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AN AGRICULTURAL SURVEY OF THE MARKHAM VALLEY IN THE MOROBE DISTRICT.

By Colin C. Marr, Inspector and Instructor.

This tract of country presents most interesting features, and it merits a detailed description as it appears from many points of view to be one of the most promising in the Territory of New Guinea (together with the Ramu and Purari Valleys) for the grazing of cattle, and the possible development of native agriculture under administrative supervision.

Topographical Features.

A.—Mountain Ranges.

The River Markham flows into the head of the Huon Gulf. Viewed from the sea its valley appears as a broad cleft dividing the high mountain ranges of the Huon Peninsula from the equally high mountain ranges of the mainland.

The valley runs in a north-westerly direction from the mouth of the river. At its headwaters, at an elevation of 1,350 feet, the river is separated from the Ramu basin by a grassy plain, the actual divide being almost imperceptible. The Ramu basin continues on from this point also in a north-westerly direction until the Ramu River enters the sea near the mouth of the Sepik River on the northern coast of New Guinea. The remarkable similarity in type and in direction of the two valleys, points to a common geological origin.

The valley of the Markham about half-way up, changes its direction abruptly through an angle of a few degrees, and in its upper portion runs in a more northerly direction than the lower portion. On the eastern flank of the valley at this point there is a low range of hills with a strikingly regular saw-edge summit—sierras on a small scale.

The Markham basin is bounded on the east by the high mountains of the Huon Peninsula including the Finisterre, Cromwell, Saruwaged and Rawlinson Ranges, and on the west by the Kratke, Kuper and Herzog (Buangs) Ranges. The influence on the climate of the valleys of these large mountain masses on either flank is important, and will be referred to later under "climate".

B.—Rivers.

The River Markham is approximately 95 miles in length, and flows in a general south-easterly direction into the Huon Gulf. Its course follows along on the extreme western edge of the valley bottom, practically hugging the foothills. The plains, therefore, are on the eastern side of the river, and are drained by tributary streams from the mountains on that side. They are all surface streams, some without any clearly defined watercourse, and these are apt to change their course within the limits of a wide bed. The whole width of channel of every stream is covered with water-worn pebbles. None of these rivers has a muddy bottom, and if transport vehicles come to the valley, no difficulty should be experienced in crossing. Normally the streams have little or no water except in the case of the River Leron. They rise and fall quickly, and are in fact, merely

flood channels which carry off storm waters after downpours in the mountains. Except in the case of the western bank of the Leron River which is about 20 feet high, the stream bed in every case is level with, or within a few feet of, the level of the plain.

The following is a list of the tributary streams in order of position beginning at the mouth of the Markham River, with a few notes on each as supplied by G. Bryce, D.Sc. (Edin.), late Director of Agriculture, Rabaul, in a report compiled in 1925:—

R. Munum—at 15 miles from Lae. Width of bed 20 yards. Gravel bottom. Water running only in small shallow channel. Bed level with plain.

R. Ilap—at 28 miles from Lae. Bed ½ mile across. Pebbly bottom. Water running in two channels each 20 yards across and 2 feet deep. Bed level with plain.

R. Mararomi—at 32 miles from Lae. Bed 30 yards across. Pebbly bottom. Water running in channel 2 yards across, and 2 inches deep. Bed level with plain.

R. Narawantopa—at 33 miles from Lae. Bed 10 yards across. Gravel bottom. Only a trickle of water running, stream probably usually dry. Banks 3 to 4 feet high.

R. Shangat—at 34 miles from Lae. Bed 20 yards across. Gravel bottom. Only a trickle of water running, stream probably usually dry. Banks 6 feet high.

R. Wowin—at 38 miles from Lae. Bed 7 yards across. Gravel bottom. Shallow stream occupying whole bed, probably permanent. Bank 4 feet high.

R. Romu—at 40 miles from Lae. Bed about 1½ miles across. Gravel bottom. Water running, in three channels respectively 20 feet across, 3 feet deep, 8 feet across shallow, and in third channel three small streams each 8 feet across and shallow. Bed level with plain.

R. Safeh—at 43 miles from Lae. Bed 20 yards across. Gravel bottom and dry. Banks 12 feet high. A second channel occurs ¼ mile to the west. Bed 60 yards across, gravel bottom. Stream 8 feet across and shallow. Banks 3 feet high.

R. Leron—at 50 miles from Lae. Bed about ½ mile across with pebbly bottom. Three streams each 10 to 15 feet across and 1 to 2 feet deep. Main stream 25 yards at crossing, and 3 feet deep, flowing about 8 miles per hour. East bank level with plain. West bank 18 feet high. Stream bed 4 yards across with sandy bottom. Stream 20 feet across, 3 feet deep. Banks 3 feet high.

R. Iroap—at 56 miles from Lae. Bed 20 yards across with gravel bottom. Stream 20 feet across and 2 feet deep, banks 3 feet high.

R. Manyang—at 66 miles from Lae. Bed 2½ miles across with gravel bottom. Bed level with plain. Four main channels respectively 150 yards across, 100 yards across, 50 yards across, and 200 yards across, each with an insignificant flow of water.

R. Oroboar—at 68 miles from Lae. Bed 30 yards across with gravel bottom. Stream 20 feet across, shallow. Bed level with plain.

R. Markham—Markham crossing at 70 miles from Lae. The bed at the crossing from the Atzera to the Amari district is about 600 yards across with a pebbly bottom. There are three channels, but only one contained water, and this was about 30 yards across, 3½ feet deep with a flow of 8 miles per hour; the stretch from Gabsonket to the sea, down which we travelled by raft, is about 20 miles in length. The breadth of the bed is about ¼ mile, the stream is much broken up into channels by sand and gravel, with banks of considerable size. The channels vary in depth, generally only one channel being navigable by canoes or rafts It is unlikely, therefore that it will prove of any great use for transport.

NOTE.—The Rivers Ilap, Romu, Manyang which are described as having beds of 1 or 2 miles across are in reality surface streams, flowing only after rain in the hills. The whole width is unbroken, the bed being frequently split up by banks of varying depths covered with grass. These rivers, obviously, change their channels frequently within the limits of the bed as indicated by Dr. Bryce, and it probably gives a truer appreciation of the circumstances to set down, as he has done, the whole width of country over which they flow at one time or another. They present no difficulty to wheeled transport, save that of loose gravelly surface and an occasional flood.

C.—PLAINS.

The Markham Valley from the sea to its headwaters forms one plain with a gradual rise in elevation. The elevations noted on this inspection are—

Lae—sea level.
River Wowin—480 feet.
River Leron—600 feet.
River Markham crossing—1,250 feet.

Laterally the valley is level throughout its course, and the valley floor may be represented diagrammatically as an inclined plane rising from the sea level. There are, of course, fluctuations in level, notably slightly undulating country west of the River Wowin, but these are inconsiderable, and the diagrammatic representation may be taken as true for all practical purposes.

With such conditions as to level, it is to be expected that the plain would be well drained, and this is the case. There is an almost complete absence of swampy land, such infrequent marshes that occur being small in size. The largest marsh seen is 6 miles east of the Leron River, and measures approximately ½ mile in diameter.

As the valley floor is level across its width, the foothills on each side appear to arise abruptly from it, though the actual angle of their slope is not great.

The Markham plains are a remarkable feature in a mountainous country like New Guinea, and indeed, considered in conjunction with the topography of the district, they would be remarkable anywhere.

Between the Rivers Ilap and Iroap—a distance of 30 miles—the valley is, on the average, 12 miles wide, and in the vicinity of the River Leron—where there are no trees—the whole sweep of the valley with the mountains towering in the distance lies before the eye.

Similar wide views may be obtained in other parts of the valley, but the presence of trees reduces the area visible at any one time.

The estimated area of the plains of the valley as shown, may be taken conservatively—

Gabsonket to the River Wowin ..	..	378	square miles
River Wowin to River Leron ..	..	243	„ „
River Leron to River Iroap ..	..	97	„ „
River Iroap to River Markham	..	110	„ „
River Markham to the valley-head	..	100	„ „
River Watut Valley	..	120	„ „
Total	..	1,048	„ „

The forest area at the river mouth is not included here, and it must be remembered that the River Watut comes in on the west side of the Markham River.

To obtain the cultivable position there requires to be deducted the areas of river beds from which the soil has been denuded. The areas occupied by the above rivers are estimated as under—

River Markham	..	95	square miles
River Ilap	..	27	„ „
River Romu	..	27	„ „
River Leron	..	36	„ „
River Manyang	..	20	„ „
River Watut	..	20	„ „
Others streams, say	..	100	„ „
Total	..	325	„ „

The total area of cultivable land is, therefore—

1,048 less 325 equals 723 square miles or approximately 450,000 acres.

D.—Geological Features.

It has been suggested elsewhere from time to time, that the valleys of the Markham and the Ramu owe their origin to a great fault or rift in the terrain, although, incidentally, this fault has been utilized by both rivers as a convenient means of access to the sea.

The valley is bounded on either side by high mountain ranges which reach an altitude of 12,000 to 13,000 feet, and exercise a profound influence on the climate of the valley plains below.

The sierra in the Leron region is composed of conglomerates, soft friable sandstone and mudstones with fossil shells. Many water-worn pebbles of these rocks were seen in the bed of the Leron. These sedimentary rocks probably continue down the valley towards the coast, though they do not form in other places this remarkable saw-edge summit. In the stream flowing through the forest region near the mouth of the Markham River brown coal has been picked up. The deposit has been known for some considerable time. This deposit probably comes from the same geological formation as that of the sierra.

The rocks forming the high mountains behind the sierra and on the Huon Peninsula are apparently mainly diorites, as the greater portion of the large pebbles in the river-beds is derived from this rock.

No metamorphic rock specimens were seen. On the western side of the valley outcrops of crystalline limestone occur.

The geological history of the region in recent times gives the impression that the Huon Peninsula was an island, and at this stage the corals were formed. As the land rose the sandstones and conglomerates of the sierra of the Leron region were deposited, and at the same time the fine loam of the valley bottom was laid down. Subsequent uplift must have been rapid as the valley still presents these features in its present condition. It seems probable that the soil of the valley was laid down under estuarine conditions, and the presence of brown coal near the mouth of the valley tends to support this theory. It does not seem to be possible otherwise to explain the great depths of fine loam that are to be seen in the river-bank sections, where the surface loam is found unchanged at depths of 20 feet or so, below soil level. Many profiles were examined over various parts of the valley, and in no instance was the transition from soil to sub-soil in any such sections observed.

E.—Soil.

The soil of the valley is one of its most outstanding features. In view of the type of soil deposition it would be natural to expect the valley to be extremely fertile, but actually the fertility is anything but consistent throughout. The so-called Markham Valley is really a rift, and the whole country is geologically very new, and shows evident signs of recent uplift.

The Markham and its tributaries have not yet had time to carve out beds for themselves, and at present they are shallow and turbulent streams flooding over the surrounding surface. In some cases they have actually built up a bed for themselves that is higher than the level of the surrounding country. The current is in all cases very swift.

Considering the moderate volume of water these rivers usually carry, their beds cover a very wide area since they frequently change their courses. The Manyang River, for instance, has a course which is 3 miles wide, and flows in two or three channels. It brings down large quantities of stones, gravel, and coarse sand, and frequently bursts its banks, tearing out fresh channels, and depositing large quantities of rubbish, thereby ruining much good agricultural land. The Ramu is another example, but in this case the stream passes through foothills of sandstone, and consequently alluvial deposits of sandy loam are beginning to form in the lower reaches of its course.

The Markham itself is so swift flowing, and has such a steep bed, that it has not yet had time to deposit much alluvium on its banks, and its flood plains are consequently covered with stones and layers of coarse gravel.

To the casual observer the vast plains of waving grasses will convey an impression of luxuriance and deep fertile soils, but the hasty survey the patrol was able to make showed that this was not the case.

Large areas of fertile soils do occur, but equally large areas consist of shallow stony soils, which would probably not be worth cultivating, although they should eventually prove to be of considerable value for pastoral purposes.

The land on both sides of the Leron River several miles in width, consists of gravel patches covered with a thin layer of soil varying from 3 inches to 1 foot in depth.

Away from the river banks the soil often improves, but generally speaking the extent of good soil is larger between the Wowin and the Ilap rivers than it is between the Wowin and the Leron. However, about a mile north of the Wowin River, a stretch of exceptionally fertile soil occurs which appears to have been an old lake-bed several square miles in extent.

The soils in the valley are generally black, chocolate or grey coloured medium loams with good sub-soil drainage, towards the headwaters of the Markham River. Large areas of this type of land with a foot to 18 inches of soil may be worth experimentation with shallow rooting crops, more especially as they are not deep enough for bananas, taro, yams and other root crops, and so are not likely to interfere with the native food supply.

The deep heavy soils are usually denoted by a heavy growth of Kunai or "blady" grass (*Imperata arundinacea*), heavy swamps carrying cane-grass (*Saccharam spontaneum*) and a reed.

Soils of medium depth carry a heavy growth of Kunai mixed with a large kangaroo-grass (*Themeda gigantea* or *Anthistera sp.*).

Shallow stony soils carry sparse short kangaroo-grass probably *Themeda elatior*, and a smaller annual species.

The incidence and growth of the above grasses afford a very good guide to the character of the soil in the valley.

Sufficient was seen to indicate that when this valley is opened up and land settlement is undertaken, as presumably will be the case, one of the first things to be done will be to make a careful soil survey of the whole area, since the character of the soil varies greatly and within short distances.

F.—The Climate.

No accurate information of the rainfall, temperature, and humidity are available since it is only recently that this area has really come under control. There seems to be no doubt, however, that the lower part of the valley has a different season from the middle and upper portions.

However, an average rainfall of 100 inches per annum was recorded over a period of five years at Kaiapit (approximately 70 miles from Lae) by the Lutheran Missionary stationed there, whilst at Sangan Experimental Station in 1926, about 55 miles from Lae, and in the centre of the valley, an average rainfall of 70 inches was recorded. In both cases practically the entire rainfall was recorded during the north-west season.

The average annual shade temperature noted was 86 degrees.

The dense heavy rain-forest around Lae and for about 28 miles inland has a much greater rainfall than the upper reaches of the Leron River during the south-east season, i.e., from June to October.

The dividing line between the two regions is somewhere about the line of the Ilap River, which is 4 miles beyond Gabsonket village, and about 28 miles from the sea. From here up the valley there are signs of a much drier climate, and it is believed that the majority of the rain falls during the north-west season, November to May. There is no record of the total annual rainfall, but it is obviously very much less than lower down the valley or in the ranges that bound the valley on either side.

One peculiar feature of the climate is the prevalence of winds. The occurrence of high winds from the north-west at certain seasons has been remarked by the Reverend Oertel, Lutheran Missionary at Kaiapit, and likewise the prevalence of winds from the opposite direction during the south-east season. This was particularly the case in the treeless region in the neighbourhood of the Leron and Wowin rivers.

Two other climatic factors are worthy of mention. They are atmospheric humidity, and the prevalence of cloud and of early morning mists, as in the Wampit and Bulolo valleys.

The two main climatic seasons in this territory are controlled by the north-west (monsoonal), and the south-east winds respectively.

The north-west period is generally regarded as the wet season, but there are places in the territory where the position is reversed. The coastline fronting the Huon Gulf from the mouth of the Markham River to Cape Fortification enjoys a dry spell in the north-west monsoonal period, and gets all its rain in the south-east season.

Prevailing winds are the decisive factor, governed by the coast and inland mountain ranges, for the annual rain period, and for this reason, contrasting conditions appear at small distances apart. Thus as might be expected over such large land areas as are found in this valley, the climatic conditions vary considerably.

During the north-west monsoonal period, although the Huon Gulf country is undergoing a dry spell, the inland mountain ranges are being subjected to continual heavy rains, and it is during this season that the Markham River becomes a raging torrent, overflowing its banks for many miles, and inundating low-lying country for weeks at a time.

G.—Botanical Features in the Valley.

Although no definite data is available as to the origin of this grassland, the presence of old devoru (*Alstonia scholaris*) and other trees are proof that the land was once covered with intermediate forest, and that the present growth has been artificially caused by the shifting agricultural methods as practised by natives in the past.

Grass cannot ordinarily compete with weed-trees, and were it not for the annual burn-off, to which this valley is regularly subjected, it would not be so very long before the valley would be converted back from grassland to secondary forest.

Unfortunately, the native pursues only one system of agriculture throughout the whole Territory of New Guinea as he has not yet learned the use of modern implements and methods. This system comprises the cutting down of bush, burning it off, and the planting of tuber crops. When the ground is thoroughly worked out grass and weeds and small trees take hold, but before the latter can become permanently established, fires are lit by the natives in the dry season to drive out the bush rat, pig and wallaby, which are hunted for food. Thus the natives have come to rely upon these annual burnings as one source of food supply. Were the native to forego burning the grasslands for a few years, the weed-trees (low secondary bush) would doubtless re-establish climatic conditions and environment; woodlands have a decided advantage over grasslands.

Throughout the whole of the areas examined weed-trees were seen struggling for existence, and of the many varieties observed, the extraordinary predominance of *Albizzia procera* in the drier, and *Sarcocephalus* (*Nauclea*) in the wetter areas were noted species. Here and there in the valley, but more particularly east of Chivasing village, thick barked *Clerodendrons* flourish despite fire, whilst *Erythrina* thrives along the higher banks of watercourses.

Grasslands occur sporadically between Kaiapit and Sangan, but it is only after leaving Sangan that the first of the large areas of grasslands occurs. Between the villages of Chivasing and Sangan lies a considerable flat stretch of country comprising the cleanest stand of pure grass in the valley. This stretch is broken by the Leron River and its confluents, which are timbered along the banks, but apart from these, the land is free from tree growth.

Along the foothills of the mountains to the north and stretching down into the plain for perhaps 2 miles, a cycad (*Cycas media*) is to be found, and this gymnosperm is so numerous as to give character to the landscape. The area of this stretch of country would be about 60 square miles, and in this area there are no pure stands of kunai grass (*Imperata arundinacea*) to be seen.

The flora on this portion of the valley contains an admixture of grasses, the main two being "kunai" (*Imperata arundinacea*), and a species of "kangaroo" grass (*Themeda* or *Anthisteria sp.*). The proportion of the two grasses would be approximately 25 per cent. kunai to 75 per cent. kangaroo.

In addition to these two grasses many more were seen, including a species *Saccharum spontaneum*, which occurs in damper lands, and a wild sugar-cane *Saccharum robustum* predominates along the low-lying stony river flats where the land is subject to flooding. *Saccharum spontaneum* grows profusely, and takes up all the marshy land, and in March and April the banks of the Markham, and most low-lying land in the valley are white with tasselled tops of this species. This grass is closely related to the Pollinia grasses of which possibly many more occur than were seen, owing to the nature of the country and the limited time available for inspection.

On the better quality and deeper alluvium, kunai grass takes a firm hold, but on the poorer stony soils such as those found on the slopes of the valley, kunai grass is gradually replaced by kangaroo grass, and as one ascends higher the kunai is completely eradicated by this species.

This grass extends into the hills on either side of the valley, and, aided annually by the natives' hunting fires and clearing operations, has reached an elevation of approximately 3,000 feet in places. Thus, with the help of this kangaroo grass, the savannah of the Markham Valley has extended up into the mid-mountain forests. Two varieties of this grass were seen, and have since been identified as *Themeda gigantea* and *Themeda amboinensis*.

On leaving this area and proceeding out into the valley towards the Markham River about 50 miles from the coast, we find that the admixture of kunai and kangaroo grass is gradually replaced by *Saccharum spontaneum* (wild cane of Asia), and the dense matted rhizomes of these two main grass species form those grasslands which prevent the establishment of the rain-forest timber species.

These grasslands are not natural xerophilous regions, but are converted rain-forests, whilst on the less fertile land secondary weed-tree growth has established itself. Thus throughout the valley there are large areas of grasslands dotted with trees which, from a distance, give the appearance of natural savannah forest.

That cultivation began and hunting fires finished the conversion of this area is evidenced by the presence of significant devoru (*Alstonia scholaris*) and various living trees on all parts of the valley. Thus on land which has evidently been farmed continuously for many years we find *Macaranga spp.* cropping up, and to a lesser extent *Kleinhovia hospita, Alstonia longissima* and *Ginginsia pruinosa.*

Originally the gully forests were made up of hygrophyllous trees, but now only fire-resisting species such as Clerodendrons can establish themselves in open forest formation.

Albizzia sp. are treelets which spring up all through these grasslands, Chivasing and Wowin, and as previously stated, are present in extraordinary quantities. These are not large trees, and with the exception of *Albizzia alba,* which yields a valuable hard wood that is white ant resisting, the wood is of no consequence. They are a savannah forest type, and become leafless in the dry season when they also seed prolifically.

Various varieties of *Albizzia* were noticed throughout the valley of which possibly the commonest is *Albizzia moluccana,* and *Albizzia alba,* but perhaps the most predominant variety is *Albizzia procera* which occurs on the moister lands, and all grow as well here as in the rain-forest.

Two other varieties of trees which are worth mentioning were noticed in the valley. They have no known commercial value, and are only mentioned because of their recurrence throughout the valley.

The first *Rhus simarubaefolia* occurs in wooded gullies or edaphic regions of the grassy hills in the valley, and the second, known as *Diplanthera tetraphylla* is to be found in grass patches up the slopes of the valley between 1,000 and 2,000 feet.

Many other varieties of trees were seen along the edges of the valley, and these will be mentioned later.

Prior to enumerating the various Gramineae found in the valley it is necessary to indicate this important fact, that, apart from several small isolated stands of pure kunai of only a few hundred acres in extent, it was found that the Markham Valley is covered with a very mixed stand of grasses, the predominant species in their order of importance being—

Imperata arundinacea (*Imperata cylindrica*).
Themeda gigantea.
Saccharum spontaneum.
Imperata exaltata.
Eragrostis vars.
Paspalum vars.
Polliniae spp.

On the poorer types of soil bordering the upper reaches of all rivers or confluents, and on all grass-covered hills, *Anthistiria gigantea* predominates, completely eradicating kunai grass.

On higher land a species of the sub-family *Andropogoneae*, identified as *Andropogon serratus*, is to be seen, and to a less extent *Cymbopogon nardus var-Flexuosus*, and it is quite possible that many more varieties of *Andropogoneae* thrive in these regions than were observed.

In addition to *Imperata arundinacea* (kunai) in the valley, another grass was noticed occurring with it, but more particularly in the moister areas, which very closely resembles kunai grass, and this is probably a variety known as *Imperata exaltata*.

