CHEMICAL DATA FOR SOIL SAMPLES FROM A COCO-NUT PLANTATION, NAMATANAI SUB-DISTRICT, NEW IRELAND, TERRITORY OF NEW GUINEA.

Site.	X.				Y.			Z.
Sample Number.	1.	2.	3.	4.	1.	2.	3.	3.
Waite Institute Sample Number.	5390.	5391.	5392.	5393.	5395.	5396.	5397.	5398.
Depth in Inches.	..	..	..	..	..	..	..	..
	%	%	%	%	%	%	%	%
Coral limestone	..	..	..	63.7	..	..	..	..
Fine earth	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Coarse sand	1.0	0.7	0.3	0.2	2.4	1.0	0.2	0.2
Fine sand	3.5	2.0	1.1	0.5	8.4	3.5	1.0	1.6
Silt	7.3	5.0	3.7	0.8	20.1	10.1	2.2	3.0
Clay*	78.6	85.2	88.8	40.2	62.4	79.4	90.0	89.0
Loss on acid treatment ..	1.7	1.6	1.9	56.3	1.6	1.1	1.4	1.1
Moisture	5.5	5.1	5.3	2.5	5.7	5.6	6.0	6.1
Loss on ignition	19.1	17.2	16.1	..	16.5	15.5	14.5	13.2
Phosphoric acid P_2O_5.. ..	0.32	0.29	0.32	..	0.28	0.27	..	0.41
Potash† K_2O	0.03	0.03	0.04	..	0.04	0.04	..	0.06
Nitrogen N	0.27	0.25	0.15	0.10	0.22	0.15	0.14	0.10
Soil reaction pH	6.1	6.0	6.7	8.3	6.5	6.1	5.7	5.1

* Note high content. † Note low content.

"Frond Choke" and "Die-back" of Coco-nuts.

(Comments by Mr. Hosking.)

"It is unlikely that the diseases of coco-nuts at either the Kokopo Plantation, mentioned in the earlier report, or the particular plantation in Namatanai, which form the subject of this report, are the result of major plant nutrient deficiency, since, apart from the low content of potash in the latter soils, all soils examined are very well supplied with them. At the same time, the probable importance of minor elements must not be overlooked.

"After reading through the various reports by Mr. R. E. P. Dwyer, either published in the *New Guinea Agricultural Gazette* or forwarded with the soil samples, and, also, following a discussion of the problem with Mr. D. B. Adam, Plant Pathologist at the Waite Institute, it would appear that there is more than a chance resemblance between the 'frond choke' and 'die-back' described in New Guinea and the 'bronze-leaf wilt' described by Briton-Jones(4) (also Bain(2)), in Trinidad. [Their findings are detailed in a later section of this article.]

"The common feature is the general wilting of the young, shallow-rooting coco-nut palms after long spells of dry weather, with, usually, subsequent recovery following general rains.

"While this feature has usually been observed only on light soils, it does not preclude a similar occurrence on the Namatanai type of soil, despite its apparent heaviness.

"Water-holding capacity determinations indicate that under conditions which restrict or entirely prevent drainage, the soils from Kokopo will absorb from 60 to 100 per centum of their own weight of water, and the Namatanai soils examined from 65 to 90 per centum. The Kokopo soils are extremely porous and the sandy nature of the sub-soils allows the water to drain away rapidly. Dwyer has indicated in his report in the *New Guinea Agricultural Gazette*, 1938, Vol. 3, No. 1, p. 56, that the soils on this particular plantation at Namatanai are readily penetrated by water and the extremely cavernous nature of the underlying coralline limestone will, therefore, allow of just as rapid drainage as in the case of the lighter Kokopo soils. During periods of drought, therefore, both types of soil will dry out rapidly, especially in the surface layers, and the shallow-rooting young coco-nuts are, therefore, the more likely to be affected. Following heavy rains, the high water-holding capacities allow the soils to regain their normal moisture status and restore the water balance in the palm."

The present writer comments that it will be seen from the various reports, of which these analyses form a part, that these comments by Mr. Hosking are a valuable contribution towards the solution of the nature of the coco-nut disease at Namatanai. It is pointed out, however, that the pathological symptoms of the occurrence in New Ireland are much more complex than those at Kokopo, New Britain, and, undoubtedly, other factors are involved. There has been further work done on the occurrence from Namatanai, since the publication in the *New Guinea Agricultural Gazette* mentioned, and, in this regard, the comments of Professor Ashby, Director of the Imperial Mycological Institute,(1) also those of Dr. Ocfemia,(19) of the Philippine Islands, are most enlightening, and show that the issues are not so clear as it may appear.

The indication of a low percentage of potash in the Namatanai soils is most important in view of the conclusions of Bain, F. M.,(2) on his work on the causes of "bronze-leaf wilt" disease of the coco-nut palm in Trinidad, of which a *Review of Applied Mycology* review is given verbatim. It may be noted, however, that the disease in Trinidad has apparently not been always associated with coco-nut palms coming to the bearing stage, as seen in New Guinea at Kokopo, Namatanai, near Kieta on Bougainville Island, and elsewhere. The causes underlying the similar occurrences recorded by Jack in Malaya(15) may be closely related to what has been found in these present investigations.

As pointed out in the remarks on the plantation at Kokopo, the poor type of seed nuts used in that particular area, as well as the presence of "kunai" or "Alang Alang" (*Imperata arundinacea*), in the early stages, were contributing factors to the poor condition of the palms. Such circumstances rendered them more susceptible to any unfavorable soil and moisture relationships which may exist in times of drought, or when the palms are coming into bearing.

Particulars of Rainfall.

Unfortunately rainfall records have not been kept at the particular plantation from which the "maturation wilt" was recorded. Records kept at the Namatanai Government Station, which is only a few miles away, have, therefore, been consulted.

NAMATANAI RAINFALL.

(*See* Graph.)

——	Average for 21 years.	1936.	1937.	Rainfall wet season, average 21 years.	Rainfall dry season, average 21 years.
	Points.	Points.	Points.		
January	15.23	20.93	19.96	*	†
February	17.34	15.18	15.14	15.23	8.64
March	16.07	20.12	19.85	17.34	7.49
April	13.79	7.11	12.44	16.07	8.84
May	8.64	7.00	7.14	13.79	6.75
June	7.49	2.60	4.29	11.37	5.33
July	8.84	6.24	6.77	17.14	8.74
August	6.75	14.18	12.18	..	..
September	5.33	5.20	8.06	..	..
October	8.74	12.66	6.17	..	..
November	11.37	17.21	11.47	..	..
December	17.14	14.26	19.96	..	..
Total	136.73″	152.59″	143.43″	90.94″	45.79″