Other *Gramineae* identified were *Coix lachyrma-jobi* (a native of India) which was found in waste areas; *Eragrostis elongata* and *Chrysopogon aciculatus* (Love grasses); *Eleusine indica* (finger grass) was also noticed on wet, moist places; *Manisuris granularis* was seen vieing with kunai in places, and another variety known as *Manisuria cylindrica* found growing on marshy areas. Pigeon grasses *Setaria aurea* and *Setaria glauca* (based on *Panicum glaucum var. elongatum*) occur all through the valley as do Panic and Paspalum grasses of which the most common is *Panicum pilipes, Panicum distachyum, Paspalum conjugatum* and *Paspalum longifolium*. Both these grass types occur on open plain country. Two other grasses identified as *Polytoca macrophylla* and *Apluda mutica* were noticed frequently amongst the taller perennial grasses, and to a lesser extent *Pogonatherum crinitum*.

A good fodder grass known as *Pennisetum marcostachyum*—closely resembling the well-known *Pennisetum ruppellii*—occurs, together with *Sorghum plumosum*. This latter is a wild sorghum found in most tropical countries, and often referred to as *Andropogon australis*.

Several *Ischaemum* grasses were seen to be thriving well in thickets bordering low-lying wet lands, the only one identified being *Ischaemum muticum*; but possibly varieties such as *Ischaemum intermedium* and *Ischaemum turneri* also are to be found, as conditions are similar here to other localities in the territory where these varieties are known to exist.

The mountains south of the Markham River and running parallel to it are clothed in forests, into which in some cases, as previously stated, grass has forced its way; but the mountains along the northern boundary of the valley are almost entirely clothed in artificial grassland. On the north-east corner of the valley, however, a lot of natural forest still remains, and here an indication as to the nature of the tree growth was obtained.

In flying over this country it is most startling to see such a large sea of grassland country lying adjacent to a typical rain-forest, in some cases completely surrounding it, whilst on the slopes of the valley at no greater height than 2,000 to 3,000 feet, areas of the conifer known as Hoop Pine, *Araucaria klinkii*, are to be seen growing alongside *Sarcocephalus* species.

On the lower slopes the following species were seen:—

Afzelia bijuga (*Intsia bijuga*).
Gnetum gnemon.
Pometia pinnata.
Breynia cernua.
Albizzia moluccana and *Albizzia alba*.
Chisochaeton biroi, *Dysoxylum* spp., *Baccaurea* spp. } affinities.

In addition to these, other trees forming the rain-forest belt on lower-lying country are enumerated as under:—

Celtis philippensis.
Pterocymbium spp.
Octomeles sumatrana.
Bombax malabaricum.
Vitex cofassus.
Morinda citrifolia.
Chrysophyllum roxburghii.
Planchonia timorensis.
Alstonia scholaris.

Of the above there appears to be a predominance of *Celtis philippensis.*

Several herbs occur amongst the grass, the more common being *Osbeckia chinensis* and *Exacum tetragonum*, whilst another small plant known as *Bola (Baca) lanuginosa* was noticed in abundant quantities in the grass hills. *Urena lobata*, a mallow, was also seen in the valley but not in large quantities.

Many years ago the Administration commenced a roadway from Lae to Gabsonket village, but this scheme was abandoned in favour of aerial transport, and at the present time this road is impassable for traffic; indeed it is with the greatest difficulty that one is able to traverse the road on foot.

The usual method of transport down the Markham River is by raft, for owing to the swiftly flowing nature of the Markham, and its many confluents—which are of an extremely shallow nature, and contain snags and debris in great quantity—boats or canoes are impracticable.

The favoured method of transport to-day is by aeroplane, as there are many aerodromes and emergency landing grounds situated throughout the valley. The same may also be said for the Ramu Valley.

Should a time come when these valleys are occupied and cultivated by settlers, it will be necessary to re-open the road from Lae which was originally commenced by the Department of Agriculture, in 1926, as a means of communication to the "Cotton Experimental Station" situated at Sangan.

In conclusion, it may be stated that the Markham and Ramu valleys have a healthy climate suitable for white settlers, a soil of great potential fertility, and a climate suitable for the grazing and fattening of cattle.

ACKNOWLEDGMENT.

It is desired to thank Mr. C. E. Lane Poole, of the Australian Forestry School, Canberra, for assistance in aiding in the identification of several tree types in the valley through the medium of his report "The Forest Resources of the Territories of Papua and New Guinea".

BIOLOGICAL CONTROL OF INSECTS.

B. A. O'Connor, B.A., B.Sc.Ag., Assistant Entomologist.

One commonly hears allusion made to the phenomenon known as the "Balance of nature", the principle on which are based all attempts at biological control, that is, the control of one species of living thing by another. The phrase "Balance of nature" describes the state of equilibrium which occurs in any given locality between the native species of plants and animals. Any one species is prevented from multiplying to such an extent that it will jeopardize the welfare of the others, and each component of the native fauna and flora takes its part in confining the other components to a limited sphere. The principle is well illustrated by the predatory animals which keep down the numbers of other wild life.

Man, however, in his agricultural activities, interferes with natural conditions, and provides large areas of succulent food, on which various species of native insects thrive. Moreover, he frequently introduces, usually by accident, new kinds of insects from distant localities, often without the parasites which preyed upon them in their natural habitat. Hence the newly introduced insect, free from attack by its natural enemies, spreads with a rapidity which threatens serious damage to crops and stock, and it then has to be controlled artificially or biologically. Biological control consists of finding parasites of the injurious insect in the locality from which it was brought, and introducing them into the new area in the hope that they will adapt themselves to the new environment and reduce the numbers of the pest below the danger level. Obviously this method of controlling insects is ideal, for, once established, the parasite costs nothing, and in successful cases it keeps its host down to negligible proportions. But first the parasite must be found, and later successfully introduced into its new environment. The rewards of victory are so great, however, that many countries keep permanent staffs working on parasite introduction alone, the United States of America in particular spending huge sums on this work.

Though parasitism of insects by other insects has been known to observers since the beginning of the seventeenth century, it was not until 1889 that the first really great success was achieved by biological control methods. It was in this year that Koebele imported into California from Australia the lady-bird beetle *Vedalia cardinalis*, and thus saved the Californian citrus industry from the ruin which threatened it as a result of the ravages of the Cottony-Cushion Scale, *Icerya purchasi*. The story of this accomplishment, the first great landmark in the history of the biological control of insects, has often been told, but nevertheless it cannot be omitted from any discussion of the subject.

The Cottony-Cushion Scale had become firmly established in the citrus groves of California, and was the cause of immense loss to the growers, owing to the cost of controlling it by artificial methods. Riley, who was in charge of the entomological work of the United States Department of Agriculture, knew that the insect had been introduced from Australia or New Zealand, and by corresponding with entomologists in those two countries, he found that while the pest was abundant and injurious in New Zealand, it was not considered a pest in Australia. From these facts he concluded that Australia was the home of the insect, and that it was held in check there by natural enemies. In 1887, specimens of a parasite were sent to him from Australia, proving to be a remarkable new species of fly

now known as *Cryptochaetum iceryae*. Riley was now eager to go to Australia to obtain supplies of this parasite, but was unable to do so. It happened, however, that in the following year an international exposition was to be held in Melbourne, and the United States of America intended sending a party of representatives. Riley arranged for one of his assistants, Albert Koebele, to be included in the party for the purpose of collecting parasites of the Cottony-Cushion Scale.

On his arrival in Australia, Koebele collected and sent back material containing *Cryptochaetum*, which, however, did not prove a success; but he found *Vedalia cardinalis*, the lady-bird beetle, feeding on the scale, and forwarded several colonies to Los Angeles, comprising 139 beetles in all. A few months later, the lady-birds were liberated in the field, and within twelve months the Cottony-Cushion Scale was practically wiped out in California. The growers and many of the leading men in the horticultural industry were wildly enthusiastic over this spectacular success, and were convinced that at last the panacea had been found for the control of all insect pests. As a matter of fact, Dr. Howard, of the United States of America Department of Agriculture, states that this achievement was by no means an unmixed blessing, as it set back control work against insects for many years, due to a lack of faith in artificial methods of control. *Vedalia cardinalis* was subsequently sent to many parts of the world where the scale was a pest, and everywhere it registered a complete and rapid victory.

The investigation of the reasons for the great success of *Vedalia cardinalis* is of particular importance to the student of biological control, as it sheds considerable light on the question of the qualities in a parasite or predator which should be looked for as desirable. The main factors in the success of the lady-bird may be tabulated as follows:—

1. It is largely independent of climatic conditions, flourishing in almost every locality where its host is found.

2. It is a "specific predator", that is its activities are confined to one insect species, instead of being dissipated on a number, and it devours large numbers of its host in all stages of its (the parasite's) life-history. (An insect which devours its host is usually referred to as a predator, the term "parasite" being commonly restricted to internal parasites, which develop within the body of their host. Predators usually are not specific, this characteristic being more often found among internal parasites.)

3. It is very active, and spreads rapidly, while its host is sedentary.

4. It has approximately three generations to the scale's one.

5. It is exceptionally free from natural enemies.

A great deal of work has also been carried out in California on the Black Scale, *Saissetia oleae*. Several parasites of this insect have been introduced, and the best of them is *Metaphycus lounsburyi*, brought from Australia in 1916. It is, however, by no means as effective as it should be, because it is attacked by a secondary parasite, *Quaylea whittieri*, which was introduced from Australia in 1901, and liberated under the mistaken idea that it was a parasite of the scale. It lived on another parasite of the scale until the introduction of *Metaphycus*, which was its preferred host, and to which it has now transferred the bulk of its attention.

The introduction of secondary parasites is a danger which nowadays is carefully guarded against by entomologists who attempt to import parasites, for once they are established in the field, they cannot be got rid of, and may cause, as in California, the annual loss of thousands of pounds. Two precautionary measures which definitely establish whether a parasite is primary or secondary are first the examination of the parasitized material from which the insect has emerged, to see if there are any remains of the larvae or pupae of primary parasites, and second a trial of whether the suspected parasite will breed in unparasitized specimens of the host insect. For instance, before *Dorinia leefmansi*, a primary parasite of *Sexava* eggs, was transferred from Lavongai to Manus, these tests were applied, revealing the fact that *D. leefmansi* was a primary parasite. Similar precautions were taken with *Leefmansia* before its introduction from Amboina as a parasite of *Sexava* eggs.

One of the most interesting phenomena met with in biological control work on insects is "multiple parasitism", that is, a simultaneous attack on a host insect by two or more species of parasites. The practical considerations arising out of this phenomenon are among the most important in the whole field of biological control, because they affect in the most decided fashion the policy to be pursued in the introduction of parasitic insects. Entomologists who have studied the subject have held radically different views on the question of whether it is better to introduce only one parasite of any given stage of an insect's life-history, choosing, of course, the most efficient, or to bring in as many different species of parasites as are available.

The point at issue is that if one parasite attacks say 80 per cent. of the hosts in its natural habitat, and the other only 40 per cent., would it not be better to introduce only the former, as it is the more efficient, rather than have the two competing with one another, possibly to the detriment of the better parasite. It oftens happens, too, that when two such parasites have both attacked the same host, the less efficient one proves more hardy, and survives while the other perishes. This subject has been extensively studied by Willard and Pemberton working on parasites of fruit fly in Hawaii. Several species of parasites have been introduced, and Willard and Pemberton came to the conclusion that it would have been better if only the most efficient of these had been utilized. This view was opposed, however, by Smith, a noted Californian expert on biological control methods, and his arguments are very convincing. In the work on local parasites of *Sexava*, Smith's ideas were followed, and an attempt was made to introduce several parasites from Lavongai to Manus, most important of them being *Dorinia leefmansi*. Unfortunately, however, these parasites, though doing excellent work in Lavongai, are by no means as robust as *Leefmansia bicolor*, the Amboina parasite, and their introduction to Manus has as yet shown no signs of success.

In no part of the world has biological control been more successful than in the Hawaiian Islands. In these islands an immense amount of work has been done by Muir, Perkins and others, employed by the Hawaiian Sugar Planters' Association. Muir, writing shortly before his death in 1931, ascribed the signal success obtained to two main factors, namely, the peculiar biological conditions existing in Hawaii, and the recognition of these factors by the entomologists resident there. The peculiar biological conditions alluded to are worthy of some discussion. The Hawaiian islands are the tops of a lofty chain of mountains

which rises from the bottom of the sea, and extends from the north-west to the south-east. With the exception of a few deposits of mud and coral, the islands are composed entirely of volcanic rock. From this fact, and from the unique nature of the flora and fauna, we can conclude that the land is purely oceanic in origin. It rose slowly from the ocean, and was built up by outpourings of lava over a long period of time. The islands were never joined up to any large continental land mass, and this accounts for the peculiar nature of the flora and fauna. Only such plants and animals as could be borne by birds, or by the wind, or on floating logs and similar material could establish themselves. Muir claimed that even to-day it may truthfully be said that in a broad sense the native flora and fauna are composed almost entirely of types that arrived in this way, or their descendants.

Later on, primitive man arrived, bringing with him domestic plants and various insects attacking them, and by cultivating the food-plants of the insects, he provided them with plentiful sustenance, which, in conjunction with the suitable climate, provided ideal conditions for their rapid multiplication. However, many of these insects had parasites in the country of their origin, which, in the course of ages, had adapted themselves to the particular species concerned, or to closely allied species, and when they were introduced, they also found abundant food and suitable climate, and consequently, in many cases, proved very effective in controlling the injurious insects concerned.

So far, the discussion has been confined to the introduction of parasites from one faunal region to another, but there is a further aspect of the question which should be considered, namely, the breeding and dispersal of parasites already present in a region. At first sight this does not seem a very promising line of activity, because one would imagine that if the conditions were favorable for the spread of such an insect, it would spread without the aid of man, and that its failure to do so should be sufficient evidence that it could not be a success. Nevertheless, attempts in this direction have sometimes met with success, particularly when done on a large scale. One of the best examples is to be found in the annual breeding and distribution of the lady-bird beetle *Cryptolaemus montrouzieri*, an insect predaceous on the *citrophilous* mealy bug in California. The lady-bird is not a native of California, having been brought from Australia in 1892 as a parasite of the mealy bug. However, it did not come up to expectations, for though every now and then it succeeded in controlling an outbreak of the pest, its efforts were too spasmodic, and usually too late in the season to be of any real value. By the year 1916, however, it had firmly established itself in the fauna of California, so it can be taken as an example of an insect already existing in a faunal region.

The Californian entomologists concluded that the trouble with *Cryptolaemus* was that it destroyed an outbreak of mealy bug and was then starved out, as it confined its feeding strictly to the one insect. Thus, when a fresh outbreak of the pest occurred, the lady-bird took a long time to breed up again, with the result that its beneficial effects were spasmodic. They considered therefore, that if they could keep a constant large supply of *Cryptolaemus* on hand, they would be able to distribute the parasite whenever it was called for by an outbreak of mealy bug, and thus give it an opportunity to cope with its host. The chief difficulty in this scheme was to evolve a satisfactory technique for breeding the

beetle throughout the year. At first, the food used was green citrus fruits, chiefly lemons. Unfortunately, however, the laboratory conditions suitable for the welfare of the host plant and for that of the mealy-bug were not compatible. Gas heat was necessary for the rapid development of the mealy bugs, but it had the effect of curing the fruit and toughening the skin in such a short time that the insects either died or migrated unsuccessfully in search of more suitable food. It was at this juncture that the use of potato sprouts was initiated, and it proved a great success. A little experience in the technique of this method led to the production of a continual supply of mealy bugs on which to feed the lady-birds, and so large numbers of *Cryptolaemus* were available for distribution when required. The work of breeding and distribution has been aided considerably by the erection of branch insectaries in various countries of California, together with private insectaries on the properties of some of the more important citrus growers.

Often, ignorance of a very small detail in the life-history of a parasite will hold up successful breeding, and as often as not it is by chance that a solution is arrived at. A good illustration of this is the case of the introduction of a wasp, *Meteorus versicolor,* from France to the United States of America, for use in the control of the Gipsy Moth. Almost all parasitic *Hymenoptera* (the order which includes ants, bees and wasps) deposit eggs whether fertilized by a male or not, the unfertilized eggs almost always producing only males. Hence it is important to see that mating takes place, in order that both sexes may be available for breeding. The imported Gipsy Moth parasites laid freely in the caterpillars of their host, and in due course cocoons were spun and wasps emerged. However, they proved to be all males, indicating that mating had not taken place in the first instance. Further attempts were equally unsuccessful, so that finally it was decided to liberate in the field a small colony of the parasites bred from imported material. This colony was put in a glass tube, and, in the course of its being carried to the woods, it was struck by the direct rays of the sun. Immediately mating took place. It was then recognized that sunlight was necessary to induce mating, and from that time onward no difficulty was experienced in breeding the wasp.

The foregoing remarks should serve to show what a fascinating pursuit the study of biological control can be, and also what wonderful successes it is capable of achieving. But it also gives some indications of the many disappointments that are met with, and the amount of thought and labour that may be expended before any tangible result is obtained. Nevertheless, every day the fund of knowledge regarding our insect friends is being augmented, and the time may come when most of the worst insect pests will be controlled by means of parasites.

CHARCOAL MANUFACTURE FROM COCO-NUT SHELL.

By F. C. Cooke.

[Extract from the *Malayan Agricultural Journal*, Vol. XXIII., April, 1935.]

When coco-nut shell is heated in a closed space without the presence of air, decomposition ensues, resulting in the formation of charcoal and in the evolution of large quantities of volatile products which can be recovered only by using an efficient retort and condensing plant. If charcoal alone is required, but no volatile by-products, it is sufficient to carbonize the shells in a stack or pit.

Methods of Manufacture.

The shells used require a certain amount of selecting, as pieces with husk adhering yield a tarry or dirty product. Thin shells should be discarded and only shells from fully matured nuts, and those that have a clean bald surface selected.

The normal method of charcoal manufacture practised in Malaya is the age-old method of burning in turf or mud-sealed heaps. The enclosed heap is fired and when the shells are thoroughly burning, the supply of air is cut off, carbonization proceeding without further combustion. This primitive method is capable of producing good charcoal.

A tall stake is driven into the ground and shells are built round it to a height of about 4 feet. The pile is then covered with earth and grass which is damped. The stake is removed and fire inserted after which the heap is sealed and allowed to burn for 12 hours. In the morning the pile is doused with water and allowed to cool off.

On certain estates, the process is simplified still further by merely throwing water on a large, burning, uncovered heap of shells. This results in a charcoal which is not uniform, and which is of an inferior quality.

In Ceylon, where in coco-nut districts it is possible to excavate without reaching water, pits from 4 to 6 feet deep are filled to the top with shells which are then covered with green fronds and damp turf, sealed with earth and the shells fired.

There are two alternative methods of procedure. In one, fire of shells is started at the bottom of the pit, more shells are added until the pit is full and when these are well alight the fire is sprinkled with water until the flames have died down. The glowing mass is then covered with damp fronds, turf and earth, and left for twelve hours. Alternatively, a large pit 6 feet deep and 8 feet in diameter is dug; a hollow bamboo pipe is placed vertically in the centre and the pit is filled to ground level with shells. Paraffin is poured down the pipe and lit, after which water is sprinkled over the burning shells. They are then completely smothered with wet fronds, sacking and earth and left overnight.

Requirements and Specification.

The distillation of creosote and other by-products from the shells must be practically complete as, for use in cooking, the object is to obtain a smokeless fuel. For chemical purposes, the charcoal will not act as an absorbent if the pores

of the charcoal are clogged. In the production of producer gas for use in suction gas engines, the object is to obtain maximum gas output and to keep the fouling of the scrubbers and filters to a minimum.

A London firm of importers gave the following specifications:—

(*a*) Not more than 15 per cent. volatiles.
(*b*) Not more than 10 per cent. moisture.
(*c*) Pieces to be of a size, not less than 10 per cent., remaining in a mesh with 1-inch holes; nor more than 5 per cent. passing through a mesh with ¼-inch holes.

Requirement (*c*) is severe for there may be considerable damage and breakdown during shipment.

Properties of Coco-nut Charcoal.

An actual sample of Malayan charcoal received which contained 25 per cent. moisture, gave 5,730 calories as the calorific value. This in terms of dry charcoal is equivalent to a gross calorific value of 7,640 calories.

Pieces of charcoal of good quality are uniformly dark, and free from adherent dirt due to husk. When dropped on a stone floor such pieces emit a clear bell-like ring and the broken edges show a black lustrous surface with a sharp conchoidal fracture. A badly burnt piece will emit a dull sound, and its broken surface is dull, dirty and irregular. An overburnt piece is very thin and has a smooth wavy indented edge beginning to curl. Thin overburnt pieces are very brittle, and are therefore unsuitable for inclusion for export as they are quickly reduced to dust.

Great care, experience and skill are required if the necessary high quality is to be obtained and slight misjudgment may result in a mixed mass of woody half-burnt charcoal, as a result of incomplete combustion, or a low yield of thin brittle copra through over-ventilation or over-burning. It will be appreciated, therefore, that the training of the operators may be a lengthy process and many batches of charcoal may be spoiled before the necessary skill and judgment are acquired.

Yields.

The theoretical yield of shell charcoal is half the weight of the coco-nut shell. In practice, 25 per cent., or even considerably less, is obtained according to the efficiency of production and the thickness of the original shell.

An approximate formula for estimating the number of shells required per picul of charcoal (133⅓ lb.) is four times the number of nuts required per picul of copra, e.g., 250 nuts per picul of copra equals 1,000 shells per picul of charcoal.

If shells are also to be used as fuel in the copra kiln, it would not be safe to assume that more than 30 per cent. of the total shells would be available or suitable for conversion into charcoal.

Cost of Production.

In one instance, charcoal is now being manufactured and bagged on contract at the rate of 28 Straits cents per picul. Three bags are required per two piculs of charcoal and this together with handling and road transport brings the total cost to about 60 cents per picul f.o.b.

The conference tariff on coco-nut charcoal is about 72s. per long ton ex ocean port, less 10 per cent. deferred rebate. Cost of production, above, is equal to about 25s. per ton. Selling charge, insurance, &c., bring the total c.i.f. cost to about £5 per ton.

In view of the possible local extras not included above, an all-in cost of £6 per ton should be allowed.

The Market.

In 1931, the price offered by European buyers was between £10 and £11 per ton, but a more recent quotation was as low as £7 per ton delivered. Demand has hitherto been neither large nor sustained. In Ceylon, there is a considerable industry, the charcoal produced being either sold in the villages for kitchen use; for use in laundries; for conversion into producer gas; or for consumption in smelting works in Colombo. In Malaya, the bulk of the charcoal used for cooking purposes is obtained from baku wood and the local demand is somewhat limited.