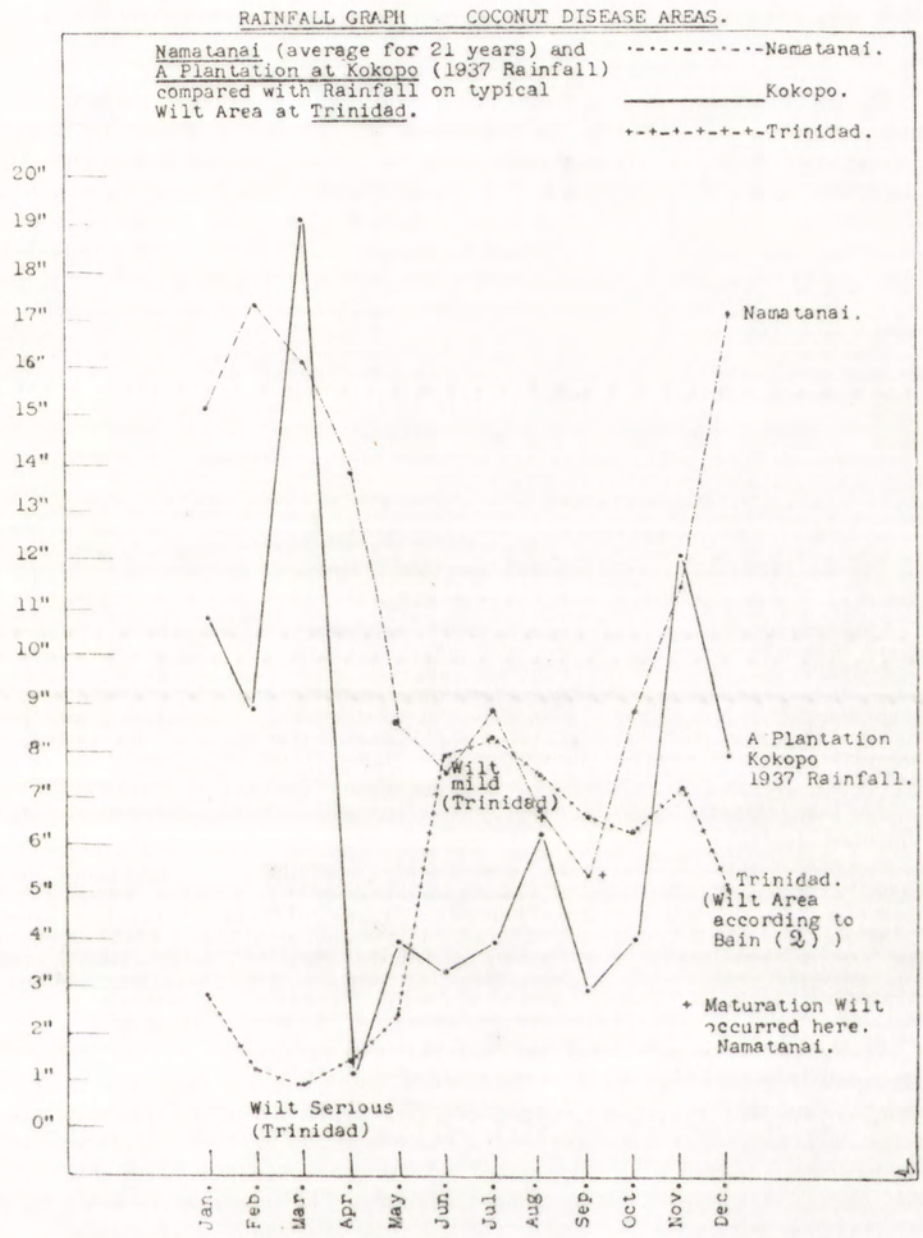
* November-April inclusive. † May-October inclusive.

It will be seen from the above records that the rainfall should be ample for coco-nuts. The wet period in this district is from November to April. There are six dry months of which the driest month is September—August ranking next. It will be noted that about twice the normal August rainfall was recorded in 1936 and 1937. Abnormal rainfall periods occurred in June, 1935, when 141 points of rain only were recorded, and curiously in June, 1936 (260 points) and June, 1937 (429 points) abnormally low rainfalls were again recorded. It will be seen that the rainfall for both these years was heavier than average, so that the contrast between the wettest and driest months is much greater than normal.

The contrasts between the wet and the dry seasons here are not nearly so great as that in the Madang District, or in parts of New Britain, for example, where sometimes eight times as much rain falls in the wet season as in the dry season. This was one of the considerations which led one to think the young palms would recover as soon as conditions become normal.

The fact that in New Guinea coco-nut palms are generally grown under much wetter rainfall conditions than those which prevail in many other parts of the world may have some bearing on the relatively limited occurrence of physiological, or true, drought wilts here. The land here has not been in cultivation for such long periods as in other parts of the world (such as the West Indies) and this would also greatly lessen the chances of wilts occurring here.

The rainfall distribution at Namatanai is compared (*see* graph) with that of a typical bronze wilt area in Trinidad, shown diagrammatically by Bain.[2]



It is seen that in the wet season he depicts, they would generally receive less rain than in a typical dry season at Namatanai. It would appear, however,

that, although the rainfall is much heavier, the fluctuations from the wet to the dry season are more marked in the latter instance. According to Bain, in a typical wilt area in Trinidad there is a marked dry season—February, March and April being particularly dry. From May onwards precipitation there is quite large (in comparison); the amount commences to decrease in December.

Earlier Incidences of the Disease.

It is pointed out that a "die-back" condition at maturity, as described, is not new to coco-nut palms in the Namatanai district, as was generally stated by the planters there. It was recorded from two plantations in 1923, when these plantations were at a comparatively young stage. The Entomologist of this Department, Mr. J. L. Froggatt, briefly described the same condition from the particular plantation under investigation on 26th November, 1934 (unpublished information), and the following remarks are quoted verbatim from his diary:—

"*Coco-nut Dieback.*—On the affected palms, one frond emerges and is apparently choked while the pinnae (leaf division) appear black where this occurs. The following frond becomes smaller and more choked and finally the folded pinnae appear as completely blackened. According to the owner, the palms may be killed if not cut back to the fresh tissue, above the cabbage, and tarred."

The palms were about four to five years old, and some were carrying their first nuts. He was also informed at the time of his visit, that the condition had been seen before on this same plantation.

Nature of the Disease at Namatanai.

In the 1936-37 Annual Report (*see* also League of Nations Report, p. 83, 1936-37),[17] the following notes are given:—

"Physiological diseases of coco-nuts were investigated at Namatanai. This rather obscure disease has been noticed here since 1923. It is apparently physiological and due to unsuitable soil and climatic conditions, while the palms are at the critical bearing period. Palms coming into the stage of maximum maturity have been noticed to suffer a physiological set-back, which often affects the production for upwards of two years. This has been noted here on several occasions, similar occurrences have been noted from Malaya,[15] and it is most prevalent on certain types of soil under particular climatic conditions."

In the Departmental Annual Report for 1937-38, the disease was again mentioned as follows:—

"Professor Ashby considered that, amongst other possibilities, the physiological disease present in coco-nuts just coming into bearing may be identical with the 'cadang cadang' disease described by Ocfemia in the Philippines,[19] and believed to be a virus disease. In August, 1937, this physiological 'set-back', as described in the last annual report, was again seen at Namatanai in palms reaching the bearing stage, but the fact that the palms soon recovered, when conditions were favorable, seems to show that the condition is physiological and is influenced by the extra demand for water and nutrients not being met under certain dry weather conditions on a heavy soil, at this critical stage."

It therefore appears that the reduced nutrient supply to the developing palms and fruits follows on the reduced water supply in the dry season at a time when the demand for nutrients is greatest. No doubt the effects were exaggerated by the deficiency of potash recorded. The contention that this may be a virus disease cannot afford to be overlooked, but the present author does not believe that this is the case in this particular instance. This opinion is based on the fact that the palms usually recover and do not often show a recurrence in the same area. There is little doubt that virus diseases are present on coco-nut palms here, as was recorded in the earlier article,[9] but, so far, no work has been done to indicate the importance of these types of diseases in coco-nuts.

Coco-nut Palms Showing "Frond Choke" and Bearing Poorly.

KOKOPO DISTRICT—NEW BRITAIN.

*(Report by the Economic Botanist.)**

On two distinct sections of an extensive plantation at Kokopo, New Britain, a large proportion of the coco-nut palms growing there presented a "frond-choked" appearance, and were bearing rather badly when visited first in November, 1937. The palms in these areas were either just past the first bearing stage, or, in other instances, had been bearing for no more than three years.

It is not uncommon for coco-nuts which have just reached the bearing stage, or have been in production for two or three years only, to show evidence of "frond choke" and similar disorders. In many parts of this Territory coco-nut palms have been noticed to suffer a physiological set-back at this stage, which often affects their production for two years or more. This has also been reported from Malaya, and is most prevalent on certain types of soils under particular climatic conditions. As for example, it has been seen on comparatively rich soils on young bearing palms after a dry spell following a wet period. It must be remembered that palms reaching the bearing stage are at a physiologically critical period, owing to the extra strain placed on the plant, and the increased call for nutriment, at this period, seems to place an extra strain on the plant, which becomes apparent when, for any reason, the conditions are not entirely favorable. It is a fact that certain types of palms are more liable to this "frond choke" condition than others, and usually they can be distinguished by their erect, close growth of narrow fronds, which appear to have a rather feathery appearance. In other words, there does appear to be an hereditary tendency for palms to show this undesirable type of growth.