REPORT ON SOIL SAMPLES FORWARDED BY THE DIRECTOR OF AGRICULTURE, RABAUL, NEW GUINEA, TO THE WAITE AGRICULTURAL RESEARCH INSTITUTE.

1. Soils from Talasea District, Island of New Britain, New Guinea.

Twenty-four soil samples, representing five profiles to a depth of 72 inches have been examined.

These soil profiles have formed upon geologically recent, layered deposits of volcanic ash and are in consequence extremely immature in their development. From an examination of the pumiceous and other stone within the profiles and from a consideration of the mechanical analyses of the soils, it is apparent that a number of ash showers were deposited in the area, one on top of the other. At least three distinct layers in which the material varies from distinctly pumiceous to andesitic or rhyolitic in character are to be observed in each profile. The andesitic type of parent material is apparently dominant throughout the soils although, as in the lower layers of profile five, the rhyolitic type may be pronounced.

While the surface layer of the soils to a depth of about 12 inches is practically free from stone, about 6 per cent. of pumiceous material occurs in the second foot. The pumiceous stone reaches a maximum concentration of as high as 30 per cent. in the third or fourth foot, where lumps of pumice up to several inches in diameter may be found. Below 3 feet the lumps of pumice decrease in size and amount, their place being taken by less scoreaceous and smaller fragments of rhyolitic or andesitic material. In the lower depths, below 4 feet, these latter fragments together with glassy material and large grains of heavy minerals are present, to the virtual exclusion of pumice within the gravel fraction.

The soil profile consists of a 12-inch surface layer of a dark brown to grey yellow brown loam to clay loam, rich in organic matter overlying a light brown to yellow brown sandy loam to clay loam. To this depth of 24 inches the soils have a distinctly silty feel and a comparison of their mechanical analyses with those for soil formed from similar parent volcanic ash in New Zealand would suggest that they fall within the silt loam class. Below 24 inches the soils consist of pumiceous or andesitic or rhyolitic extremely sandy deposits yellow brown to yellow in colour, the yellow shade increasing markedly with depth.

There is little variation in the reaction values of the soils from profile to profile, although within the profiles themselves a change from slight acidity in the surface to neutral at the lower depth is to be noted.

The soils in the surface are well supplied with plant foods, the nitrogen, phosphoric acid and potash contents showing mean values of 0.4 per cent., 0.25 per cent. and 0.14 per cent., respectively. While there is a distinct decrease in the content of the nitrogen and phosphoric acid in the second foot, the potash content rises slightly.

The mechanical analyses and chemical data for the soils are given in the accompanying table. (Table 1.)

2. Soils from Upper Ramu Valley, New Guinea.

Two soil profiles, one from the alluvial flats and a second representative of the hill slopes from the Upper Ramu Valley, northern New Guinea, have been examined.

The profiles are essentially similar, being typically podsolized soils. They consist of a surface black to grey-black sandy loam, rich in organic matter to a depth of 12 inches, overlying a grey to yellow brown mottled sandy clay or light clay subsoil. Ferruginous gravel to the extent of about 27 per cent. occurs in the alluvial profile and to the extent of about 40 per cent. in the second profile.

The soils are distinctly acid. In the surface the pH values lie between pH 5.0 and pH 5.5, and rise gradually to a pH of over 6 in the subsoil.

The soils contain an adequate supply of plant nutrients as shown by Table 2.

J. S. HOSKING.

TABLE I.

SOIL SAMPLES FROM TALASEA DISTRICT, ISLAND OF NEW BRITAIN, NEW GUINEA, FORWARDED BY THE DIRECTOR OF AGRICULTURE, RABAUL, NEW GUINEA.

Locality Site Number.	1			2		3						4			5			
Waite Institute Sample Number.	5065	5066	5067	5074	5075	5078	5079	5080	5081	5082	5083	5088	5089	5090	5097	5098	5099	5100
Depth in Inches.	0–12	12–24	24–36	0–12	12–24	0–6	6–12	12–24	24–36	36–48	48–72	0–12	12–24	24–36	0–6	6–24	24–48	48–72
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Stone	..	5.3	30.1	..	5.2	..	1.4	5.8	29.3	18.1	18.2	2.3	8.3	15.2	..	8.2	1.9	..
Fine Earth ..	100.0	94.7	69.9	100.0	94.8	100.0	98.6	94.2	70.7	81.9	81.8	97.7	91.7	84.8	100.0	91.8	98.1	100.0
Coarse sand ..	9.0	36.3	63.5	11.9	7.5	9.0	3.6	5.1	61.1	77.8	71.4	14.6	33.7	74.0	11.2	15.8	46.0	50.7
Fine sand ..	28.3	30.8	23.2	33.6	35.7	26.9	18.3	27.1	24.0	13.8	17.6	24.6	22.4	18.1	27.4	20.4	34.5	14.9
Silt	18.9	15.9	6.2	17.5	18.5	18.2	19.3	33.1	6.5	3.5	3.8	24.9	16.0	2.1	18.4	19.8	9.0	14.8
Clay	24.5	4.1	1.7	13.2	20.7	25.1	36.0	18.6	2.1	1.1	2.4	13.7	8.8	1.4	17.1	18.2	3.8	7.0
Loss on Acid Treatment	2.9	2.0	1.4	2.1	1.6	2.3	1.8	1.9	1.3	1.1	1.3	2.5	1.5	1.1	2.9	1.5	1.4	1.2
Moisture ..	13.3	10.7	4.4	18.3	17.8	13.8	21.1	17.1	5.6	3.5	3.9	20.0	12.6	3.2	19.9	27.3	6.0	12.6
Loss on Ignition..	13.9	5.7	2.2	8.8	7.1	13.0	8.5	8.3	3.5	2.3	2.3	9.8	6.7	2.3	13.6	7.1	3.8	5.1
Phosphoric Acid P_2O_5	0.33	0.09	..	0.26	0.14	0.31	0.16	0.10	..	0.07	..	0.17	0.11	..	0.18	0.08	..	..
Potash K_2O ..	0.18	0.31	..	0.13	0.18	0.15	0.15	0.23	..	0.16	..	0.11	0.13	..	0.14	0.13	..	..
Nitrogen N ..	0.51	0.04	..	0.33	0.05	0.47	0.15	0.06	..	..	..	0.28	0.02	..	0.53	0.12	..	..
Soil Reaction pH..	6.6	6.8	7.1	6.4	6.8	6.2	6.6	6.7	6.2	6.7	6.8	6.6	6.5	6.5	6.9	6.5	6.7	7.0

Soil No.	Depth in inches.	% stone.	pH.
5068	36–48	24.2	7.3
5069	48–72	19.3	7.2
5076	24–48	2.6	6.8
5077	48–72	10.2	6.9
5091	36–48	28.3	7.0
5092	48–60	12.5	6.9

TABLE 2.

SOIL SAMPLES FROM UPPER RAMU DISTRICT, NEW GUINEA, SUPPLIED BY THE DIRECTOR OF AGRICULTURE, RABAUL, NEW GUINEA.

Locality.	Profile Number.	Waite Institute Sample Number.	Depth in Inches.	Moisture.	Loss on Ignition.	* Soil Reaction.	Nitrogen.	K_2O.†	P_2O_5.†
				%	%	pH.	%	%	%
Alluvial flats ..	1	5049	Surface	6.48	14.08	5.2	0.36	0.12	0.11
		5050	6	8.47	13.15	5.4	0.34	0.12	0.10
		5051	9	7.64	12.24	5.8	..	..	..
		5052	12	6.03	10.88	6.0	0.23	0.10	0.09
		5053	16	5.68	10.33	6.3	..	..	..
		5054	24	3.59	6.86	6.3	0.08	..	..
		5055	36	3.94	6.04	6.0	..	0.19	0.03
Slopes and Undulations	2	5056	Surface	11.10	14.26	5.5	0.31	0.10	0.12
		5057	6	8.61	14.36	6.2	0.24	0.07	0.12
		5058	9	9.10	14.13	6.2	..	..	..
		5059	12	13.03	13.30	6.1	0.19	0.10	0.11
		5060	16	8.71	13.49	6.4	..	..	..
		5061	24	11.70	11.32	6.3	0.08	..	..
		5062	36	10.15	10.60	6.3	..	0.13	0.07

NOTE.—All figures obtained on air dried samples.
* pH values obtained with the Glass electrode using a soil : water ratio of 2.5 : 1.
† K_2O and P_2O_5 determinations on the Stand and hydrochloric acid Extraction.

WHAT TO GROW IN THE ISLANDS.

HOW THE NEW GUINEA DEPARTMENT OF AGRICULTURE IS EXPERIMENTING TO ASSIST PLANTERS.

A very valuable and interesting review of agriculture and recent developments in primary production in the Mandated Territory of New Guinea was given by Mr. George H. Murray, New Guinea Director of Agriculture, in an address delivered to members of the New South Wales branch of the Australian Institute of Agricultural Science.

The peculiar merit of the address lies in the fact that Mr. Murray, in addition to giving his expert agricultural knowledge, has made an economic survey of the possibilities of the various plants.

The substance of the address is outlined in the following paragraphs:—

The Mandated Territory of New Guinea, which includes the Bismarck Archipelago, contains about 91,000 square miles. In this vast area climatic conditions vary from the humid lowlands near the coast to the cool mountain peaks over 12,000 feet high suitable for the growth of every crop of equatorial regions. In the early days of the German régime practically all the settlements were confined to the coast. Coco-nuts, being easily grown and suitable for such districts, were the first crops to be cultivated, and remain the staple product to this day, our export of copra being approximately 60,000 tons per annum. (The returns for the year ended 30th June, 1937, being over 76,000 tons.)

In the early days of coco-nut planting in the Pacific, methods of cultivation were more primitive than they are to-day on well-managed coco-nut estates in Malaya and Ceylon. The coco-nuts were planted more or less regularly 28 to 30 feet apart each way and they received very little cultivation, other than to keep the grass cut down, which, as cultivation, is hardly worthy of the name. Several of the plantations in the early stages of the German régime were inter-planted with cotton, the cultivation of which also helped the coco-nuts, and the cotton crop was of some assistance in reducing the labour costs. The low price of cotton to-day, however, hardly warrants the cultivation of cotton in New Guinea even for this purpose.

It should be remembered that there is practically no resting period in plant growth in the tropics, particularly in districts with heavy rainfall. Consequently, weeds are growing all the time, and the methods employed in orchard cultivation in temperate zones are quite inapplicable in the humid tropics. About 25 years ago, therefore, selective weeding and use of cover plants came into practice. The former meant encouraging the growth of leguminous weeds to combat those of an injurious nature.

Cover Crops.

Passiflora foetida was one of the first to be used as a cover plant in competition with the noxious grass, *Imperata arundinacea*, known by various names, in the eastern tropics to which it is confined: In Ceylon it is known as Illuk, in Malaya and the East Indies as Lalang, corruption of the Malay name alang alang, in the Philippines as Cogon, in the Territory of New Guinea as Kunai, in Papua by its Motuan name of Kuru Kuru, and commonly known in

the warmer parts of Australia as blady grass. Its growth in Australia, except in North Queensland, is much less rank than in New Guinea. Incidentally, this grass can be manufactured into paper, a sample of which is on show at the Agriculture Department, Rabaul. Such an industry could never be worked on a profitable basis, however, except on an extensive scale, where the grass could be cut by machinery.

Although *Passiflora* has proved successful in combating kunai in New Guinea, where soil conditions are favorable, it proved quite unsuitable in heavy soil in certain parts of Papua. It is non-leguminous and for that reason was not a satisfactory cover. Experiments over a long period were carried out with other leguminous plants for the control of weeds and noxious grasses and the two creepers *Centrosema pubescens* and *Calopogonium mucunoides* are now in general use for this purpose in the East Indies, and have proved eminently suitable in New Guinea. There was great opposition to and criticism of the use of leguminous cover plants when first recommended by the New Guinea Department of Agriculture, the planters being wedded to the old method of cutting the kunai—with scythes made of suitable sharpened hoop iron—formerly practised by Germans in the early days before the more scientific method of cover plants came into use. Many planters to-day, however, are using cover plants on their plantations, one of whom informed me that since he had established these plants on his property he was able to dispense with a gang of 60 grass cutters. Another plantation of approximately 500 acres is entirely covered with such plants, not a single labourer being employed in weed control. *Centrosema pubescens* takes a considerable time to get established, six to twelve months, but *Calopogonium* grows very rapidly once the plant commences to run, and one planter, who says he cannot remember its name, calls it "galloping home". The latter plant dies back during a continuously long period of dry weather, but the former makes a permanent cover when once established.

In very shallow soil neither plant grows satisfactorily, but coco-nuts will not thrive in such soil either.

Copra Curing Methods.

Copra, the cured meat of the coco-nut, is prepared for market by drying in the sun, over smoke fires, or in specially constructed driers heated by hot air, or in a few cases by steam. The sun-cured copra is the best quality, but only districts having considerable sunshine are suitable for this method. What is known as the Ceylon type of drier is the most satisfactory artificial method of drying. Even with this method, however, it is advisable to give the green (uncured) copra one day in the sun before putting in the drier. This method necessitates transferring the copra from one platform to another for five consecutive days after which it should be of first-class quality. This method was recommended to the planters in New Guinea and plans and particulars supplied by the Department of Agriculture.

Like many new methods that have been recommended it received criticism in certain quarters. One company after a short trial condemned it for the reason that it was said to require 44 units to produce one ton of copra. Another planter in his first attempt at curing in accordance with this method cured his copra at a labour cost of 34 units to the ton, but there can be no doubt that after his

labourers were thoroughly accustomed to the work the labour costs could be greatly reduced. This has been proved, as another planter who has always followed the advice of the Department of Agriculture informed me that his labour cost was 17 units per ton, and he has been producing first class copra, obtaining a considerably higher price than Rabaul sun-dried. The coco-nut planter in New Guinea and elsewhere must realize that the only way to make his plantation pay to-day is to reduce costs of plantation maintenance and improve the quality of his copra by curing in some such method as the Ceylon type of drier. This drier can be modified to suit large or small properties. That such methods are practicable is proved by the fact that a large estate of 18,000 acres in Malaya produces copra at an all-in-cost of less than £5 per ton f.o.b.

Every endeavour is being made by the Department of Agriculture to raise the standard of New Guinea copra by a system of copra inspection by qualified inspectors. The scheme of copra inspection has raised the standard of our copra so that planters have received as much as 25s. per ton over South Sea at which New Guinea copra was previously rated.

Sexava Insect Pest.

Coco-nuts in New Guinea are comparatively free from serious disease, but they are subject to attack by several insect pests common to the Pacific. We have, however, a very serious pest in New Guinea so far unknown to other Pacific islands, but very closely akin to a species in Moluccas and the Taland Group of islands in the Dutch East Indies. It belongs to the family *Tettigoniidae* and the genus *Sexava*. These insects may frequently be present on a plantation for years, but not in sufficient numbers to cause serious damage. Then they may suddenly increase with alarming rapidity, reaching plague proportions. The insects can best be described as long horned tree hoppers, sturdily built and about 4 inches long. They are ravenous eaters and the noise made in the evening by eating resembles a gentle breeze through the tops of the palms. Palms that have been heavily attacked are often stripped of their foliage and resemble an umbrella frame.

Ordinary methods of insect control are quite inapplicable for such a pest. In studying the problem I found that the same, or kindred insect, was found in Amboina in the Moluccas, where it was kept under control by a minute Chalcid wasp, *Leefmansia bicolor*, parasite on the *Sexava* egg. After correspondence with Dr. Leefmans, Director of the Institute of Plant Diseases, Buitenzorg, Java, recommendations were submitted for the introduction of the parasites from the Moluccas to New Guinea and a Government schooner left Rabaul for Amboina with Mr. J. L. Froggatt, entomologist, on board. Mr. Froggatt succeeded in obtaining a large number of parasitized eggs and landed them safely at a field laboratory at Manus, in the charge of Mr. J. F. Caldwell.

Many thousands of local *Sexava* eggs were duly parasitized by the *Leefmansia* and breeding operations were then established. The parasites have been obtained from *Sexava* eggs collected in the field, and we have good reason to believe that they are established in the district. The field laboratory was later removed to New Hanover under Mr. B. O'Connor and his reports showed that the parasites gradually distributed themselves in *Sexava* infested areas on the island. It is too soon yet to say what the ultimate result will be, but we certainly have good reason to hope that this campaign against *Sexava* will be a success.

Other Island Crops.

It is very unwise that any country should depend upon one crop for its agricultural development, and the Department has made every effort to encourage the cultivation of crops other than coco-nuts. About the middle of 1928 operations were started for the development of the Keravat Demonstration Plantation, about 30 miles from Rabaul. Contrary to what has been said in certain quarters our records show that many experiments and introductions of new crop plants have been made there.

Apparently many planters and even officials have the idea that there are many tropical crops at present not cultivated in New Guinea that can be grown profitably by Europeans. In New Guinea such however is not the case, particularly as the only districts at present accessible for development are those comparatively near the coast. Some tropical crops are suitable only for peasant cultivation, or on the other hand, on a very extensive scale, requiring expensive machinery.

Pimento, for which there is but a limited demand, is practically grown only in Jamaica where it is little more than a peasant crop.

Nutmegs take long years to come into bearing and the prices ruling would not justify any planter growing them extensively. It is a crop that requires careful handling and packing. There are a few trees bearing on some of the plantations to which the owners might well give their attention. The nutmegs are extremely subject to insect attack after harvesting and require careful packing. They should be packed in paper-lined boxes weighing 56 lb. each. The nutmegs should be wrapped in paper and the joins or seams of the boxes sealed with adhesive tape.

A few clove trees have also been introduced to New Guinea, but the market for this spice is limited, and more than supplied by Paemba and Zanzibar (British Protectorate) and the Moluccas, Dutch East Indies.

Pepper has been introduced by the Department and is coming into bearing at the Demonstration Plantation and Botanic Gardens. This crop takes about six years to be in full profit and requires as intensive cultivation as a market garden. Ordinarily, the stock of pepper on the London market is 4,000 tons, but there are at present 25,000 tons, and so this crop would be of no assistance in relieving planters in the present copra slump.

Arrow root, ginger, cardamons, and cinnamon are minor crops cultivated at the Demonstration Plantation and Botanic Gardens, Rabaul, but the planter would be ill-advised who entered on their culture extensively, owing to the limited market.

Vanilla, another minor crop grown at the Demonstration Plantation, has greater possibilities, but only as a side line. As is well known vanilla is an orchid, and in New Guinea must be hand-pollinated to get any crop.

The fibre plants, Manila hemp, Sanseviera hemp and Mauritius and jute are all grown at the Demonstration Plantation and the Botanical Gardens, Rabaul, but not one of these could be grown profitably in New Guinea at present, for reasons unnecessary to specify here. An improved variety or sub-species of Sisal hemp (also introduced to the Demonstration Plantation) could probably be grown profitably in New Guinea, but only if grown on a very extensive scale, and under able and skilled management. A great deal of expensive machinery

would be necessary for the successful cultivation of the crop. The same applies to tapioca, although this crop is more easily dealt with. Its production, however, on a profitable commercial scale by European planters requires considerable financial resources on account of machinery for its preparation. This crop is also being grown at the Demonstration Plantation and experiments are to be made in its preparation by simpler methods.

Desiccated coco-nut is also produced, there being three mills in operation, but there is little likelihood of expansion in this industry for the moment.

The Derris Plant.

The leguminous plant Derris is now receiving some attention as a plantation crop, and experiments are being made at the Demonstration Plantation in the cultivation of an introduced species, probably *Derris Malacceasis,* and the indigenous species at present unidentified. A small sample of New Guinea Derris was sent to the Imperial Institute in London, by the Department, and was favorably reported on. Its rotenone content was approximately 4 per cent. and considered equal to the Malay product. The rotenone content in this plant seems to be very variable, and until we have sufficient roots to make a trial shipment to London the Agriculture Department would not be justified in advising planters to enter upon its cultivation. It takes about 21 months from planting before the roots are ready for harvesting. The main toxic property in the roots is rotenone, which is now coming into use for insecticidal purposes.

Adlay, a cereal crop introduced from the Philippines, is growing very well at the Demonstration Plantation, but both Europeans and natives would need to acquire the taste for it before it could ever become an important crop in New Guinea. The grain, however, is appreciated by poultry.

The very few tropical crops left that could be grown profitably in New Guinea are cocoa, rubber, coffee (Robusta and Arabica), tea, cinchona, kapok, West African oil and sugar, all of which are cultivated at the Demonstration Plantation, while tea and cinchona have been introduced recently to the Upper Ramu at 6,000 feet.

Cocoa, Rubber and Coffee.

During the German régime there was a considerable production of cocoa in the colony, but during military occupation such plantations were greatly neglected. Efforts are now being made to revive the industry and according to returns the exports of cocoa in 1936-37 amounted to 132 tons. Mr. E. C. Green, of the Department of Agriculture, who took a post-graduate course at the Imperial College of Tropical Agriculture in Trinidad, was advised before his departure from Rabaul to specialize on cocoa and after his return he was specially detailed to inspect cocoa plantations in the Territory and advise the growers as to how to improve their methods. Before my departure on leave, the Department received very appreciative letters on the work of this officer, and there has already been a decided improvement in some of the cocoa exported from the Territory.

Amongst the cocoa trees in the Botanic Gardens, Rabaul, there are a few trees yielding beans of good type, round full seeds and light colour in longitudinal section. These trees have been selected as mother trees for seed purposes and it has also been proposed to obtain some specially selected high quality plants from Java if regulations in that country permit.

A small coffee industry has been established, there being four plantations of Robusta now coming into bearing.

At the Agricultural Station, Wau, in the Morobe goldfields district, at an elevation of little more than 3,000 feet, the Department introduced Coffee Arabica of the famous Blue Mountain variety from Jamaica. Unfortunately, the station is in private hands, but the trees are yielding heavy crops of excellent quality which find a ready local market. The rich mountain lands on the Upper Ramu and many other parts of New Guinea are eminently suitable for Arabian coffee, high quality tea and cinchona, but it is useless to consider the cultivation of these crops until suitable roads have been constructed into the interior.

Owing to the large consumption of rubber in Australia there are possibilities of this crop being worked on a profitable basis if up-to-date methods are employed. No rubber is produced in the Mandated Territory of New Guinea, but there are plantations in Papua, though I doubt if the maximum yield of dry rubber per acre in the Territory is more than 700 lb. By modern methods of rubber planting now practised in the Dutch East Indies and Malaya, that is by planting budded trees from specially selected high yielding clones, 2,000 lb. per acre or more may ultimately be expected.