In order to make certain whether or not the palms at this plantation were suffering because of natural soil conditions, soil samples were taken from a couple of widely-spaced areas where the palms were worst, and despatched to the Waite Institute, Australia, for analyses.†

The actual methods of planting at the particular sections of the plantation in question are not known, and probably planting was carried out roughly in the first instance. The source of the seed coco-nuts used was, undoubtedly, from local, unselected, native palms, and it is fairly safe to assume from the appearance of the palms and the nuts which they are bearing that no systematic seed selection of any kind was carried out. In this way, a large proportion of poorly vigorous palms can be perpetuated, which is often done because, in the first instance, the planter wishes to get his original seed nuts as cheaply as possible. Some individuals in this Territory have used germinated (or "krued") nuts without having the slightest idea from what kind of palms they were derived.

It must be mentioned, however, that some experienced planters here have referred to another cause of "frond choke" in palms. Its development has been noticed in rows where the natives, in the course of planting, had split the nut and detached the young plant—"krue"—from the nut, and eaten the kernel, and,

* Original report to owner by the author.

† The reports on soil samples from Kokopo by Mr. J. S. Hosking refer to these.

probably, the endosperm. They have even been known to dig up the nuts and eat this portion after they have been planted out, and then place them back in the same hole. The edible part is much prized by natives and it is likely that, at times, natives would eat this delicacy on new plantations unless they are closely watched. When there are no other groves in the vicinity they, of course, follow the easiest way to augment their rations. This is not common where proper supervision of the plantings is attended to.

It is believed, however, that the original seed coco-nuts were at fault in the affected areas, though it is very probable that the palms growing there will improve when they grow older.

As the owners are still planting up large areas, it would be preferable to obtain seed nuts from a bearing plantation which was known to be derived from selected nuts in the first instance, and, in this connexion, particular plantations in Kar Kar Island were mentioned by the owners as being suitable places from which to bring in seed nuts.

It is well known that Kar Kar nuts are noted for their size and weight, and there is a distinct possibility that they are the result of some original selection in the first instance.

It must be remembered, however, that the development of nuts on Kar Kar may be largely due to the environment. If it happens that the palms there represent a selected, or distinct, regional strain, that gives more chance of success. Some authorities, such as Sampson,[25] say that it is best to select good palms from areas where the soil approximates that where the palms are to be grown. Smith,[29] in Malaya, worked it out that it was best to select from the heaviest yielding areas which could be found, so that the chances were greatest of only good palms crossing amongst themselves. This is a complicated subject which is elucidated in an article on "Coco-nut Improvement by Seed Selection and Plant Breeding".[11] (See *New Guinea Agricultural Gazette*, Vol. 4, No. 3, p. 24.)

A common method of selecting seed nuts here is to select them from heaps gathered for copra cutting, and, in this instance, good, round, heavy nuts are usually, but not always, selected. This type of selection is definitely better than none at all, because the chances are high that good nuts would be obtained from good palms.

The great objection to the selecting of coco-nuts from a garnered heap is that one has no knowledge concerning the good points, or defects, or of the appearance and types of individual palms from which such seed coco-nuts were derived. A poor looking and weak palm may, in some instances, bear a very few good, shaped nuts, which would be selected from the heap and thus perpetuated.

A few of the most experienced planters in New Guinea have marked individual palms on old plantations and observed them singly for use as mother-palms for the production of seed nuts, as it is believed has also been done on some company plantations here. The idea, of course, is to select heavy bearing palms, and then to eliminate any uneconomic types. But all coco-nuts are the products of cross-fertilization, and, although the seed nuts are derived from good palms,

they do not necessarily breed true. The nuts from some palms are known to give a lower percentage germination than those from others, which is an hereditary tendency, and such palms should be avoided.

Selection in the nursery is not only desirable, but necessary, and only seedlings should be taken which are strong, sturdy and healthy. All inferior types and non-germinated nuts should be entirely discarded. It must be remembered that, as the seed nuts are the product of cross-fertilized flowers, regardless of the outside appearance of the nut, the seedlings derived from any one palm will display considerable variation. Long, rangy plants, or plants having a tendency to yellowing (chlorosis), should be avoided. Leggy, poor type seedlings can never produce good type palms, neither can those which are twisted or sickly.

It is also quite certain that, in addition to the above precautions, selective replantings in the field are a payable proposition, because it is not possible to separate out all the plants which are not likely to thrive from nursery selection alone. All plants which are not thriving and all misses in the planted areas should be replaced with strong, sturdy replants, and the best time for replanting is while the surrounding palms in the plantation are still young, and not too tall or well-developed, so that the replants receive little root competition, &c., and no excess shade. Any injuries to the young seedlings during replanting, or to the growing point by insects, rats, or animals in the young stages, provide a serious set-back to the plants for all time. Injured plants should be replaced as soon as they are noticed, and at as early a stage as possible.

The next important recommendation is that a substantial percentage over and above that just barely required to plant a certain area should be set out in the nursery. This, again, appears costly, but it is money well spent when it is remembered that the palms will be growing for over 50 years. Finally, if the owner-company has found that palms on any of their plantations are from nuts of good strain, well selected in the first instance, they are the ones recommended for use as a source of seed nuts. It is not now possible to say how coco-nuts from Kar Kar Island shifted to this Kokopo plantation will thrive, but probably they would be quite all right judging by experiences elsewhere.

All of the later plantings made by the owners, and these comprise the bulk of the planted areas, have been made with selected seed nuts under good, practical supervision. The difference between these well-planted palms and those seen on the earlier-planted areas is most strikingly in favour of the well-selected and properly-planted nuts.

The areas in question were recently visited—just twelve months after the report was made—and the improvement in the affected palms, especially those growing on one area, was clearly evident. There is still a proportion of the palms showing "frond choke" and "yellowing" plus a tendency to "leaf-droop".

The palms which have improved least of all are those which are in an area which was said to have been badly overgrown with "lalang" or "kunai" grass, *Imperata arundinacea,* in the early stages, and most of which has since disappeared. The fact that the ground, at this particular spot, is undulating,

and that closely-spaced, almost parallel tributaries running into a deeper stream are present, may increase the drainage and water run-off, and thus affect the palms growing on this light soil.

Reference should be made to the rainfall graph (page 45), where the rainfall for the year 1937 at the Kokopo plantation under investigation is compared with that of Namatanai, and a typical wilt area in Trinidad. It will be seen that this was a year of severely fluctuating rainfall, as, for example, compare the 19 inches recorded in March with the little 1 inch rainfall recorded in April, or the 3 inches in September with the 12 inches in November. One could expect physiological derangement of young bearing palms where a seven months' dry spell was experienced on the porous soils described, i.e., apart from the other contributory factors present.

Report on Soil Samples from New Guinea.*

(New Britain District.)

(By J. S. Hosking.)†

"Soil samples, representing two profiles from the coco-nut plantation in the Kokopo District, on the Island of New Britain, have been examined and the results are appended.

1. *Soils from Backward Area of Coco-nut Plantation, Sub-district of Kokopo.*

These soils have formed on geologically recent, layered deposits of volcanic ash, very similar to the deposits resulting from the recent volcanic eruptions at Rabaul and, like the Talasean soils, are extremely immature in their development. The deposits are of the pumiceous type, but show only a small proportion of pumiceous stone, about 3 per centum in the lower layers of the second profile.

The profiles consist of about 12 inches of a dark grey-brown to grey-brown clay loam to light clay, rich in organic matter overlying, in the case of (1) a light grey-brown clay loam to a depth of 42 inches, and in (2) a light grey-brown loam to 24 inches over a grey, passing to grey-white, pumiceous sand. Except for the sandy layer of the second profile, these soils have a distinctly silty feel and might well be classed as silty clays or silty loams.

Both profiles show reaction values which vary little from neutrality (pH 7) throughout their depth.

The surface soils are well supplied with plant foods, the nitrogen, phosphoric acid and potash contents showing average values of 0.4 per centum, 0.2 per centum and 0.3 per centum respectively. In the sub-soils, while the nitrogen content decreases rapidly, phosphoric acid and potash show only slightly diminished values.