By an agreement between the main rubber producing countries it is impossible to get any plant material from these high yielding clones, but if a thorough investigation of the rubber tree were made in Papua by the estate managers there in co-operation with our Department, it is possible that we might discover clones equal to some of the record yielders of Sumatra and Java.

SUMMARY.

1. *Rubber* at low and medium elevations.
2. *Cocoa* at low and medium elevations.
3. *Coffee* Robusta at low and medium elevations.
4. *Coffee,* Arabian, at elevations of 3,000 feet, and upwards.
5. *Tea,* Up-country at elevations of 3,000 to 5,000 feet.
6. *Tea,* Low-country is not proving at all profitable to-day.
7. *Kapok.* Can be grown successfully in many classes of soil, from near sea level to medium elevations.
8. *Sisal Hemp.* Did not prove profitable in New Guinea under German régime, owing partly to unsatisfactory labour. A new variety of species found at the Amani Agricultural Research Station is reported to have double the percentage of fibre as *Agave sisalana,* and to be of much finer quality. The director of that institution has been requested to forward a quantity of suckers to New Guinea for trial purposes.
9. *Tobacco.* There are possiblities for this crop in New Guinea. It is somewhat of a gambler's crop, however, yielding high returns at one time and proving a failure at others, owing to susceptibility to disease and insect attack.
10. *Cotton* has proved to be an unreliable crop owing to climatic conditions.

11. *Derris.* There seem to be reasonable prospects for the cultivation of this crop in New Guinea, as it is coming largely into use in certain insecticides. Several hundred plants were sent from the Botanic Gardens to the Keravat Demonstration Plantation, and the department for some time past has been obtaining information from buyers in England and America, and if the data supplied is sufficient to warrant its cultivation in New Guinea, a bulletin on the subject will be published by the department.

12. *Pepper* is hardly suitable for European cultivation. It is almost entirely grown by Chinese and Malays, and to yield remunerative crops must receive highly intensive cultivation like a market garden. Small quantities, however, are grown on European plantations in Java as a side line.

13. *Spices* and many other minor crops of the tropics are only suitable for peasant or native cultivation, and it will be seen, therefore, that the choice for the European planter is limited.

COPRA DRYING—CEYLON DRIERS.

The type of hot air copra drier in general use in this Territory, and known as the New Guinea drier, consists of a large chamber containing a series of relatively shallow trays heated from beneath by a system of flues.

Such a system of drying, besides being costly, is scientifically unsound as there is no escape of moisture from the lower trays except through those above, with the result that the copra from the latter is partly steamed, and yet copra is supposed to be cured by such method in 20 to 24 hours.

In many cases where the owner gives careful personal supervision to his drier the product is clean when it leaves the drier, but even the best samples have the outside of many pieces case-hardened, and nearly always tinged with brown or oven-scorched, while the inside usually shows a waterline, a sure indication of imperfectly cured copra.

Owing largely to the work of the copra inspectors, the copra from this territory has been improved and maintained at a higher standard than that from neighbouring countries, with the result that it is known on the European market as Rabaul Hot Air obtaining 15s. to £1 5s. per ton more than South Sea.

This, however, is not enough, and there is no reason why planters here should not produce copra equal to the best from other parts of the world, but this can only be done by abandoning the rapid methods of drying long favoured in this territory.

First-class copra can only be cured by slow even heat, as free from draught as possible, and provided due care and supervision is given, such copra can be produced in driers of the attached plan,* one of the types, in common use in Ceylon.

On a compact plantation with good transport facilities it is advisable to bring the coco-nuts to a central depot adjoining the barbecue for husking and splitting, as the labourers are then under closer supervision than when such work is done in the field.

The nuts should be split into halves as early in the day as possible, and placed on the barbecue concave side up, providing, of course, that the weather is not wet or showery. If the weather is dry, an extra day in the sun is a great advantage, but in that case the half nuts should be covered at night with sheets of iron or other suitable material.

In the evening or the late afternoon of the first or second day as the case may be, the copra (half nuts) should be placed on the first day table of the drier.

Special half nut arrangement on the platform or table, although not absolutely necessary, is advisable. The bed of copra (half nuts) should consist of as few layers as possible for the first and second days, but on subsequent days it can be as much as 18 inches in depth, every precaution, however, being taken to prevent half nuts cupping one within the other.

Every day the copra should be transferred from one table to the adjoining, so that on the second day the copra that formed the top layer on the first day table will be at the bottom layer on the second table, a daily reversal which proceeds until the copra has reached the last table.

* See pages 35–36.

In the plan shown on pages 35-36 only four tables are given, but where any district is subject to much wet weather so that the barbecues are not in use as much as could be wished, it would be necessary to have five or even six such tables.

In using this type of drier, firing is most important, and those who have not seen one in use before will need to watch the process very carefully at first, as a thorough knowledge of the right quantity of fuel and time required to cure the copra satisfactorily, can only be acquired by personal experience.

The fuel (coco-nut shells, *not husks*), should be stored at least three days in the verandah of the drier so as to be absolutely dry before use, and no more should be used than is absolutely necessary to produce an even steady heat. Too much fuel will be apt to scorch the copra and produce over-much smoke.

The object of this drier is to obtain a clean heat like that from a charcoal brazier, consequently it is necessary to give personal supervision to the work.

In wet weather it is sometimes advisable to use double rows of shell fuel, and in exceptional weather when the atmosphere is supercharged with moisture, drying may be suspended and only resumed when relatively dry again. It is, therefore, advisable to have an extra drier to deal with an accumulation of nuts after an unusually long spell of very wet weather. Considering, however, that the drier can be erected cheaply of native material, this is not a serious matter.

In very dry weather the shells will soon come away freely from the "meat", but in any case they will do so after a couple of days in the drier.

The fuel consisting of half shells, should be lined or cupped together on the floor of the fire pit in lines 2 feet apart across the pit, the concave sides facing alternate directions.

Under the first day table the shells should be laid in single lines 4 to 6 feet apart, so that the temperature will be approximately 122° Fahr.

Under the second and third day tables double firing should be adopted, i.e., two lines of shell 2 feet apart.

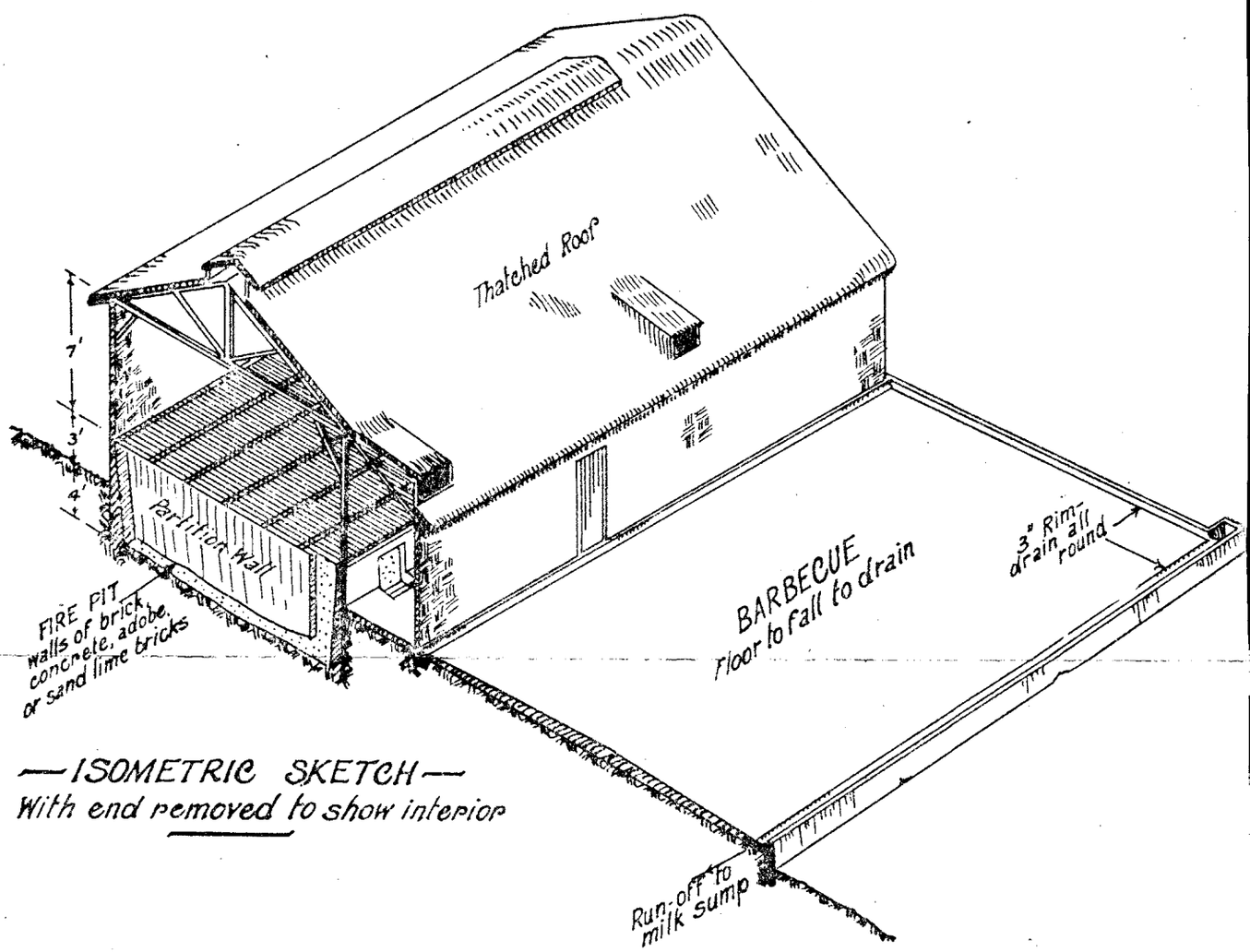
On the fourth day drying should be so far advanced that the wider single row firing should be sufficient, and due care must be taken at this stage as over firing will result in scorching or discolouration of the copra.

In starting the fires, every alternate line of fuel should be lighted at opposite ends, and they should, of course, be started before placing copra on the tables.

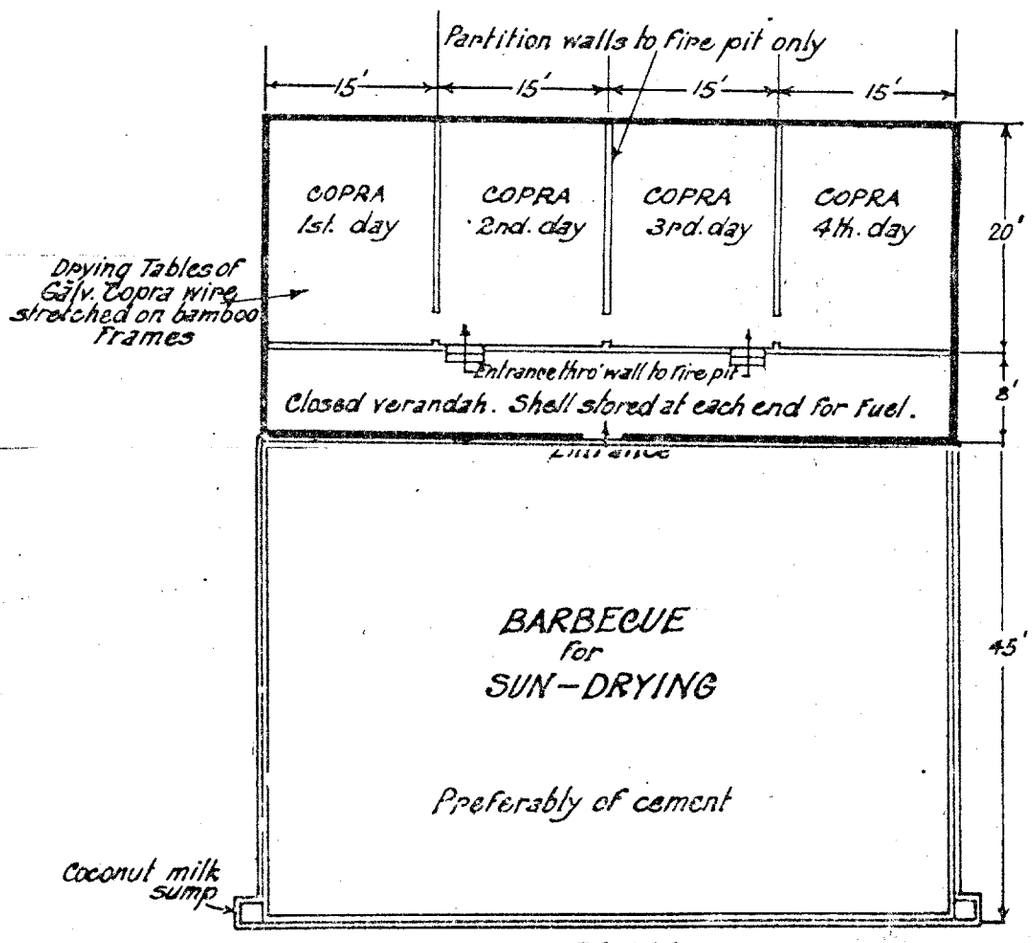
For several years past the Department of Agriculture had advocated the Ceylon method of copra production. Several planters erected driers according to plan, and turned out first-class copra, but discontinued the process on the grounds that the labour involved was too costly.

It should be remembered, however, that the process was entirely new, not only to the planter himself, but to the labourers, and it could not be expected, therefore, that they could produce copra at a minimum cost until they had had considerable practice.

Apparently the main objection was the cost of husking the nuts, but it must be remembered that it takes a native about two or three months to be sufficiently expert to husk 1,200 nuts per day. It has been proved in the territory, however, that our labourers can husk this number, if provided with suitable husking iron or strong sharpened stake firmly fixed on a solid foundation.



—ISOMETRIC SKETCH—
With end removed to show interior



— PLAN —
Scale 1" = 16 feet

LAGRAM OF ONE TYPE OF CEYLON COPRA DRIER

MEALY BUG ON COFFEE.

By John L. Froggatt, B.Sc., Entomologist.

During investigations into an outbreak of "mealy bug" on coffee in this Territory, it was ascertained that the pest had first appeared on the *Erythrina* in the plantation, and later spread to the *Leucaena glauca* and coffee; the *Erythrina* was a local species, cuttings having been obtained for planting from the scrub about 1 mile from the coffee area.

A search in the surrounding scrub revealed that the *Erythrina* growing in its wild state was also heavily infested with a "mealy bug" apparently the same species as that in the plantation. Specimens from both the scrub *Erythrina* and the cultivated coffee were sent to Mr. F. Laing, British Museum of Natural History, London, who has identified both series of specimens as *Ferrisia virgata, Ckll,* with the comment "this mealy bug is rather common on a wide range of host plants throughout the tropics".

In view of the fact that the indigenous species of *Erythrina* is the host of a pest with a wide range of host plants, care should be exercised in its introduction into any area where economic plants are cultivated.

RAINFALL NOTES.

B. G. Challis.

"What is it moulds the life of man?
The weather.
What makes some black and others tan?
The weather.
What makes the Zulu live in trees,
And Congo natives dress in leaves,
While others go in furs and freeze?
The weather."

W. J. Humphreys.
(*Weather Proverbs and Paradoxes.*)

Rainfall has a considerable influence on all crops. It regulates their germination, production and harvesting. It has a bearing on the life cycles of pests and incidence of diseases associated with various crops, while the period and quantities of its precipitation, whether light or heavy showers, makes all the difference on growth and yield. For instance, in New Guinea, it has been observed that the peak periods of coffee yield correspond with the periods of low rainfalls, and there is practically no yield during months of heavy rainfall.

Rainfall also greatly concerns many other items such as transport, factories, engineering and general public health matters and is of supreme importance for our domestic water supply in this territory where we have no irrigation or reticulation schemes or means of conserving water, other than by small domestic rainwater tanks.

Rain is a condensation of water vapour in the atmosphere in the form of drops which fall towards the earth, but may evaporate before reaching the ground. Clouds are usually the origin. If the temperature of the upper part of a cloud falls below the dew-point or temperature of complete saturation, large drops form round the comparatively few dust particles suspended in the atmosphere and these fall through the cloud, embodying the smaller drops round the more numerous dust nuclei in the lower part of the cloud as they pass, and emerging as quite large drops of water.

The distribution of rain is determined mainly by the direction and route of the prevailing winds, by the varying temperatures of the earth's surface over which they blow and the physiographical features generally.

The atmosphere has been described as "a vast still of which the sun is the furnace, and the sea the boiler while the cool air of the upper atmosphere and of the temperature zones plays the part of condenser, and we on a wet day catch some of the liquid which distills over."

The pressure of the atmosphere is an important factor in precipitation. At ordinary elevations it is not appreciable to the senses but its action is amply illustrated in a pump where a piston diminishes the pressure of air in the cylinder and the atmospheric pressure outside forces the water up the cylinder of the pump.

By correlating the various barometrical pressures over wide areas meteorologists are able to predict forecasts with a considerable measure of success.

When air ascends over high ground it expands because there is less air above; hence the pressure becomes less and it usually results in the loss of its water content. It then passes on as a dry wind and as it subsequently descends it will be warmed at 5½ degrees Fahrenheit for every 1,000 feet of descent as a result of compression when it comes down into levels of high pressure.

Generally speaking rainfall increases with elevation on the windward side of mountains up to a level of about 9,000 feet in New Guinea after which precipitation decreases with higher elevation.

The direct influence of rainfall on forests may be debated by some authorities, but there is a decided beneficial effect which warrants their extension and protection because they act as wind breaks, control evaporation and arrest soil erosion by wind or rain, one of the gravest concerns of agriculturists to-day throughout the world. Trees as wind breaks and controllers of soil erosion, could be successfully planted on kunai plains. They should be planted at right angles to the direction of the prevailing winds and if planted at distances of not less than half a mile apart, they will afford shelter for the enclosed areas. The abundant rainfall and uniformly high temperatures experienced in New Guinea will make for profuse growth.

Historical records prove however that the destruction of forests has ruined nations. Deserts to-day in parts of North Africa were once the granaries of the Roman Empire where Greek, Roman and Venetian cities thrived. The destruction of the forests caused an unequalizing effect on their climate, the shade temperatures and evaporation increased together with a higher relative humidity, with the consequence that the land became burnt up and those countries to-day form part of a great desert.

The forest countries of Palestine, Mesopotamia, Sicily and China, now barren, once supported a dense and prosperous people who cut down and burnt off their forests with disastrous results.

Lord Lugard in his *Dual Mandate* states—

> Forests serve as a reservoir which feeds the head-waters of streams, and with their destruction the torrential rains carry away the surface soil, and deposit sand and debris on the plains, thus rendering them unfit for cultivation, while the rivers cease to be navigable.

Trees distribute rain water evenly and allow the water to filter through to springs and rivers. Their canopy keeps the ground underneath cool and prevents the rapid drying up of the moisture by the heat of the surrounding atmosphere.

Tests have proved that about 90 per cent. of the rainfall is absorbed by the leaf mould of the forests and the distribution of such water takes a little over two years.

In the absence of forests no such conservation is made and with heavy rains the top soil and humus are washed away so that gradually the productiveness of the land declines, property values are reduced and unless preventive measures are adopted starvation will present itself.

A local example of the beneficial influence by partial clearing of a forest, on climate, may be observed in the Edie Creek area of the Morobe District.

In 1926, when the upper area of the Edie was discovered by Messrs. Royal and Glasson, the mountains and the slopes of the gorge, through which the creek flows, were heavily timbered down to the edge of the river bed. As the alluvial workings were developed, it was found that terraces and slopes of the gorge were rich in gold, and to work these, it became necessary to fell the forest on either side of the creek. Later still, when the large companies such as " Edie Creek Pty. Ltd.," " Day Dawn Ltd.," and " New Guinea Goldfields Ltd.," commenced operations on a large scale, huge areas of forests had to be felled and cleared to provide quarters, stores, roads and water races. The introduction of hundreds of native labourers further called for the provision of rigorous sanitation schemes to cope with the prevalence and danger of infectious diseases such as dysentery, etc. The only way to deal with such a danger, having regard to the ignorance of the native, and the difficulties of supervision over sanitary conditions in a thickly afforested area, was to clear and expose the whole of the locations where the natives were housed and employed.

In this way also vast areas were cleared of timber, and to-day the whole aspect of the Edie Creek area is quite unrecognizable from the densely timbered district of 1926.

The early prospectors and miners who invaded the rich alluvial area from 1926 to 1928 describe the misery and discomfort which prevailed at that time.

The ground was completely covered with a deep moss and humus, in which one sunk to one's ankles. Sunshine was conspicuous by its entire absence, under the dense canopy of the foliage, and an incessant moisture fell day and night from the low hung clouds and mist which lay just on the tree tops at this altitude of 7,000 feet. Hardly a day passed without its complement of rainfall, and the cold winds which blew through those gloomy mountain gorges made life an abject misery.

To-day the scene is completely changed. From an aeroplane one can trace the roads from Wau to the source of the Edie Creek. Huge mining camps lie exposed to the sun and terraces and gardens flourish in their new environment. Moss and fungus are non-existent, and except in very rainy weather, living conditions are very comfortable, and even more desirable than in the heat of the coastal areas. Warm sunshine, the absence of mist and the introduction of good motor roads have completely revolutionized the Edie Creek area, and those who live there to-day would not exchange their habitat for any other in the Territory.

If, however, the forest slopes are indiscriminately and completely cut away in these areas, erosion may occur and the only remedy (if adopted in time) will be re-afforestation and the planting up of thickly matted cover crops which have close packed roots.

Apart from forestry there is nothing man can do to influence rainfall. The theories that gunfire or other atmospheric concussion promotes rain is exploded by the fact that during the Great War in spite of the terrific and incessant bombardments, the rainfall in Europe was only about normal.

Rainfall is measured in terms of the depth of water which would be collected on a level area of any size supposing the rain to fall uniformly over the area at the rate at which it falls into the gauge. An inch of rain means 100 tons of water per acre, or about 64,000 tons to the square mile. For record purposes it is registered in a rain gauge and its amount is stated in the number of inches or millimeters. (To convert points of rain into millimeters divide by 40). It should always be recorded to tenths of a millimetre or to hundredths of an inch and it is desirable to note the time of beginning and ending of heavy showers. Any day on which one point (.01 inch) or more of rain is recorded is regarded as a rain day.