Mechanical analyses and chemical data for these soils are given in Table I.

Water-holding capacity determinations indicate that under conditions which restrict or entirely prevent drainage the soils from Kokopo will absorb from 60 to 100 per centum of their own weight of water. The Kokopo soils are extremely porous, and the sandy nature of the sub-soil allows the water to drain away rapidly.

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* Abstract from a general report including other soil samples.

† Of the Division of Soils, Council for Scientific and Industrial Research, located at the Waite Institute, South Australia.

It is unlikely that the 'frond choke' conditions of the coco-nuts in this section of the plantation are the result of major plant deficiency, since all the soils examined are well supplied with plant nutrients.

A feature which is usually observed on light soils is the general wilting of the young, shallow-rooting coco-nut palms after long spells of dry weather, with, usually, subsequent recovery following heavy rains. During periods of drought, this type of soil will dry out rapidly, especially in the surface layers, and the shallow-rooting, young coco-nuts are, therefore, the more likely to be affected. Following heavy rains, the relatively high water-holding capacities allow the soils to regain the normal moisture status and restore the water balance of the palms."

Mr. Hosking's remarks on the comparison of the soils showing the described symptoms in coco-nut palms at Kokopo with soils growing palms similarly affected at Namatanai, New Ireland, are included earlier with a more detailed pathological description of the latter occurrence by the Economic Botanist.

TABLE 1.—MECHANICAL ANALYSES AND CHEMICAL DATA FOR TWO SOIL PROFILES FROM A SECTION OF AN EXTENSIVE COCO-NUT PLANTATION, KOKOPO DISTRICT, NEW BRITAIN, TERRITORY OF NEW GUINEA.

Site Number	1.			2.			
Sample Letter.	A.	B.	C.	A.	B.	C.	D.
Waite Institute Sample Number.	5382.	5383.	5384.	5385.	5386.	5387.	5388.
Depth in Inches.	0–12.	12–24.	24–36.	=0–12.	12–24.	24–36.	36–42.
	%	%	%	%	%	%	%
Pumiceous stone	..	..	..	..	..	3.4	2.4
Fine earth	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Coarse sand	4.1	8.2	15.4	7.1	19.6	31.9	33.6
Fine sand	22.4	26.9	31.2	26.3	38.4	45.4	43.0
Silt	30.1	33.0	26.4	29.3	25.0	16.2	14.3
Clay	28.9	21.2	22.3	22.7	11.0	4.8	5.8
Loss on acid treatment ..	4.1	2.9	1.4	3.7	1.8	1.1	0.4
Moisture	8.4	6.7	4.0	7.3	4.0	1.0	2.6
Loss on ignition	13.7	9.4	6.5	12.7	5.9	3.0	2.6
Phosphoric acid P_2O_5	0.21	0.10	0.03	0.21	0.15	..	0.13
Potash K_2O	0.26	0.27	0.14	0.35	0.34	..	0.28
Nitrogen N	0.42	0.20	0.08	0.36	0.08	0.03	0.01
Soil reaction pH	6.9	6.9	6.9	7.1	7.0	7.4	7.3

Other Records of Maturation Wilts in New Guinea.

Inquiries and personal observations lead one to the conclusion that there are few plantations in New Guinea where some areas of coco-nut palms do not display symptoms of nutritional disturbances, to a greater or lesser extent, when they are coming into bearing.

In Bougainville Island, near Kieta, the author saw palms at this stage which were similarly affected to those at Namatanai, except that the disease

was not so serious and the palms later recovered without any considered treatment on the part of the owner. In this case the areas affected were some 60 feet above the level of a small river and, as the ground was very free working, the water, apparently, got away easily. A good deal of pumice was mixed in with the soil. The fronds showed the same distinct spotting as was seen in the fronds from New Ireland and, also, a certain amount of tip-wither and leaf-break.

It was also seen that scale and mealy-bug insects were prevalent, especially one described by the Imperial Institute of Entomology for the Entomologist as a completely new genus, as yet unnamed. Also *Aspidiotus destructor* (red scale) and many colonies of *Aleurodicus destructor* were seen, together with a good deal of *Pestalozzia* spotting. The striking feature was the manner in which the various pests appeared to concentrate on the poorly vigorous palms. These palms were seen in the dry season, and later on, after heavy rains, were said to recover to a very large extent.

Since that time careful observations on several plantations, where palms were just coming into bearing, have shown that, in most places, patches are present in which the fronds show a typical yellowing or spotting, just as in the cases described. In some instances this is only apparent to a keen observer who is on the look out for the condition, and may pass unnoticed by the planter on the spot. This is mainly because, in such cases, the change in colour is not very great, and, secondly, because the symptoms disappear as soon as the climatic conditions improve and the stage of maximum nutrient requirements is passed.

In the same plantation it has been remarked, on numerous occasions, that palms on areas which have previously grown native foods or are planted over old native gardens present the worst appearance at the critical stages. It will be shown that there are sound chemical and physiological reasons for this being the case. Any retarding of the nutrient and water supply to the plant will have a quicker and more decided effect on palms growing on soils already exhausted, to a large extent, by previous cropping.

Observations have already shown (also recorded from other countries) that the effects of drought are greater on young palms than on adult palms.

Maturity of Coco-nut Palms in Malaya.

Dr. Jack[15] has made the following interesting comments concerning coco-nut palms coming into bearing:—

"Individual palms vary in the age at which they reach maturity, although field observations reveal no difference in growth.

On flat, alluvial land in this country (i.e. Malaya), it is commonly noticed that young palms, usually about ten years old, which have yielded well for two or three years, sustain a set-back and produce poorly for one to two years before again yielding good crops.

This habit is possibly an environmental effect resulting from a high water-table, which probably arrests the development of the natural root system temporarily, causing a shock which retards the growth for a time. The habit is, however, also recorded on estates which maintain a fairly low water-table (4 feet or more), so that it may be merely a growth character, marking the period after which the palms may be said to be mature."

It will be seen that this description fits several similar occurrences recorded in New Guinea.

Wilts at Maturation Period Compared with Wilting in the Mature Stages.

Were the disease in Namatanai to occur in the West Indies and elsewhere, it seems most probable that this type of disease which is herein tentatively referred to as "maturation wilt", would be classed in the same category as "bronze wilt" and as influenced by the same limiting factors. The disease at Namatanai seems, however, to be a more temporary derangement, and the necrotic spotting and streaking of the midribs appear to differentiate it.

It appears to us that this type of "die-back" is of a closely related type. It must be recognized that in a young palm just reaching the bearing stage there are several other contributory and interlocking, limiting factors acting which are not present in the same degree, once the palms have settled down to permanent bearing. The chemical composition, the relative amount of dry matter to moisture present, the root system and the economy of a young palm are quite different from that of an old, fully-bearing palm. As laid down for "Vernalization" procedure, it is necessary to distinguish between development and growth, and, as the plant develops from germination to maturity, it goes through several distinct stages. It stands to reason that the behaviour, or reaction, of the palm at one stage (in this case a critical stage in its life cycle, that of coming into bearing) to its environment is not the same as the reaction of an old palm to the same soil and climatic environment, e.g., the young palms are more susceptible to drought.

It will be seen from descriptions given later on, and references quoted,[4-2-8] that in the West Indies there is a tendency for coco-nut wilts to occur frequently in young palms, but one has seen no account of the disease appearing at such an early stage as was recorded at Namatanai.

The advisability of distinguishing "maturation wilt" from more permanent and serious "mature palm wilts", such as those described from New Guinea, in the latter portions of this article, must be considered.

In the next issue of this *Gazette*, the occurrences in New Guinea are compared with similar physiological diseases of coco-nuts recorded from other countries. The chemical and physiological changes which occur in coco-nut palms at various stages of growth are also discussed, in relation to the diseases described from New Guinea and elsewhere.

The importance of proper cultural conditions for the control of most coco-nut diseases, particularly those of physiological origin, is also stressed.

(*To be continued.*)