There are two types of rain gauges used, either 5 inches (12.5 centimeters) or 8 inches (20 centimeters) in diameter. The amount of rain measured in a rain gauge with a rim of 5 inches does not vary much from that measured in the gauge with a diameter of 8 inches, although the recorder must be careful to note that his glass or other measure is properly certified for either an 8-inch or 5-inch gauge, otherwise his recordings will be far from accurate as was proved recently when one plantation manager forwarded returns which appeared excessive coming from his particular district.

Instructions as issued by the Commonwealth Meteorologist in the use of a rain gauge were published in the last issue of this *Gazette*.

The Measuring Glass.

With each instrument a graduated measuring glass is supplied, to a capacity of ½ inch of rain water. It is important to see that the proper gauge glass has been supplied, for ½ inch of rain will naturally give a much smaller volume of water in a 5-inch, than it does in an 8-inch gauge. On all reliable glasses, a figure is engraved showing the size of the gauge for which it is intended to be used.

Occasionally the measuring glass may be mislaid or broken. In such a case, before a new one is obtained, it is always possible to use a graduated ounce—or c.c.—measure from the nearest hospital. The area of a circle of 5 inches diameter is 19.64 square inches: 1 inch of rain will, therefore, be equivalent to a similar number of cubic inches of water, in such a gauge. And 19.64 cubic inches are equivalent to 324 c.c., or 11.4 fluid ounces. If, therefore, we measure 11.4 fluid ounces from the collecting glass of a 5-inch gauge, we know that it represents 1 inch of rain.

An 8-inch gauge has an area of 50.28 square inches, and 1 inch of rain will give approximately 29 fluid ounces, or 825 c.c.

The following table of reference will give an emergency reading for use in such circumstances, until a new measuring glass can be obtained.

EMERGENCY TABLE FOR ESTIMATING RAINFALL WHEN THE RAIN-GAUGE GAUGE-GLASS IS MISLAID OR BROKEN.*

With a 5-in. Rain-Gauge.		Approximate Equivalent Rainfall.		With a 8-in. Rain-Gauge.	
Fluid Ounce Measure.	Cubic Centimetre Measure.	Inches.	Millimetres.	Fluid Ounce Measure	Cubic Centimetre Measure.
M 30	1	0.004†	†0 1	1 dram	3.5
1 dr.	3.5	0.01	0.24	2 dr.	8
1¼ dr.	4	0.012	0.25	3 dr.	10
1½ dr.	5	0.016	0.41	4 dr.	13.5
1¾ dr.	6	0.018	0.45	4½ dr.	15
2 dr.	7	0.022 ‡	‡ 0.55	5 dr.	18
2¼ dr.	8	0.025	0.63	6 dr.	20.5
2½ dr.	9	0.028	0.7	6½ dr.	23
2¾ dr.	10	0.03	0.75	7 dr.	25
3 dr.	11	0.034	0.85	1 fl. oz.	28.4
3¼ dr.	13	0.04	1.0	9 dr.	32
4 dr.	14	0.044	1.1	10 dr.	37
4¼ dr.	15	0.048	1.2	11 dr.	40
4½ dr.	16.5	0.051	1.3	1½ fl. oz.	42
5 dr.	18	0.056	1.4	13 dr.	46
5¼ dr.	20	0.61	1.5	14 dr.	50
6 dr.	21	0.065 §	§ 1.6	15 dr.	53
6½ dr.	23	0.07	1.8	2 fl. oz.	56.5
7 dr.	24	0.075	1.9	17 dr.	60
1 fl. oz.	28.4	0.087	2.0	2½ fl. oz.	71.5
8½ dr.	30	0.098	2.4	22 dr.	80
9 dr.	33	0.1	2.5	23 dr.	84
1¼ fl. oz.	35	0.105	2.6	3 fl. oz.	90
10½ dr.	39	0.12	3.0	3½ fl. oz.	99
11 dr.	40	0.125	3.1	3¾ fl. oz.	100
1½ fl. oz.	42.5	0.13	3.3	4 fl. oz.	106
2 fl. oz.	56	0.17	4.4	5 fl. oz.	137
17 dr.	60	0.18	4.6	5¼ fl. oz.	150
2¼ fl. oz.	65	0.20	5.0	5½ fl. oz.	163
2½ fl. oz.	71	0.22	5.5	6 fl. oz.	184
2¾ fl. oz.	80	0.24	6.0	7 fl. oz.	200
3 fl. oz.	85	0.26	6.6	8 fl. oz.	212
3¼ fl. oz.	95	0.30	7.6	9 fl. oz.	240
3½ fl. oz.	100	0.31	7.7	9½ fl. oz.	250
4 fl. oz.	112	0.35	9.0	10 fl. oz.	280
4¼ fl. oz.	119	0.37	9.2	10½ fl. oz.	300
4½ fl. oz.	126	0.39	9.5	11 fl. oz.	325
4¾ oz.	133	0.40	10.0	12 oz.	330
5 oz.	140	0.44	11.0	13 oz.	350
5¼ fl. oz.	150	0.49	12.3	14 fl. oz.	400
5½ fl. oz.	159	0.50	12.7	15 fl. oz.	425
6 fl. oz.	168	0.53	13.2	16 fl. oz.	437
6¼ fl. oz.	175	0.55	13.8	16½ fl. oz.	450
6½ fl. oz.	182	0.57	14.3	17 fl. oz.	475
53 dr.	188	0.60	15.2	18 fl. oz.	490
6¾ fl. oz.	190	0.61	15.3	18½ fl. oz.	500
7 fl. oz.	196	0.62	15.4	19 fl. oz.	510
7¼ fl. oz.	200	0.63	15.5	19¼ fl. oz.	520
7½ fl. oz.	208	0.66	16.5	19½ fl. oz.	545

* The Malayan Agricultural and Horticultural Association Magazine—January, 1934. † Mark as: " A trace ".
‡ Slight Precipitation. § " If more than the above, is ' wet day '."

EMERGENCY TABLE FOR ESTIMATING RAINFALL WHEN THE RAIN-GAUGE GAUGE-GLASS IS MISLAID OR BROKEN—*continued.*

With a 5-in. Rain-Gauge.		Approximate Equivalent Rainfall.		With an 8-in. Rain-Gauge.	
Fluid Ounce Measure.	Cubic Centimetre Measure.	Inches.	Millimetres.	Fluid Ounce Measure.	Cubic Centimetre Measure.
7¾ fl. oz.	210	0.67	17.0	19¾ fl. oz.	550
8 fl. oz.	224	0.70	17.8	1 pint	575
8¼ fl. oz.	230	0.74	18.5	21 fl. oz.	600
8½ fl. oz.	238	0.75	19.0	22 fl. oz.	625
9 fl. oz.	250	0.80	20.0	23½ fl. oz.	650
9½ fl. oz.	262	0.84	21.0	24¾ fl. oz.	675
10 fl. oz.	275	0.86	21.5	26 fl. oz.	700
10½ fl. oz.	287	0.90	22.9	27 fl. oz.	750
11 fl. oz.	300	0.98	24.5	28 fl. oz.	800
11¼ fl. oz.	307	1.00	25.4	29 fl. oz.	825
11½ fl. oz.	325	1.05	26.5	30 fl. oz.	850
12 fl. oz.	350	1.10	27.6	33 fl. oz.	900
13 oz.	375	1.17	29.0	35 oz.	950
14 oz.	400	1.25	31.0	37 oz.	1 litre
15 fl. oz.	450	1.39	34.9	2 pints (1 quart)	1146
17½ fl. oz.	500	1.50	38.1	45 fl. oz.	1315
1 pint	550	1.76	44.1	2½ pints	1400
21 fl. oz.	600	1.86	46.6	55 fl. oz.	1½ litres
23 fl. oz.	650	2.00	50.8	3 pints	1700
25 fl. oz.	700	2.17	54.4	70 fl. oz.	1800
28 fl. oz.	800	2.48	62.2	75 fl. oz.	2 litres
30 fl. oz.	850	2.50	63.5	77 fl. oz.	2010
32 fl. oz.	900	2.78	69.7	4 pints	2200
25 fl. oz.	1 litre	3.00	76.2	90 fl. oz.	2500
2 pints (= 1 quart)	1100	3.25	87.8	5 pints	2750
45 fl. oz.	1200	3.50	88.9	110 fl. oz.	3 litres
47 fl. oz.	1290	3.75	95.2	120 fl. oz.	3250
2½ pints	1375	4.00	101.6	130 fl. oz.	3500
54 fl. oz.	1445	4.25	107.9	135 fl. oz.	3700
55½ fl. oz.	1510	4.50	114.3	140 fl. oz.	3800
57 fl. oz.	1580	4.75	120.6	145 fl. oz.	3900
3 pints	1650	5.00	127.0	150 fl. oz.	4 litres
3¼ pints	1790	5.25	133.3	155 fl. oz.	4250
67 fl. oz.	1895	5.50	139.7	1 gal. (= 8 pints)	4500
3½ pints	2 litres	5.75	146.0	175 fl. oz.	4700
72 fl. oz.	2040	6.00	152.4	180 fl. oz.	4900
75 fl. oz.	2080	6.25	158.7	185 fl. oz.	5 litres
77 fl. oz.	2120	6.50	165.1	192 fl. oz.	5200
78½ oz.	2160	6.75	171.4	200 oz.	5400
4 pints	2200	7.00	177.8	207 oz.	5600

EMERGENCY TABLE FOR ESTIMATING RAINFALL WHEN THE RAIN-GAUGE GAUGE-GLASS IS MISLAID OR BROKEN—*continued.*

With a 5-in. Rain-Gauge.		Approximate Equivalent Rainfall.		With an 8-in. Rain-Gauge.	
Fluid Ounce Measure.	Cubic Centimetre Measure.	Inches.	Millimetres.	Fluid Ounce Measure.	Cubic Centimetre Measure.
82 fl. oz.	2240	7.25	184.1	215 fl. oz.	5800
85 fl. oz.	2280	7.5	190.5	220 fl. oz.	6 litres
87½ fl. oz.	2320	7.75	196.8	225 fl. oz.	6200
4½ pints	2360	8.00	203.2	240 fl. oz.	6400
95 fl. oz.	2440	8.50	215.9	250 fl. oz.	6800
97 fl. oz.	2480	8.75	222.2	260 fl. oz.	7 litres

The average rainfall in various parts of the world differs considerably, for instance, in the British Isles, the average annual rainfall for England is 37.4 inches, but in Styhead, Cumberland, a rainfall of 247.3 inches was recorded in 1923. The wettest station in the world is Cherrapunji in Assam, where the annual fall exceeds 500 inches, and the daily fall has reached 40 inches, whilst in one year just over 900 inches is alleged to have fallen. For New Guinea the record rainfall was registered at Pal Mal Mal in the Jaquenot Bay district in New Britain, viz., 320.12 inches, although it should be noted that in 1934 the rainfall for this particular station was 166.64 inches, while in 1936, 213.36 inches were recorded. In 1927 Talasea Government station recorded 312 inches. The lowest rainfall for the Territory is at our inland stations, Ramu 78.57 inches, Bulolo (six years) 55.06 inches, Baiune 65.90 inches (three years).

Plantation managers and private individuals have assisted considerably in the supply of rainfall information and returns, and it is hoped they will continue to do so. Additional rainfall records are also desirable from other stations, and persons interested who may care to supply such information, will be assisting in a great service towards acquiring essential data concerning the general potential knowledge of this territory. Rainfall records are really invaluable to all agriculturists and horticulturists. They will determine the best time to plant, the type of crops to plant, and the most favorable season to produce the best germination. The expense of installing a rain gauge will be found small, and the illuminating results will well repay the observer, and even if instruments are not available, a diary kept of the weather will be found of great interest over an extended period, and throw light on crop failures or successes, activities of pests and diseases, results of spraying, &c.

It may be of interest to quote the following table showing the rainfall and temperatures of various world cities:—

RAINFALL AND TEMPERATURES—VARIOUS CITIES.

Place.	Annual Rainfall.				Temperature.					
	Height above M.S.L.	Average.	Highest.	Lowest.	(*a*) Mean Summer.	(*b*) Mean Winter.	Highest on Record.	Lowest on Record.	Average Hottest Month.	Average Coldest Month.
	Ft.	In.	In.	In.	Fahr.	Fahr.	Fahr.	Fahr.	Fahr.	Fahr.
Adelaide ..	140	21.17	30.87	11.39	72.9	53.1	116.3	32.0	74.0	51.9
Berlin ..	161	22.72	30.04	14.25	64.8	33.0	98.6	−13.4	66.0	31.8
Bombay ..	32	70.54	114.89	33.42	82.7	74.7	100.2	53.2	84.3	73.9
Brisbane ..	137	45.31	88.26	16.17	76.7	59.8	108.9	36.1	77.2	58.6
Calcutta ..	21	61.82	98.48	38.43	85.6	68.0	111.3	44.2	86.0	66.4
Canberra ..	1,920	23.03	33.71	16.31	67.7	43.9	104.2	14.0	68.6	42.8
Colombo ..	24	88.53	123.96	53.56	81.6	78.7	97.2	61.6	82.0	78.6
Hobart ..	177	24.06	43.39	13.43	61.4	46.9	105.2	27.0	62.2	45.8
Hong Kong ..	109	85.61	119.72	45.84	81.5	60.5	97.0	32.0	82.0	58.8
Johannesburg	5,750	31.63	50.00	21.66	65.4	54.4	93.6	20.8	68.2	48.0
London ..	18	23.80	38.18	12.16	60.8	39.9	94.0	9.0	62.3	39.1
Madras ..	22	49.85	78.92	21.74	89.0	76.8	113.0	57.5	89.9	76.1
Madrid ..	2,149	16.23	27.48	9.13	73.0	41.2	107.1	10.5	75.7	39.7
Melbourne ..	115	25.72	38.04	15.61	66.6	50.1	111.2	27.0	67.6	48.8
New York ..	314	44.63	58.68	33.17	71.4	31.8	102.0	−13.0	73.5	30.2
Paris ..	164	22.68	29.80	10.94	63.5	37.9	101.1	−19.5	64.8	36.7
Rome ..	166	32.57	57.89	12.72	74.3	46.0	103.0	21.4	76.1	44.6
Shanghai ..	21	45.00	62.52	27.92	78.0	41.1	102.9	10.2	80.4	37.8
Singapore ..	8	91.99	158.68	32.71	81.2	78.6	94.2	63.4	81.5	78.3
Sydney ..	138	47.32	82.76	23.01	70.9	54.3	108.5	35.7	71.6	53.0

Meteorological Records—Madang.

(*New Guinea Central.*)

The driest month in the Madang district is August, and the wettest April. The rainy season is practically continuous from October to May, and the dry season a short one during July, August and September. There are, however, parts of this district which have a considerably longer dry season.

The district immediately north of Madang—Sepik—has a similar dry season, though it continues comparatively dry for two months longer; nor are the monsoonal rains so heavy when experienced.

The rainfall in Madang for April is the heaviest recorded on the mainland of New Guinea, and is exceeded in few districts in the Territory. December is also an exceedingly wet month in this district.

On the coastline of Madang, recent deposits of coral limestone may be seen from the head of Astrolabe Bay to Stephen Strait. All the islands about Madang and Sek (Alexishafen) consist of it. The limestones do not extend very far inland, and cannot be more than 50 feet thick. It rests on some recent volcanic rocks near Isumrud Strait, and is frequently interbedded with friable volcanic material. Beyond Stephen Strait the deltaic deposits of the Sepik and Ramu rivers have prohibited the growth of coral reefs, even as far back as early Pleistocene, and consequently no occurrences of limestone are seen. Again, at Melamu (Konstantine Harbour), large deposits of boulders and river gravels have invaded the coral strands, the Kabenau and Minjem rivers being responsible for the denudation of the thin veneer of coral limestone replacing it with river sediment during the process of elevation.

On the coastline between Sarang and Dylup plantations the raised coral reefs are interbedded with coarse, partly fossiliferous grits and conglomerates containing magnetite sand occasionally cemented with lime. The limestone outcrop on the plantation of Dylup occasionally exhibits a peculiar banded or striated structure not unlike phosphatic rock.

The soil around the foreshore of Madang is a sandy coral loam; pure coral being met at depths ranging from less than 1 foot to 2½ feet.

Towards the back of Modilon, the adjoining plantation, the soil is a heavier volcanic nature with coral outcrops and a clayey sub-soil.

Madang experiences many thunderstorms, and the tall trees are often affected by the visitations of lightning strike.

The only other stations in this district from which official records are received, are Kulili and Kurum on Kar Kar Island. The department would welcome rainfall records from additional plantations on the mainland.

MONTHLY AND YEARLY RAINFALL TOTALS (IN POINTS), MADANG.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Total.
1917 ..	1,379	1,015	1,745	1,284	1,999	1,212	928	671	1,255	1,755	1,491	693	15,427
1918 ..	617	1,131	1,269	1,007	1,654	625	447	311	428	1,209	642	441	9,781
1919 ..	1,250	2,424	2,792	2,449	1,679	1,607	165	3	133	795	1,484	1,749	16,530
1920 ..	1,362	1,004	2,583	1,218	1,725	1,333	553	207	912	2,074	1,400	1,660	16,031
1921 ..	1,804	947	831	3,120	965	1,313	1,446	310	539	862	1,777	1,360	15,274
1922 ..	1,569	1,219	1,407	2,085	785	872	451	598	524	1,098	1,357	*	*
1923 ..	384	1,687	1,682	1,284	2,444	2,765	579	307	86	738	1,666	696	14,318
1924 ..	1,324	654	1,217	1,007	1,549	879	461	*	*	*	1,637	607	*
1925 ..	10	482	495	1,164	703	1,246	963	129	370	373	1,644	765	8,344
1926 ..	2,120	1,498	1,533	1,700	2,247	1,135	598	53	175	1,085	803	1,747	14,694
1927 ..	701	744	1,057	1,077	1,523	1,285	501	782	472	616	1,042	3,180	12,980
1928 ..	1,316	1,283	955	2,177	2,033	920	449	762	720	1,911	1,277	1,013	14,816
1929 ..	1,200	930	1,009	1,973	2,004	856	1,108	1,152	169	1,041	1,158	1,506	14,106
1930 ..	861	1,146	2,089	2,562	1,581	761	1,577	268	6	297	1,206	1,782	14,136
1931 ..	1,023	962	2,083	1,896	737	274	309	275	125	802	981	1,890	11,357
1932 ..	1,895	1,245	693	1,404	722	1,247	685	141	489	348	1,721	1,189	11,779
1933 ..	1,815	1,296	1,617	1,081	1,112	1,088	1,279	394	1,129	1,173	756	2,104	14,844
1934 ..	334	560	794	1,358	677	1,124	1,234	300	712	930	1,277	814	10,114
1935 ..	2,127	1,267	1,226	3,047	2,523	579	617	610	819	586	1,377	550	15,328
1936 ..	1,136	1,366	1,871	479	1,677	370	925	1,495	786	729	2,085	2,483	15,402
Average ..	1,211	1,143	1,447	1,669	1,517	1,075	764	461	518	970	1,339	1,380	13,626

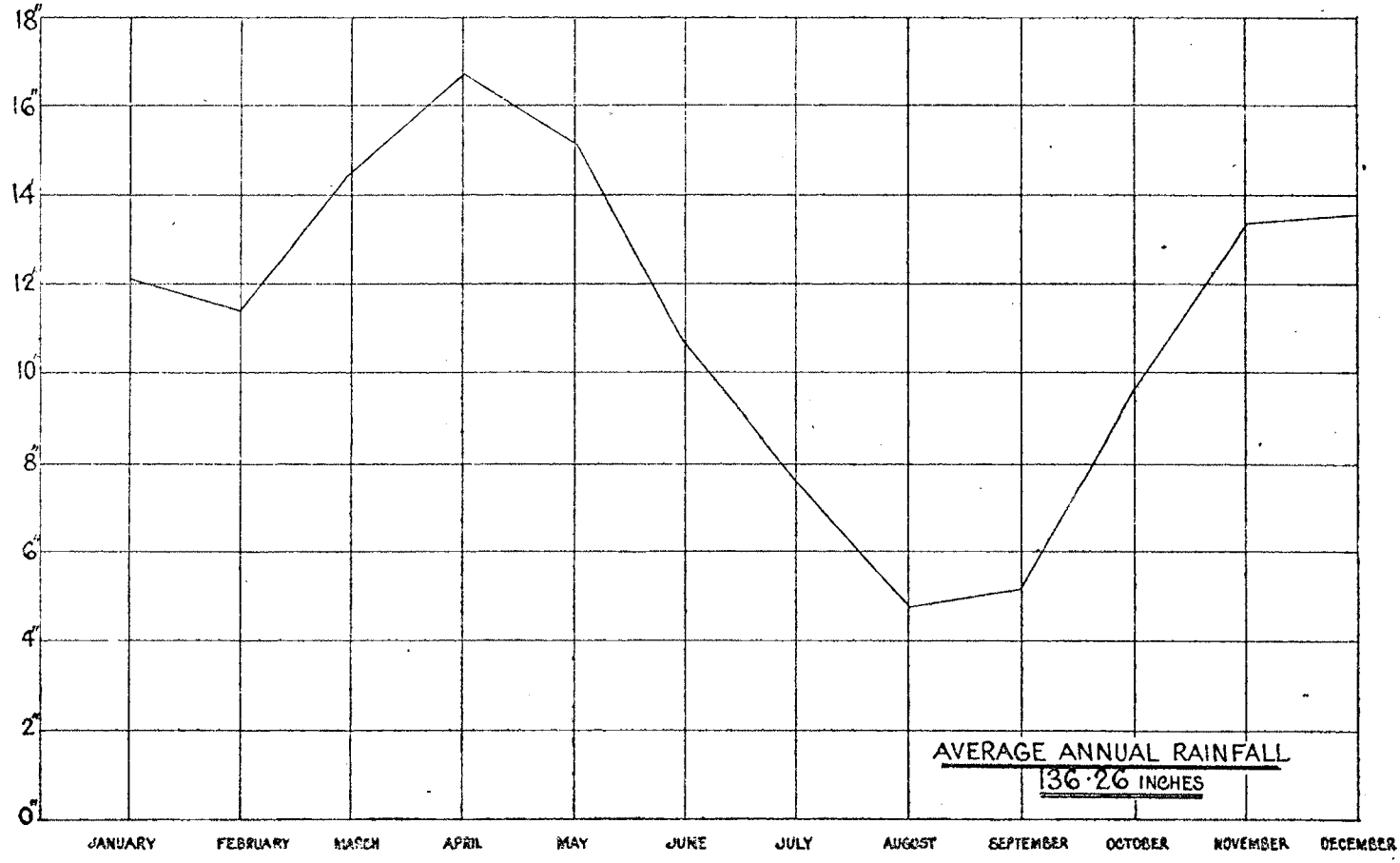
* No records taken during these months.

MADANG (MAINLAND). 5° 11′ S., 145° 48′ E.

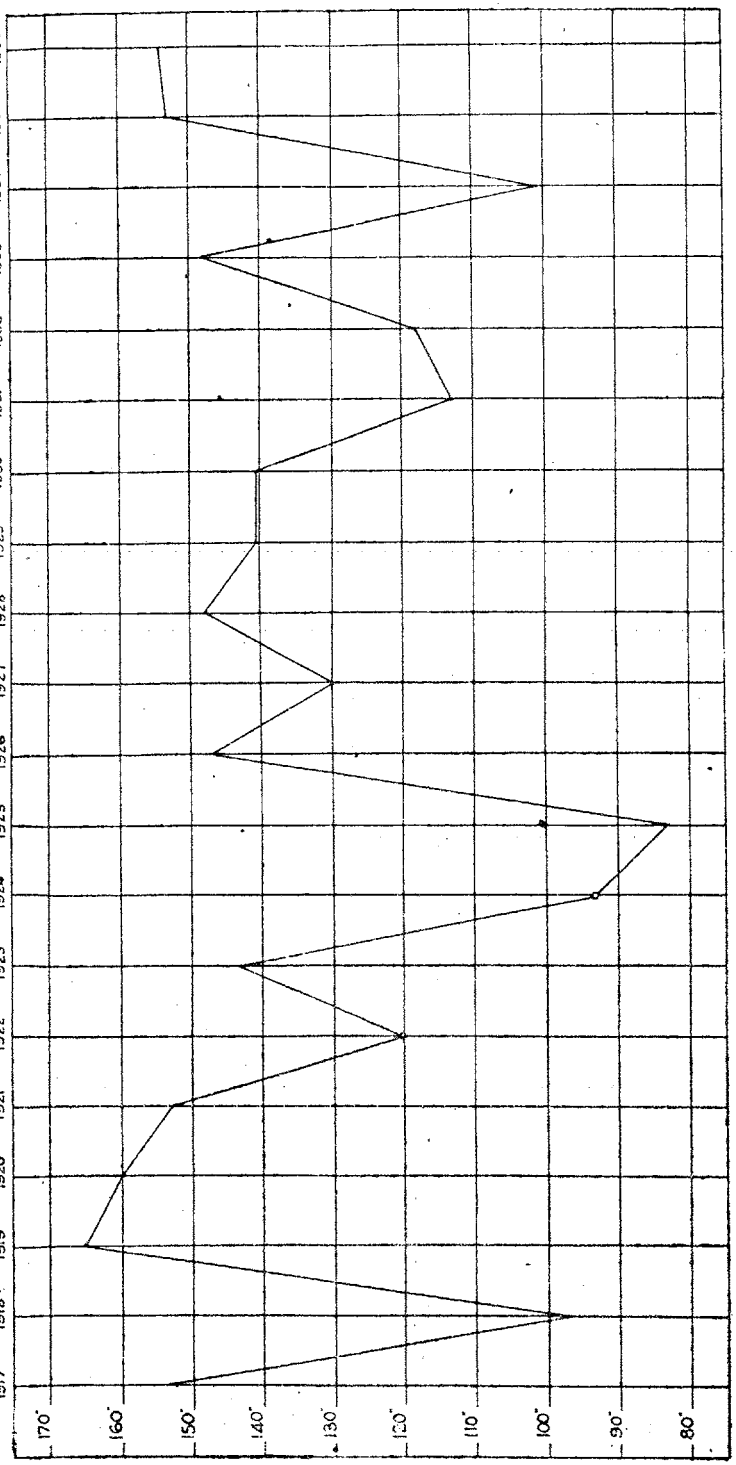
Month.	1936.		Averages for 20 years (1917–1936).	
	Rainfall.	Wet Days.	Rainfall.	Wet Days.
January	11.36	23	12.11	19.4
February	13.66	19	11.43	17.8
March	18.71	22	14.47	20.7
April	4.79	12	16.69	20.4
May	16.77	25	15.17	19.4
June	3.70	14	10.75	17.3
July	9.25	15	7.64	14.0
August	14.95	17	4.61	9.0
September	7.86	15	5.18	14.2
October	7.29	15	9.70	13.2
November	20.85	27	13.39	16.3
December	24.83	21	13.80	19.5

Rainfall for 1936—154.02 inches. Rainfall average for 20 years—136.26 inches.

GRAPH SHOWING MONTHLY AVERAGES RAINFALL 1917–1936 (20 YEARS) FOR MADANG, TERRITORY OF NEW GUINEA.



GRAPH SHOWING ANNUAL RAINFALL FOR MADANG, TERRITORY OF NEW GUINEA.



KULILI PLANTATION (KAR KAR ISLAND)—MADANG DISTRICT.

Month.	1936.		Averages for Two Years.	
	Rainfall.	Wet Days.	Rainfall.	Wet Days.
January	14.43	28	14.43	25.5
February	14.60	24	14.60	22.0
March	14.05	17	17.73	14.5
April	10.76	19	11.09	19.0
May	9.66	17	11.33	20.0
June	8.10	13	6.52	14.0
July	5.71	18	4.83	14.5
August	9.05	20	6.41	16.0
September	4.93	18	6.33	17.0
October	14.02	22	12.97	21.0
November	20.14	20	23.38	21.5
December	21.29	18	16.51	16.5

Total rainfall for 1936—146.74 inches. Annual average for 2 years—146.13 inches.

KURUM (KAR KAR ISLAND)—MADANG DISTRICT.

LUTHERAN MISSION STATION.

Month.	1936.		Averages for Thirteen Years.	
	Rainfall.	Wet Days.	Rainfall.	Wet Days.
January	22.90	17	11.08	17.5
February	9.10	13	10.77	16.2
March	11.74	13	12.13	17.6
April	7.73	9	10.48	17.6
May	9.90	7	11.88	17.4
June	4.25	8	7.83	15.8
July	6.37	11	6.65	12.9
August	11.60	14	6.82	12.4
September	6.42	16	6.23	12.6
October	15.35	19	11.25	15.8
November	9.61	23	9.65	16.0
December	19.44	19	10.30	15.8

Rainfall for 1936—134.41 inches. Annual average for 13 years—115.07 inches.

TANGLEFOOT BANDING OF COCO-NUT PALMS AGAINST *SEXAVA*.

By John L. Froggat, B.Sc., Entomologist.

In preparing a scheme of investigations into the *Sexava* problem, every possible avenue of attack had to be considered. In view of the fact that the eggs are deposited mainly in the soil, and the nymphs have to ascend the palms, experimental trials with tanglefoot banding of the palms appeared to be well worth carrying out to determine what results could be obtained in destroying the young hoppers before they could reach the head of the palm.

Such trials were first carried out on Pak Plantation, Manus, with a mixture having a resin base. The results demonstrated that large numbers of first, and to a lesser degree second, stage nymphs were caught in the bands and destroyed; a few were found to cross the obstruction, but their movements showed that a sufficient amount of the mixture adhered to their "feet" as to hamper their movements and render them an easy prey to ants, &c. These tests were carried out by Mr. N. E. H. Caldwell, B.Sc., Assistant Entomologist.

Further trials were later carried out on Mokareng Plantation, Manus, but the pressure of the parasite breeding and liberation forced this line of work into abeyance for the time being.

In January-February, 1937, Mr. B. A. O'Connor, B.Sc.Agr., Assistant Entomologist, laid out two plots side by side for comparative testing of two types of tree-tanglefoot, the one with a resin base, the same as that used in previous trials, the other with a waxy base. Although the question of damage to the palm by the direct application of the resin-base mixture on to the trunk did not arise in this case, it is a matter of considerable importance with soft-barked trees; the waxy base material has been developed to eliminate this danger, and samples were given to the Entomologist by the English manufacturers while in England on leave in 1936.

These plots were in a moderately infested area of palms, and lay in the direction in which dispersion would probably take place.

Due, possibly, to climatological conditions, the waxy-base material, although yielding good catches for about two weeks, steadily deteriorated, and became useless in a very short time. This matter has been taken up with the manufacturers, who advise that they will endeavour to prepare a material that will stand up to the exacting conditions experienced (*vide* Graph No. 2).

On the other hand, the resin-base material gave good results for about two and a half months, and remained tacky and operative in a lesser degree for four months.

A peculiar feature in these trials was the attack by wild bees on the waxy-base material about two weeks after the inception of the trials; two bands were completely denuded within a week, and others were removed later. After the waxy-base bands had been severely affected, the bees began to remove the resin-base material.

The results for the first eleven weeks showed a marked and more or less regular fluctuation in the numbers caught, particularly noticeable when the counts per row per week are examined (*vide* Graph No. 1), but we were not able to definitely link this with variations in the emergence of *Sexava* nymphs.

The variation in the numbers caught on even adjacent palms was very great, even from day to day; this was also noted in the case of individual palms; some palms yielded consistently higher catches than others. The counts per palm per week to 1st April are shown in the appended table.

On some occasions, for unavoidable reasons counts were made at two, and occasionally three, day intervals, and it was noticeable that on these occasions there were remains of nymphs, such as one leg, showing that some of those caught on the bands had been removed by predators such as small lizards and ants. These were counted as well as possible but some may have been removed completely, and were not countable. There is, therefore, evidence to show that although the counts made represent the majority of the nymphs caught, they do not represent the absolute total, as there was an indeterminable number that could not be included.

Older nymphs than those referred to and adult *Sexava* were able to cross a 6-inch band, but in the process they collected a certain amount of material on the tarsi (or feet) which would possibly lead to their being attacked more easily by lizards, &c.

Bands of different widths were used, but it was found that any under 4½ inches were not satisfactory, both in catching and lasting qualities. In practice, the simplest method of application was by hand, this not only being quicker than with a piece of board, but it also gave the approximately correct width.

One pound of this material is sufficient to treat five palms, so that 1 cwt. should be sufficient to treat over 500 palms; the rate at which it can be applied depends very greatly on the celerity of the operator. We have received advice that this material can be supplied from England at 100s. (sterling) per cwt. in cwt. lots.

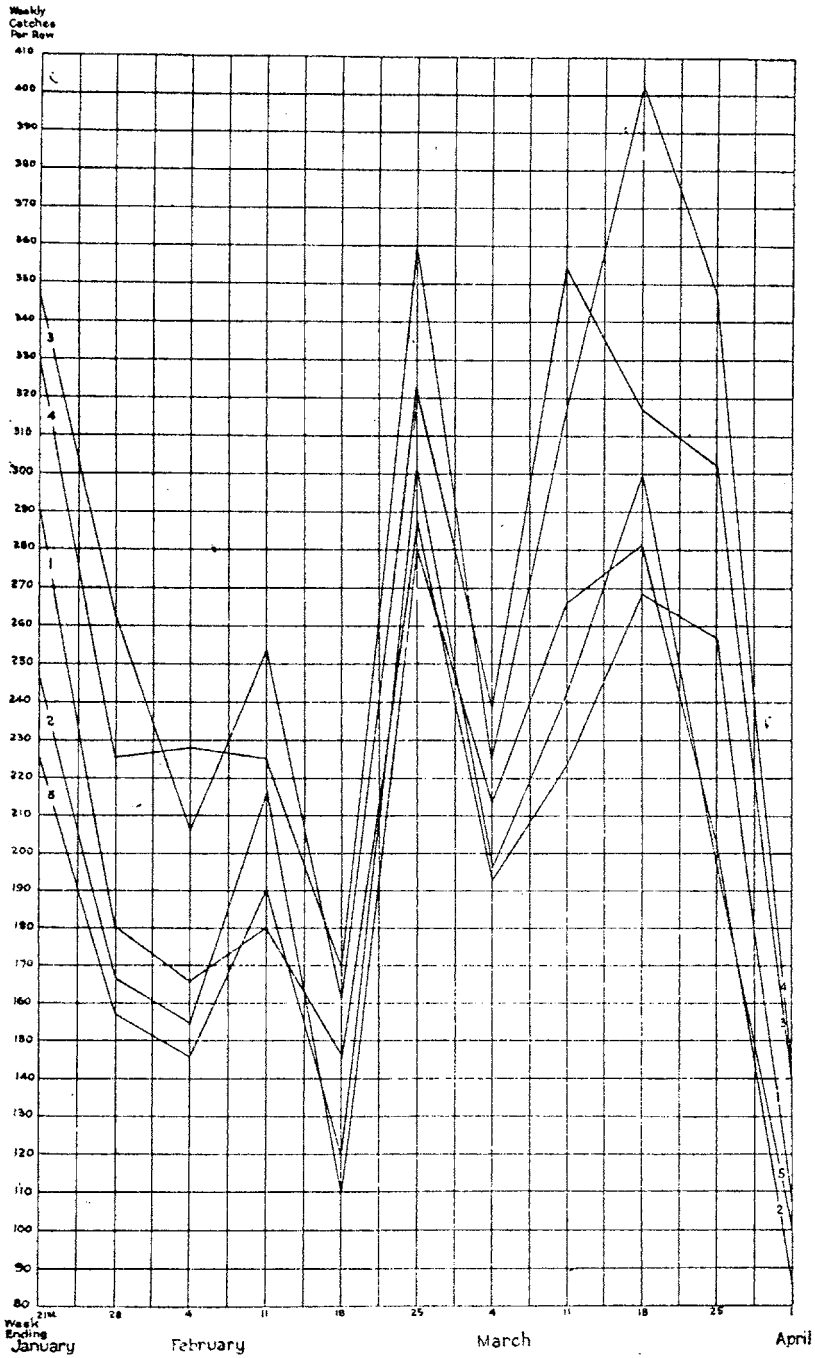
It seems possible that in the early stages of infestation, when the hopper is relatively localized, this method might be used with considerable benefit in reducing population of the early stages before the nymphs can reach the head of the palms.

TANGLEFOOT BANDING (RESIN BASE).

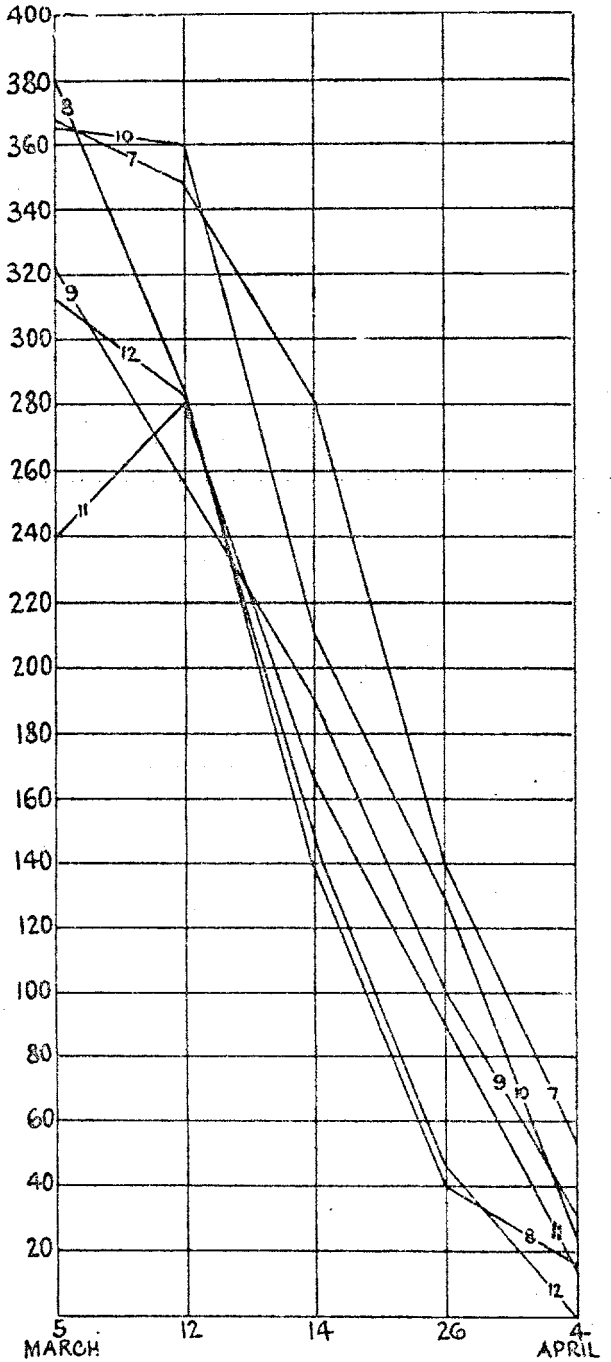
Weekly catches per palm, Nos. 1–30.

Palm No.	For Week Ending—											Total.
	January.		February.				March.				April.	
	21.	28.	4.	11.	18.	25.	4.	11.	18.	25.	1.	
1 ..	15	10	6	11	10	18	18	23	14	19	7	151
2 ..	32	28	29	21	15	39	30	21	40	37	31	323
3 ..	59	44	47	70	52	94	48	54	58	82	42	680
4 ..	53	25	21	20	21	47	35	52	56	54	23	407
5 ..	91	47	29	26	30	63	39	42	47	30	19	464
6 ..	42	27	34	32	19	27	23	39	63	36	14	346
7 ..	34	35	28	21	13	25	27	28	34	28	21	294
8 ..	33	24	23	42	10	42	29	31	31	19	13	277
9 ..	67	33	29	60	33	72	39	45	38	28	12	456
10 ..	32	13	11	14	16	21	10	31	49	27	9	233
11 ..	37	30	22	26	24	57	52	62	57	49	24	440
12 ..	45	32	42	37	14	62	57	70	74	55	24	512
13 ..	55	51	32	26	23	31	27	27	44	38	9	363
14 ..	48	33	20	30	20	43	26	53	37	23	13	346
15 ..	55	34	30	32	28	56	46	46	37	49	50	473
16 ..	47	31	21	32	15	62	33	54	48	53	31	427
17 ..	71	49	55	46	34	61	44	72	66	71	33	592
18 ..	69	56	48	51	37	68	62	103	97	69	25	685
19 ..	41	13	32	27	22	49	24	45	64	48	19	384
20 ..	51	44	26	30	23	54	21	59	60	64	28	440
21 ..	69	49	23	18	16	60	29	29	27	37	12	369
22 ..	52	38	38	30	33	84	37	49	60	71	37	528
23 ..	73	47	60	66	56	53	45	57	78	53	18	606
24 ..	50	35	50	40	20	63	61	81	112	73	51	636
25 ..	40	24	17	19	19	27	23	27	47	24	9	276
26 ..	33	27	13	15	13	36	15	22	23	21	5	223
27 ..	16	19	10	15	8	40	28	25	28	29	21	239
28 ..	72	58	57	60	34	86	50	62	67	47	25	618
29 ..	39	18	29	30	19	46	41	50	52	53	30	406
30 ..	21	12	22	39	26	56	43	56	81	27	24	407

GRAPH No. 1.—TANGLEFOOT BANDING (RESIN BASE)—ROWS 1-5.—
NUMBERS CAUGHT PER ROW PER WEEK.



GRAPH No. 2.—TANGLEFOOT BANDING (WAXY BASE).—ROWS 7-12.—
CATCHES PER ROW PER WEEK.



REPRINT AGRICULTURAL RESEARCH AND DEMONSTRATION IN THE DUTCH EAST INDIES.

By Leslie C. Coleman, M.A., Ph.D., Director of Agriculture in Mysore, in General Services Bulletin No. 14 of the Department of Agriculture, Mysore State.

ORGANIZATION UNDER PRIVATE CONTROL.

. . . a characteristic feature of work concerned with agricultural development in the Netherlands East Indies is the extent to which private organizations of growers (largely Europeans) support agricultural research. This is a feature which should be borne constantly in mind. It is not too much to say that the acknowledged reputation of these colonies for research in tropical agriculture is based largely on the work that has been done on experiment stations supported and controlled by private enterprise. Until comparatively recently, the individual experiment stations were organized and supported by comparatively small organizations of planters formed, either on the basis of crops, or on geographical position. Within the last few years, however, a need for co-ordination of effort has been felt and this has led to the formation of large organizations controlling a number of separate stations. Thus the sugar industry, which formerly had three separate experiment stations controlled by three separate organizations, has now one organization for the control of all its experimental work. Similarly, all the experimental work done in Java on the so-called "mountain cultures" tea, coffee, rubber, and cinchona, which was formerly controlled by a number of different organizations is now under the control of the General Agricultural Syndicate. There are, however, still a number of experiment stations under the control of smaller organizations who have not joined the syndicate. Thus, the experiment station for Vorstenland tobacco at Klaten is supported by a comparatively small group of tobacco companies. The rubber-planters of East Sumatra, and the tobacco-planters of the province of Deli in Sumatra have each their own experiment station. The tobacco companies of Besoeki province (East Java) have retained their independence and partially support the experiment station at Djember in that province where valuable work on the improvement of tobacco is in progress.

TROPICAL AGRICULTURE THEN AND NOW.*

By W. G. Freeman, B.Sc., A.R.C.S., F.L.S., Imperial Institute, London, late Director of Agriculture, Trinidad and Tobago.

. . . our knowledge of scientific tropical agriculture is of quite recent growth. On the other hand what may conveniently be termed the art of agriculture in the tropics as practised by various native races, is based frequently on very long experience and very close observation.

Take with respect to the latter point the discoveries made by native races on the properties of plants. They are indeed remarkable. The modern world uses large quantities of three beverages, tea, coffee and cocoa, the first prepared from leaves the others from seeds, but all alike containing as their essential principle caffeine or a closely similar alkaloid. Two other plants of considerable, but not such wide use for the sake of their stimulating alkaloids are cola (caffeine) and coca (cocaine). In these cases beverages are not prepared, but the seeds or leaves respectively are chewed. The discoveries of the properties of these plants and the methods of utilization were made not only in widely separated parts of the world, tea in Indo-China, cola in tropical Africa, coffee in Arabia, cocoa in Central America and coca in the Andean region, but so long ago that they are lost in the mists of antiquity. What is still more remarkable is that primitive man seems to have conducted his researches so thoroughly that all the resources of science have not as yet discovered any other plants containing important supplies of these alkaloids. I have often wondered when strolling through a tropical forest or through a botanic garden how primitive man made his discoveries, for casually chewing a cola nut or a coca leaf produces no appreciable stimulation. Similarly it would be a piece of very long range research to prepare and test infusions of all the available seeds or leaves.

On a point of agricultural practice too, we know that some tropical crops, e.g., coffee and cacao, are commonly grown under the shade of other trees, the practice having been handed down from remote times. When, by experiment, we endeavour to ascertain whether this is a desirable practice or not, it is very difficult to arrive at a definite conclusion even when we restrict our attention to the use of one particular kind of tree. We might expect that native races in Central America who shade their coffee do so as the result of observation, and that they would use any trees which happen to be available—and they are many. As shown, however, a good many years ago by O. F. Cook this is not so. In different districts they use different trees, but with one thing in common; they practically all belong to the *Leguminosae*. In other words the practice is a form of green manuring applied to permanent crops. These folks have not an ancient literature or we might have the advantage of being able to read their views on the use of these leguminous shade trees set down as precisely as those of the Chinese, the Greeks and the Romans on the green manuring of annual crops.

This extract from p. 10 of Dr. A. J. Pieters' *Green Manuring* must suffice. "In Ts'i Min Yao Shu of Chia Szu Hsieh, who lived about the fifth century B.C., there is a passage which reads: 'For manuring the field, lu tou (*Phaseolus mungo*

* Reprinted from "The Colonial Services Club" Magazine.

L. var. *radiatus Bak.*) is best, and siao tou (*P. mungo* L. var.) and sesame rank second. They are broadcast in the fifth or sixth month, and ploughed under in the seventh or eighth month . . . Their fertilizing value is as good as silk worm excrement and well-rotted farm manure.' "

Plant breeding, or at any rate the selection and propagation of improved types must also have been pursued from very early times. Amongst tropical examples we may cite the countless varieties of rice in the Eastern tropics, the large number of edible seedless bananas in the Indo-Malayan region all necessarily propagated vegetatively, and the races of maize in tropical America "improved" out of all resemblance to any known wild plant.

Early man often took great pains to conserve the fertility of the soil as so well described in F. H. King's *Farmers of Forty Centuries or Permanent Agriculture in China, Korea and Japan*, a book which all should read. As a more tropical example there is the case of Ceylon where for some 1,500 years the food supplies for a large population were grown in the arid northern region with the aid of an excellent system of irrigation works. The evidence of the bygone civilization of this district is indicated now by the famous Buried Cities. European man favoured the wet montane areas for his coffee, and later tea plantings, but was not so wise in his methods. As Mr. John Still says in his charming book on Ceylon entitled *The Jungle Tide*, "it is now about one century since coffee-planters attacked the forests of the hills. They have at last begun to conserve the soil, but in the early days of planting they lived on nature's capital, and the humus laid in store by the leaf fall of millions of years was flayed off by the rainfall of a few thousands of days when first the soil was denuded of its protecting forests, and carried down in spate to the sea; and now the older tea lives on fertilizers."

"In time the jungle tide will swing once more, and then those who care for other things than wealth will wander back to the wet side of the monsoon line, and while elephants browse where tea is now plucked, antiquaries will unearth the ancient bungalows of the British period, or even of the Scottish which will lie beneath it, and classify the different kinds of bottles found among the ruins, and arrange them in museums. Having both planted tea and arranged the antiquities of a museum, I venture to prophesy that this picture will be realized in very much less than fifteen centuries, perhaps in one-fifth of that, or perhaps in one-tenth."

There are many other tempting topics to touch upon, but I must not digress further. I have attempted to sketch, however cursorily, the development of our modern agricultural organisations in the tropical colonies. Our own knowledge and experience of agriculture in those countries is as yet very limited, whilst in many countries our officials come into touch with, and have to serve as advisers to, peoples whose agricultural practices are based on experience gained through many centuries. All I would urge now on the young agriculturist is to go out with an open mind prepared to admit that if a native people do not follow some recognized British practice it is not necessarily because they are foolish or obstinate. By study of their methods he may arrive at the reason for them, and then with the modern resources at his command be able to lead them on to improvements.

DRESSINGS FOR STOCK.

By G. F. Gee, H.D.A.

On recent patrols it has been found that very little attempt is made by planters to obviate fly strike on sores in cattle, or after castration of stock, except that in some cases a coating of tar is painted on. Although better than nothing, this is not entirely suitable as a hard scab is formed, under which maggots or organisms may develop, if present before the application.

Two recipes are given below which are very suitable for treating sores and castration wounds. The first is very cheap and gives good results. The second acts also as a fly repellant, but is more expensive.

When castrated stock become blown, care should be taken to remove all maggots present by the use of forceps and the dressing then applied.

(1) *Wound Oil*—

Creosote	1 part
Turpentine	16 parts
Linseed Oil	48 parts

(2) *Antiseptic Oil*—

Iodoform	1 part
Eucalyptus Oil ..	14 parts
Olive Oil	20 parts

BOUNTY PAID UNDER PAPUA AND NEW GUINEA BOUNTIES ACT ON IMPORTATION INTO AUSTRALIA FROM THE TERRITORY OF NEW GUINEA.

Year.	Cocoa Beans.		Nutmeg.		Mace.		Total Bounty.
	lb.	£ s. d.	lb.	£ s. d.	lb.	£ s. d.	£ s. d.
1926–27 ..	..	..	..	..	..	..	Nil
1927–28 ..	29,501	184 7 7	..	..	..	..	184 7 7
1928–29 ..	262,104	1,630 10 4	..	..	..	..	1,630 10 4
1929–30 ..	169,325	1,058 4 6	150	0 18 9	..	..	1,059 3 3
1930–31 ..	151,096	944 7 1	211	1 6 5	23	0 2 10	945 16 4
1931–32 ..	163,449	829 15 0	126	0 12 7	..	..	830 7 7
1932–33 ..	126,266	631 5 9	145	0 14 6	27	0 2 8	632 2 11
1933–34 ..	165,477	830 15 0	..	..	..	..	830 15 0
1934–35 ..	286,039	1,430 3 3	..	..	..	..	1,430 3 3
1935–36 ..	233,164	1,165 16 1	..	..	..	..	1,165 16 1
1936–37 ..	257,094	1,285 8 9	..	..	..	..	1,285 8 9
Total to 30.6.37..	1,843,515	9,990 13 4	632	3 12 3	50	0 5 6	9,994 11 1

BOUNTY PAID ON IMPORTATIONS INTO AUSTRALIA FROM PAPUA.

Year.	Cocoa Beans.		Kapok.		Sisal Fibre.		Total Bounty.
	lb.	£ s. d.	lb.	£ s. d.	Tons cwt. lb.	£ s. d.	£ s. d.
1926–27..	..	..	..	..	..	..	..
1927–28..	1,610	10 1 3	..	..	..	..	10 1 3
1928–29..	1,643	10 5 5	..	..	..	..	10 5 5
1929–30..	..	..	..	..	..	..	..
1930–31..	..	..	..	..	6 14 8	40 4 5	40 4 5
1931–32..	..	..	..	..	..	..	..
1933–34..	..	..	2,007	13 7 7	..	..	13 7 7
1934–35..	..	..	..	..	..	..	..
Total	3,253	20 6 8	2,007	13 7 7	6 14 8	40 4 5	73 18 8

A HANDY BREEDING TABLE.

By G. F. Gee.

The following table should be of assistance to those planters breeding different classes of stock throughout the Territory:—

Date of Service.	Cattle. 283 Days.	Horses. 340 Days.	Pigs. 112 Days.	Goats. 147 Days.	Sheep. 150 Days.	Dogs. 63 Days.
1st Jan. ..	10th Oct.	6th Dec.	22nd Apr.	27th May	30th May	4th Mar.
8th Jan ..	17th Oct.	13th Dec.	29th Apr.	3rd June	6th June	11th Mar.
15th Jan. ..	24th Oct.	20th Dec.	6th May	10th June	13th June	18th Mar.
22nd Jan. ..	31st Oct.	27th Dec.	13th May	17th June	20th June	25th Mar.
29th Jan. ..	7th Nov.	3rd Jan.	20th May	24th June	27th June	1st Apr.
5th Feb. ..	14th Nov.	10th Jan.	27th May	1st July	4th July	8th Apr.
12th Feb. ..	21st Nov.	17th Jan.	3rd June	8th July	11th July	15th Apr.
19th Feb. ..	28th Nov.	24th Jan.	10th June	15th July	18th July	22nd Apr.
26th Feb. ..	5th Dec.	31st Jan.	17th June	22nd July	25th July	29th Apr.
5th Mar. ..	12th Dec.	7th Feb.	24th June	29th July	1st Aug.	6th May
12th Mar. ..	19th Dec.	14th Feb.	1st July	5th Aug.	8th Aug.	13th May
19th Mar. ..	26th Dec.	21st Feb.	8th July	12th Aug.	15th Aug.	20th May
26th Mar. ..	2nd Jan.	28th Feb.	15th July	19th Aug.	22nd Aug.	27th May
2nd Apr. ..	9th Jan.	7th Mar.	22nd July	26th Aug.	29th Aug.	3rd June
9th Apr. ..	16th Jan.	14th Mar.	29th July	2nd Sep.	5th Sep.	10th June
16th Apr. ..	23rd Jan.	21st Mar.	5th Aug.	9th Sept.	12th Sept.	17th June
23rd Apr. ..	30th Jan.	28th Mar.	12th Aug.	16th Spt.	19th Sept.	24th June
30th Apr. ..	6th Feb.	4th Apr.	19th Aug.	23rd Sept.	26th Sept.	1st July
7th May ..	13th Feb.	11th Apr.	26th Aug.	30th Sept.	3rd Oct.	8th July
14th May ..	20th Feb.	18th Apr.	2nd Sept.	7th Oct.	10th Oct.	15th July
21st May ..	27th Feb.	25th Apr.	9th Sept.	14th Oct.	17th Oct.	22nd July
28th May ..	6th Mar.	2nd May	16th Sept.	21st Oct.	24th Oct.	29th July
4th June ..	13th Mar.	9th May	23rd Sept.	28th Oct.	31st Oct.	5th Aug.
11th June ..	20th Mar.	16th May	30th Sept.	4th Nov.	7th Nov.	12th Aug.
18th June ..	27th Mar.	23rd May	7th Oct.	11th Nov.	14th Nov.	19th Aug.
25th June ..	3rd Apr.	30th May	14th Oct.	18th Nov.	21st Nov.	26th Aug.
2nd July ..	10th Apr.	6th June	21st Oct.	25th Nov.	28th Nov.	2nd Sept.
9th July ..	17th Apr.	13th June	28th Oct.	2nd Dec.	5th Dec.	9th Sept.
16th July ..	24th Apr.	20th June	4th Nov.	9th Dec.	12th Dec.	16th Sept.
23rd July ..	1st May	27th June	11th Nov.	16th Dec.	19th Dec.	23rd Sept.
30th July ..	8th May	4th July	18th Nov.	23rd Dec.	26th Dec.	30th Sept.
6th Aug. ..	15th May	11th July	25th Nov.	30th Dec.	2nd Jan.	7th Oct.
13th Aug. ..	22nd May	18th July	2nd Dec.	6th Jan.	9th Jan.	14th Oct.
20th Aug. ..	29th May	25th July	9th Dec.	13th Jan.	16th Jan.	21st Oct.
27th Aug. ..	5th June	1st Aug.	16th Dec.	20th Jan.	23rd Jan.	28th Oct.
3rd Sept. ..	12th June	8th Aug.	23rd Dec.	27th Jan.	30th Jan.	4th Nov.
10th Sept. ..	19th June	15th Aug.	30th Dec.	3rd Feb.	6th Feb.	11th Nov.
17th Sept. ..	26th June	22nd Aug.	6th Jan.	10th Feb.	13th Feb.	18th Nov.
24th Sept. ..	3rd July	29th Aug.	13th Jan.	17th Feb.	20th Feb.	25th Nov.
1st Oct. ..	10th July	5th Sept.	20th Jan.	24th Feb.	27th Feb.	2nd Dec.
8th Oct. ..	17th July	12th Sept.	27th Jan.	3rd Mar.	6th Mar.	9th Dec.
15th Oct. ..	24th July	19th Sept.	3rd Feb.	10th Mar.	13th Mar.	16th Dec.
22nd Oct. ..	31st July	26th Sept.	10th Feb.	17th Mar.	20th Mar.	23rd Dec.
29th Oct. ..	7th Aug.	3rd Oct.	17th Feb.	24th Mar.	27th Mar.	30th Dec.
5th Nov. ..	14th Aug.	10th Oct.	24th Feb.	31st Mar.	3rd Apr.	6th Jan.
12th Nov. ..	21st Aug.	17th Oct.	3rd Mar.	7th Apr.	10th Apr.	13th Jan.
19th Nov. ..	28th Aug.	24th Oct.	10th Mar.	14th Apr.	17th Apr.	20th Jan.
26th Nov. ..	4th Sept.	31st Oct.	17th Mar.	21st Apr.	24th Apr.	27th Jan.
3rd Dec. ..	11th Sept.	7th Nov.	24th Mar.	28th Apr.	1st May	3rd Feb.
10th Dec. ..	18th Sept.	14th Nov.	31st Mar.	5th May	8th May	10th Feb.
17th Dec. ..	25th Sept.	21st Nov.	7th Apr.	12th May	15th May	17th Feb.
24th Dec. ..	2nd Oct.	28th Nov.	14th Apr.	19th May	22nd May	24th Feb.
31st Dec. ..	9th Oct.	5th Dec.	21st Apr.	26th May	29th May	3rd Mar.

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GREEN MANURING AND COVER PLANTS FOR COCO-NUTS.

By George H. Murray.

It has been proved, beyond question, by several Agricultural Departments and practical planters in tropical countries, that coco-nuts answer as readily to cultivation and fertilizing as any other crops in temperate or tropical regions.

In Ceylon, one of the most progressive tropical colonies of the British Colonial Empire, there are several firms which do a large business in the manufacture and sale of commercial fertilizers to coco-nut planters, competent managers, who would not commit themselves to the expenditure of money that did not result in increased profits. One gentleman with whom I discussed this matter locally, stated that cultivation and manuring of coco-nuts was "controversial", but there can be no gainsaying facts which have been repeatedly proved. Several planters, in the Territory, on the other hand have asked for the best kind of fertilizers to apply as top dressing in certain districts, but it would be almost useless to apply commercial fertilizers to a plantation covered with grass as the latter would be benefited at the expense of the coco-nuts.

Palms that have been circle-weeded could have suitable commercial fertilizers applied to them with benefit, and in many eastern plantations where it is still customary to graze cattle, and circle-weeding is practised, it is quite common to apply cattle manure or inorganic fertilizers. An estate known to me was, at one time, a decidedly poor yielder and the owners decided to carry out a systematic scheme for fertilizing with organic manure. All the cattle were penned at night and the manure scientifically composted each morning exactly as would be done on a well-managed farm in a temperate climate, even the poultry manure and other refuse being treated in the same way, and to-day that plantation is hardly recognizable as the same property that it was a few years ago. The crowns of the palms are all a healthy dark green bearing heavy crops of nuts, yet to use the words of the friend who accompanied me over the property, "ten years ago this was a poor estate". This improvement was only accomplished by carrying out a definite scheme of work over a period of years, but results proved that it was worth the labour, and if planters here would select a small portion of their plantation for experiment, using cover plants and circle-weeding for a radius of five or six feet, they could prove the question for themselves.

Naturally with slow-growing trees like coco-nut palms they could not expect immediate results, but there is not a shadow of doubt as to the ultimate benefit. The practice recommended by this Department for the use of cover plants is now becoming more general, but comparatively few planters are circle-weeding their palms, with the result that they complain that they cannot find their fallen nuts. Circle-weeding of sufficient radius enables the palms to obtain the full benefit of the application of both organic and inorganic manures, and most of the nuts will fall within the circle so weeded. In this connexion it might be stated that in a letter to me from the Government Chemist, Department of Agriculture, New South Wales, some years ago, he stated with reference to plantations in this Territory, "the practice of green manuring would be beneficial, but this necessitates the cleaning up of grass and weed growth, which I understand is not the general

practice". Recently I noticed on a small Mission plantation, that the ground had been hoed up, which was good as far as it went, and it was left in a fine condition for the sowing of cover plants, but such unfortunately had not been done. On a larger plantation a rotary hoe would be a very suitable implement for breaking up the ground prior to the sowing of cover plants, and if the planter would treat a portion of his property in this way annually, he would be able to deal with the whole arable portion of the plantation in the course of a few years.

It should not be forgotten that many of the plantations in this Territory, particularly in the Gazelle Peninsula, are 40, if not more, years old and that several are far from being in a healthy condition. Depreciation is rapidly going on and in a few cases it is rather doubtful if they can be brought into profit again. Rejuvenation is possible, provided the trees are not too far gone, but the more the growing point, or bud, becomes stunted the less likelihood there is of cultural methods being successful.

The soil on many of the older plantations, particularly in the neighbourhood of Rabaul, is lacking in organic matter, and the pulverised pumice of which it mainly consists is probably deficient in readily available phosphoric acid. Green manures (leguminous plants turned under) will supply the humus and the use of superphosphate would give beneficial results if applied in proximity to the tree, but the first consideration is to eradicate the kunai before manuring of any kind can be successful.

The value of green manure is not merely the supplying of elements lacking in the soil, but in improving the physical and mechanical condition of all classes of soil, heavy as well as light. The oxidation of humus resulting from the decomposition of green manures assists in rendering elements already in the soil more available as plant food, and has a stimulating effect on the activity of beneficial organisms present in the soil.

Green manures have one special property, organic matter, which they supply to soils and which is converted into humus, that essential without which no soil can be considered fertile. Artificial fertilizers can never replace organic manures (green or animal manure) because in order to be fertile soil must contain humus and be in a suitable mechanical condition essential for vigorous plant growth.

There is rapid diminution of organic matter in the soil of tropical countries and a regular replenishment is necessary to keep the soil in good heart. Even in countries where there are large numbers of cattle as in Ceylon and Java, animal manures are not in sufficient quantity for this purpose and green manures are used regularly for the supply of organic matter.

A factor of the greatest importance is that outbreaks of disease and serious attacks of insect pests are largely due to lack of organic manure and it was stated recently in *Nature* in a review of a standard work on Plant Protection that, "properly fed plants, like properly fed animals, would be largely resistant to disease, and the road to health is through organic protective foods". The use of organic manures for most tropical soils is necessary on account of leaching from heavy rains. The continued use of artificial fertilizers is no remedy, but, on the contrary, is liable to lead to evil consequences if not accompanied by adequate organic matter. Further than that, the nutritive and economic value of a crop

is enhanced by the use of an organic manure. However rich, therefore, the planter may imagine his soil to be, he should see that all animal and vegetable waste products go back into the land by systematic organic manuring, if the value of the plantation is to be maintained.

There has been a steady deterioration of the soils in many parts of the Territory for many years, because of incorrect agricultural practice, due to various causes; in certain cases to the lack of soil nutriment, in a few cases by rainfall erosion, and, in some of the low sandy island plantations where there is insufficient ground cover, by exposure of the soil to a tropical sun. It is now appreciated that some of these conditions can be improved by adding to the humus content of the surface soil by cultivating cover and green manure plants after which applications of artificial fertilizers can be employed to accelerate improvement and maintain a satisfactory balance between the cover plants and the permanent crop. Manuring, therefore, with artificial fertilizers is complementary to the development of natural or other cover plants in soil improvements.

Many of our plantations are on land that can be no longer considered virgin, having deteriorated for the reason noted above, impoverishment by kunai (*Imperata arundinacea*) and other noxious plants. Such soils require regeneration, otherwise there will be a steady decline in yield as can be noticed on many plantations already on poor, or even ordinary soils which have suffered impoverishment for years past. Soil deterioration is a world-wide problem which is now receiving attention in many parts of the world owing to the increase of the world's population and the consequent rapid utilization of land for various crops. It would appear from frequent statements heard, that the areas of land suitable for European cultivation in this Territory are almost limitless, but such is by no means the case. This might apply to a certain extent to native agriculturists who require only relatively small individual areas, but it behoves the European planter, therefore, that he should put the land on his plantation to the best possible use.

Many quotations could be given from the most reliable authorities to support these statements, but I will merely give one extract from a lecture on "Land and Land Use" by P. E. Brown, Head of the Department of Agronomy, Iowa State University, U.S.A., who states as follows:—

> "It takes 400 to 500 years to produce an inch of top soil which may be lost in one year on a steep slope, in three years on a moderate slope poorly managed, or in one rainfall of the cloud burst type".

We had ample demonstrations of this fact during the heavy downfalls of rain on the north coast, New Britain, when gullies were simply scoured out and some thousands of coco-nut palms were torn up by the roots, also in Rabaul itself, flooded with torrents of water because the surface vegetation had been covered up with pumice during the recent volcanic eruption.

I have elsewhere pointed out that the disappearance of certain ancient civilizations was due to the conversion of what were once fertile lands carrying a dense and highly civilized population, into deserts produced not by a change of climate, but by man's ignorance and lack of foresight in his treatment of the soil.

Soil conservation is of more importance in the tropics where the oxidation of organic matter takes place most rapidly. Prof. J. C. Lipman writing in *Science* of 24th January, 1936, states:—

"Amongst the major constituents of the soil whose importance we have under-estimated is the organic matter. It is not enough that a soil contains the essential ingredients for the production of plants. The soil must be able to absorb and to store sufficient quantities of water. This texture and structure should be such as to provide optimum conditions for the vertical and horizontal movements of the water and air. A good soil must furnish a source of energy to various micro-organisms which are a positive factor in crop production. Soil organic matter is a source of food and energy for micro-organisms".

It has elsewhere been stated in this periodical that there is a likelihood of a decrease in our copra production on several of the older plantations, and this also applies to certain plantations not so old, one in particular, which formerly yielded 60 tons of copra per month and is now only producing 27 tons per month, owing to the fact that the nourishment in its comparatively shallow soil is becoming exhausted. It is far easier to maintain soil in good order than to regenerate it once impoverishment has set in, and in those cases where the surface soil has been eroded by bad cultivation and lack of vegetal covering it has been rendered useless for all time. Tens of thousands of acres of land in the north-western States of America and Australia have been rendered practically valueless for this reason, and even in a new country like New Guinea, it is not uncommon to find where soil deterioration has set in through bad cultural methods. In this case the natives are amongst the worst offenders, fond as they are of making their gardens on steep hill-sides with the result that soil, particularly when of a friable nature, is carried into the valleys or gorges below, the noxious grass, kunai, then being the only vegetation able to get a footing on such a terrain.

The most valuable of all organic manures is of course animal excreta, particularly when properly composted. In Ceylon it is customary to maintain cattle on plantations largely for this purpose. They should be penned at night and the ground well provided with litter all of which is placed into a large concrete lined pit. When the pit is full it is turned into a second and finally into a third and by the time the first is again filled the compost in the third is ready for application to the trees. On certain plantations of a well-managed company in the Solomon Islands, the land is sub-divided into comparatively small blocks in which cattle are grazed periodically and in this way the grasses are kept down so that grass cutting by hand labour, so commonly seen in this Territory, is quite unnecessary. Incidentally the use of cattle in this way has been responsible for the spread of the valuable low-growing indigenous cover plant, sometimes known as Japanese clover (*Desmodium triflorum*), a cosmopolitan leguminous plant very common in the Solomon Islands and this Territory. Cattle eat it readily and ripe seeds pass through the animal and germinate in the voided excreta.

In plantations in this Territory herds of cattle are sometimes to be seen, but they are not grazed systematically, as in the Solomon Islands, or penned for manurial purposes, as in Ceylon, and are of little use in keeping down the grass if allowed free range over the whole plantation.

Selective Weeding.

The first step to put the soil in a healthy condition is to eliminate noxious growths like kunai, encouraging the growth of indigenous leguminous weeds of which there are many species, such as *Cassias, Desmodiums,* &c., and by the introduction of cover plants.

There are many indigenous leguminous plants, considered as weeds, to be seen in New Guinea, all of which should be encouraged to establish themselves on plantations. Some are of comparatively weak growth, and are, therefore, of less value than others, but all are beneficial and labourers should be taught to distinguish them from noxious weeds, so that they are not destroyed when cleaning the plantation. This is not a difficult matter, as thousands of primitive natives in Papua to-day are able to recognize leguminous plants which have been explained to them in their own tongues, as "friends of the coco-nut tree", and distinguished from other plants by mostly bearing pea-like blossoms and legumes or bean-like pods.

Amongst the most common of such plants is that usually known as "Grilly Plant", botanically as *Herpetica alata,* easily recognized by its candelabra-like influorescence. Wherever a large clump of this plant is growing it will be found that noxious grasses have been smothered out, and the surface of the ground beneath is cool and usually covered with a leaf mulch. Incidentally the plant contains a considerable quantity of chrysophanic acid, which renders it of value as a remedy for the loathsome native skin disease known as "Grilly", hence its popular name.

Crotolaria spp., particularly *Crotolaria striata,* is not uncommon in some plantations, having probably been introduced during the German régime as a green manure, for which it is much used in agriculture in other tropical countries. It grows about 3 or 4 feet in height, bears yellow flowers striped with brown, and legumes with a silky surface, about 1½ inches in length. It is not as rampant a grower as *Herpetica* (formerly *Cassia*) *alata,* but like that plant bears many nitrate bacterial nodules on its roots. There are many other species of *Crotolaria* easily recognizable by their seed pods, which rattle when the seeds are ripe, hence its generic name, which means "rattle box". The above and many species of *Cassia* are all of shrubby growth, but there are also creeping leguminous plants which should also be encouraged. Amongst the best of these latter is *Vigna marina,* a common littoral creeper in many parts of the Territory, and it was seen growing prolifically near the beach areas of a plantation on the east coast of New Ireland, where labourers were cutting it with "sarifs", as if it were a noxious weed like kunai. It forms a fairly dense carpet with creeping stems 6 to 7 feet in length, bearing small yellow flowers and should be encouraged, as it is likely to thrive in positions less suited for many other leguminous creepers.

Cover Plants.

In agriculture of the temperate zone, weeds are kept down by tillage with hand or draught implements, but this method is quite out of the question in the humid tropics, for many weeds are no sooner turned under than they start to grow again. (Tillage of course is practised in the tropics, where agriculture is

advanced, for aeration of the soil and other cultural processes.) In the place of tillage, therefore, the best system of preventing the growth of noxious weeds, is the cultivation of leguminous cover plants, which are also of manurial value.

In some countries, notably Ceylon, tall plants like *Tephrosia* are grown for this purpose and periodically lopped. The intensive methods of agriculture employed in Ceylon, however, would hardly be applicable on an extensive scale in a country like New Guinea, where cultivation is less advanced and labour less skilled. For that reason, the Department has recommended the use of leguminous creepers as cover plants, weeds in their own country, now commonly used on coco-nut and rubber estates in Malaya and elsewhere. The plants best suited for this purpose in New Guinea and which have already proved satisfactory, are the following:—

Calopogonium mucunoides.—This is one of the quickest-growing plants as a cover and forms a thick mat in about six months from sowing seed in the wet season. So rapid is its growth that one planter called it "galloping home", but it is apt to die back in a dry season, particularly if soil conditions are not altogether favorable. It forms a very dense, thick cover in good soil and the vines should be pulled back from the base of the palms for a radius of five or six feet.

Centrosema pubescens.—This has proved the best cover under most conditions. It does not form such a thick mat, as the above, but its tendrils pull down most noxious grasses and weeds when thoroughly established. It is not altogether successful with "Thurston grass" (*Paspalum conjugatum*) but, once established is permanent and does not require re-planting. It takes about twelve months to form a good cover from seed.

Pueraria javanica (*phaseoloides*).—This plant much resembles *Calopogonium mucunoides* in appearance, having hairy creeping stems, but the leaves are larger and even more vigorous in growth, so that it will even smother out "Thurston grass" and is equally effective in dealing with kunai. Its much ranker growth, however, requires more attention in keeping the circles round the palms clean. Like *Centrosema* it takes about twelve months to make a dense cover, but it is looked upon as one of the best cover plants for young coco-nuts at the Demonstration Plantation, Keravat. It does not seed freely and for a long time did not set seed at all at Keravat, consequently it is more expensive that other cover plant seeds. It is easily propagated by planting cuttings with adventitious roots at the nodes, or joints, so that once an area is thoroughly established it can be spread over the plantation. To economize the seed it would be well to plant it in a nursery first, to be planted in the field in clean ground, when sufficiently strong to hold its own. Planting cuttings should only be done in moist weather.

Method of Sowing Cover Crop Seed.

The best method of sowing cover crop seed is in mixture. The seed rate per acre depends entirely upon what the planter is prepared to spend. Up to 30 lb. per acre has been used in broadcasting on new land, but if the seed be sown in seed beds, much less will do. In a mixture of *Calopogonium* and *Centrosema*, 8 lb. of the former and 12 lb. of the latter has been recommended, but much less than that has produced a good cover on some New Guinea plantations, within twelve months.

In new plantations the cover plant seeds should be sown as soon as the land is cleared, before any grass or weeds can become established. On older plantations where grass and weeds are already in possession of the surface soil, clean beds, at least two feet in diameter, should be prepared about 6 feet apart each way. The seed should be dibbled or raked into the soil and given attention until the young plants start to send out climbing tendrils, when they can battle for themselves, and will eventually form a dense cover over the plantation.

Cover plants, being leguminous, are of value for green manure and when thoroughly established it is advisable, when possible, to turn them under every few years. The "cover" should be "sarifed" about twice a year, or it would be still better if it could be disced with a disc harrow or rotary hoe, which would have a beneficial effect in providing air for the roots, an essential for plant growth. It should also be remembered by those proposing to apply artificial or inorganic fertilizers that they are much more effective on soil comparatively rich in organic matter than on soils that are poor in such elements.

Grazing Value.

For those planters who carry stock on their properties, *Centrosema* in particular will be found very good grazing, but due care must be taken, otherwise there is danger of stock eating it out. For this and other reasons previously noted, all plantations carrying stock should be subdivided, and if worked systematically stock-raising could be made a valuable adjunct to the copra industry.

CORKS.

Various Household Purposes for which they may be Utilized.

An ordinary "wine" cork makes an excellent door-stop if a screw is driven through to secure it to the floor. The cork will not be conspicuous if coloured with household enamel to match the floor or walls of the room.

A cork screwed on to a kettle or pan lid serves as a convenient and non-conductive knob.

When a cork seems to be too big for a bottle it can be made to fit by soaking it in boiling water for a few minutes. To render a cork air-tight and water-tight, soak it in olive oil for five minutes before use.

To prevent the risk of a cork coming out of a bottle when travelling fix a strapping of adhesive plaster over the top, or tie over the cork the finger of an old glove.

INSECT PEST CONTROL.

By John L. Froggatt, B.Sc., Entomologist.

Elaboration of methods for the control of insect pests is not merely a question of the haphazard use of insecticides, the action of which can only be more or less guessed, but demands a considerable amount of careful detailed study of the life history and habits of each pest before any question of the method of control to be used can be raised. There are certain broad lines of control that may be applicable to certain groups of insects, but variations in habit and local conditions will often necessitate adaptation of such to special cases.

A thorough knowledge of the life history and habits gives data on the length of the life cycle (deposition of egg to emergence of adult); where the eggs are deposited; where and when the larvae feed—whether they are internal or external feeders; where the adults shelter and where and when they feed; any indigenous parasites, and at what stage of development of the host they are operative, and their economic importance. With this data in hand, the research worker is able to decide whether one stage of development is more vulnerable than another, what line or lines of attack offer the best possibilities of success, and how to set about their application.

In relation to plant life, insects may be divided into three classes;

(i) those which obtain nourishment by chewing (caterpillars, &c.);
(ii) those which, by specially adapted mouth parts, puncture the bark, and suck up the sap (plant bugs, aphids, &c.);
(iii) those which feed on other insects.

The first two form the pest groups (i.e. insects which interfere with agricultural production), while the third comprises insects of great value to man. It is obvious that the two pest groups require the application of very different methods for their control.

The general lines on which control may be considered are:—

(i) *Mechanical measures*; the use of insecticides by dusting, spraying or fumigation.
(ii) *Biological measures.*
(iii) *Variations in agricultural practice.*

Mechanical Measures.

There are a number of chemicals, and preparations of such, that can be used either as sprays or dusts, and are classed as:—

(*a*) stomach poisons, for chewing insects.
(*b*) contact insecticides, for sucking insects.

Of the *stomach poisons,* mention may be made of Arsenate of Lead, Calcium Arsenate, Barium fluosilicate, Paris green, Derris and Pyrethrum preparations, and of the *contact insecticides,* Lime-sulphur spray fluid, Kerosene emulsion, Miscible-oil sprays, Derris and Pyrethrum preparations. For fumigation, Hydrocyanic acid (Prussic acid) is the gas most in use, although Carbon disulphide and other chemicals have certain uses.

In the case of mechanical measures to be adopted, the type of insecticide is decided on. The next step is the method of application, either spraying, dusting, baiting or fumigation.

Spraying is a measure in which the insecticide is mixed with a fluid as carrier (usually water), and projected over the crop in the form of mist, the fluid running off and leaving the insecticide as a fine film over the plant.

Water used for this purpose must be soft (i.e. lather easily with soap), as hard water (i.e. does not lather easily with soap, but forms a hard precipitate) will cause chemical change when used with some chemicals; therefore if the only water available is hard, it must be treated with soft soap or soda-lye to eliminate the chemicals causing the hardness.

Where the area to be treated is large, water in sufficient quantity may present considerable difficulties, and add considerably to the cost of operations.

Dusting (sometimes called dry spraying) consists of the projection of the insecticide into the air as a fine dust-cloud, allowing the natural air currents to carry the powder through the crop, the dust slowly settling as the cloud travels onwards. Much larger areas can be covered in the same time and with less labour by this method, which has largely superseded spraying for most purposes; furthermore the difficulties of sufficient supplies of soft water and costs of cartage are eliminated.

Baiting consists in treating some suitable material with poison and setting it out as baits for the insects to feed on, on and around the feeding grounds.

Fumigation requires a gas-proof container, into which the plants and materials to be treated are placed and subjected to the poison gas for a given period.

The next step in the investigations is the setting up of a series of comparative trials with the insecticides selected to determine which preparation gives the best results with a minimum of cost consistent with efficiency, and without damaging the crop. These tests are made on a small scale, and, on completion, lay the foundation for field trials.

Biological Measures.

In biological control, advantage is taken of the assistance of insects which prey on others, either internally or externally. There are two groups of these friendly insects; those which confine themselves to one individual of the host (parasites), and those which wander from one member to another of the host (predators). Of the former, some are parasites of eggs, others of larvae, and still others of the adults of the host. Some are more or less specific in their host relationships, while others are found over a wide range of hosts.

Where indigenous parasites and/or predators are absent, or of little economic value, it may be advisable to consider the introduction of such from foreign countries. In these cases the very greatest care must be taken to prevent the introduction of any insect that may, under the new conditions, become a pest, or even a hyperparasite of some economically useful insect already present in the country, or even of the useful insects it is desired to introduce. Careful detailed study, preferably in the country of origin, is required for these purposes, and the breeding of the parasites through two or more generations may be necessary, should hyperparasites be present, to ensure a pure strain.

Biological control may be slow in its initial stages, while the parasites become acclimatized, but if successful will save a great deal of labour and expenditure of money, for once established it requires no further attention.

Agricultural Practice.

It has been stated that healthy, vigorous plants are not subject to infestation by pests and diseases. Although many consider this as rather too sweeping a statement, there is no doubt that a vigorous healthy plant will not be affected as badly by pests as one of low vitality.

It has been proved time and again that proper attention to agricultural practice has a very important bearing on pest and disease control.

When a crop is affected by soil frequenting insects, cultivation of other crops on that area for a period will assist in starving out the pests. A system of crop rotation may even be sufficient.

Cultivation and manuring will assist in forcing growth, and minimise damage by some foliage feeding insects, in addition to improving the general vigour of the crop.

Due attention to plantation hygiene can lead to the removal of breeding grounds and sheltering sites of many pests.

Field Practice.

In actual practice, field trials may prove that control of a pest may be more satisfactorily obtained by a combination of two or more of these lines of attack.

General Insecticides.

A few notes on general insecticides used against plant pests may act as a guide in treating common pests as they arise.

Leaf Eating Insects.

For Spraying, Arsenate of Lead, Paris Green, Derris and Pyrethrum preparations.

For Dusting, Arsenate of Lead, Calcium arsenate, Paris Green, Derris and Pyrethrum preparations.

Sap-Sucking Insects.

Kerosene emulsion, Derris and Pyrethrum preparations, Lime Sulphur fluid, Miscible Oils, Black-leaf 40 (Nicotine sulphate), and Resin wash are some of the more general sprays, depending on the pest to be treated.

Arsenate of Lead.

This insecticide is obtainable in two forms, powder and paste. With the former, it is advisable to use some preparation that will assist the poison in spray form to adhere more strongly to the foliage, referred to as a "spreader" or "sticker."

The paste form has the sticker already mixed with the poison.

For spraying, Arsenate of Lead is used at the rate of 1½ lb. of powder or 3 lb. of the paste to 50 gallons of water. When preparing the material, it should be worked up with a little water into a thin paste free from lumps; this is then poured into the full quantity of water, stirring constantly. As the poison is only in a state of suspension, the apparatus used for spraying must be equipped with an efficient agitator to prevent the powder settling out, on to the bottom of the container.

Used as a dust, Arsenate of Lead is usually mixed with hydrated lime or other inert filler in the proportion of one part of poison to three to ten parts of lime.

This insecticide has certain advantages over other arsenicals in that it is comparatively safe to use on foliage; it adheres fairly well to foliage, and when used as a spray it does not settle as rapidly as, e.g., Paris Green.

The usual spreader used with Arsenate of Lead is:—*Calcium Caseinate,* or *Casein-Lime* at the rate of 2½ oz. to 50 gallons of spray mixture.

This preparation can be made by mixing thoroughly 3 oz. of *Powdered Casein* with 7 oz. of *Hydrated Lime.* The ingredients may be added to the spray in the dry form, or first mixed into a paste with a little water, and then added to the spray. When added in the dry form, it should be done slowly while the agitator is in motion.

When the mixture is first made into a paste, the two powders must be thoroughly mixed together dry, and water added in small quantities stirring vigorously until chemical combination takes place. When this is complete, the thin paste can be diluted with water for convenience in handling, and the necessary amount added to the spray.

Calcium caseinate has advantages over other stickers in that it is compatible with all sprays, is convenient to handle and low in cost, and does not cause injury.

Paris Green.

This poison has a much more rapid action than Arsenate of Lead on insect life, but there are several reasons why it is not used more extensively; used as a spray, it settles much more rapidly, and therefore it is difficult to keep an even strength of spray through the nozzle; it does not adhere as well to the foliage, and thus necessitates more frequent spraying; furthermore it may contain an appreciable amount of water-soluble arsenic, which will burn the foliage: (this can be overcome by the addition of lime, which combines with the soluble arsenic, and reduces the risk of damage to the foliage); the greater cost as compared with other arsenicals.

For spraying the poison should be worked up into a thin paste without lumps by the addition of small quantities of water; the lime should be slacked in a little water and added to the full volume of the spray; finally the Paris Green is added. The regular formula is—

Paris Green	½ lb.
Quick lime	1 lb.
Water	50 galls.

Paris Green may be used as a dust, mixed with hydrated lime in the proportions of 1 part of poison to 6—10 parts of Lime.

This insecticide is used extensively in a bait for "cutworms", which shelter in the soil during the day, and come out to feed at dark. The general formula for this bait is—

Bran	50 lb.
Paris Green	2 lb.
Molasses	2 quarts.
Lemons	3 fruit.
Water	4 galls. (approx.).

The Paris Green is thoroughly mixed with the dry bran; the fruit is chopped up and added to the water with the molasses. The fluid is then stirred into the poisoned bran to form a damp, slightly crumbly product.

It is more satisfactory to mix the bait during the day, and scatter it on the ground at the base of the infested plants in the late afternoon, so that it is fresh when the caterpillars come out to feed about dusk.

Calcium Arsenate.

This is a light flocculent powder that offers possibilities in certain cases of dusting.

Derris.

The roots of certain Derris spp. contain chemical bodies that are very toxic to some forms of insect life, but are much less poisonous to mammals than arsenicals. A great deal of attention has, therefore, been paid to preparations in which Derris extractives are the active principle. Against caterpillars, this insecticide appears to be very satisfactory, and for dusting and spraying of vegetables has largely replaced arsenical preparations.

Pyrethrum.

Research in recent years has shown that there are greater possibilities in Pyrethrum preparations than had been heretofore realized.

This insecticide is derived from the ground-up flowers of a plant, *Pyrethrum spp.*, belonging to the Chrysanthemum family, and although very toxic to insects, has little or no harmful effect on warm blooded animals.

Resin Wash.

This spray is specially useful for scale insects on citrus trees. A formula recommended in New South Wales is:—

Caustic soda, 98% quality	5 lb.
Resin	16 lb.
Soft soap	6 lb.
Water	100 galls.

To 10 gallons of boiling water, add the above quantity of caustic soda; slowly add the resin (which must be first finely powdered) a little at a time, stirring constantly; then add the soft soap little by little, still maintaining a constant stirring of the fluid; boil the whole together from two to three hours, or until well dissolved. Add hot water, a little at a time, until there is not less than 20 gallons of hot solution. Keep well stirred. Dilute in the proportions of 4 gallons of hot water to one gallon of *hot* solution, or so as to bring the whole up to 100 gallons. *Never add cold water when cooking.*

If obtainable 3 pints of fresh oil would be preferable to the soft soap.

The concentrated solution can be kept for some time as a stock solution and diluted for use as required.

The solution should be used as hot as the hose can stand without damage, for, if allowed to cool, the spray may interfere with the valves of the pump. As it comes in contact with the air in the form of spray, the mixture will be cooled to such an extent that no harm will be done to the tree.

In spraying, see that the inside of the tree is reached as well as the outside, and the under—as well as the upper—surfaces of the leaves.

This spray will be found most effective when applied to the trees when the young scales are hatching out from the mother-scales. This must be determined by observation.

Should the trees be suffering from the effects of droughty conditions, it is not advisable to apply this wash, as it would destroy the foliage, and thus injure the tree.

Kerosene Emulsion.

The stock formula for this emulsion is as follows:—

Kerosene	2 galls.
Whale oil soap	½ lb.
Water	1 gall.

(One quart of soft soap may be substituted for the whale oil soap). The soap is first finely divided and dissolved in the water while boiling; when dissolved immediately remove from the fire and add to the kerosene. The whole mixture is then violently agitated while hot by being pumped back into itself with a force pump and a direct charge nozzle throwing a strong stream, preferably ⅛th inch diameter. After 3 to 5 minutes pumping, the emulsion should be perfect and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well-made emulsion will keep indefinitely, and should be diluted only as wanted for use. The use of whale-oil soap, especially if the emulsion is to be kept for any time, is strongly recommended, not only because the soap possesses considerable insecticidal value itself, but because the emulsion made with it is more permanent, does not lose its creamy consistency, and it is always easily diluted, whereas with most of the other common soaps, the mixture becomes cheesy after a few days and needs reheating to mix with water.

Soft soap answers very well, and one quart of it may be taken in lieu of the hard soaps. In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water, and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water employed.

For spraying, thoroughly mix one gallon of the above stock with 7 gallons of water.

Where only small quantities of the spray are required, the following formula may be used.

Water (1 kerosene tin full)	4 galls.
Sunlight soap	2 cakes.
Kerosene (good quality)	1 pint.

Emulsify the kerosene as above and spray with the liquid with just the chill off.

Miscible Oils.

In these preparations, the oils are so mixed that they are readily miscible with water; they are of two types, one for trees in a dormant condition (i.e. without foliage) and the other for trees in full growth; only the latter type are applicable to this Territory.

Against scales and mealy bugs, certain of these oil sprays have given good results.

Lime Sulphur Spray Fluid.

This is not only an excellent insecticide, but is also an important fungicide.

This spray fluid can be obtained in a concentrated form that only requires diluting with water, according to the directions supplied by the manufacturers.

The preparation can be made on the plantation, but is an unpleasant and tedious business; the field formula is as follows:—

Flowers of Sulphur	100 lb.
Good burnt lime	50 lb.
Water	50 galls.

About half the water is brought to the boil, and the lime stirred in while heating; the sulphur is mixed into a paste and added and the liquid stirred until the lime is well slacked and the contents thoroughly mixed. The remainder of the water is then added, and the whole boiled for three-quarters of an hour to one hour, but no longer. The liquid, orange red in colour, is strained to clear out any sediment, and stored in airtight containers.

The dilution of the solution depends on its density, the determination of which is done by means of a Baumé hydrometer, from which the density is read off in degrees Baumé. The appended chart will enable sprays of correct dilution to be prepared from lime-sulphur concentrate of various densities. First determine the density of the lime sulphur to be used; find the corresponding density in the left hand column. The figure in the same horizontal line in the column headed by the dilution required will give the amount of water to be added to one part of the stock solution in order to give the required dilution.

*Density of Stock solution in 0° Baumé.	Dilutions Required, Based on a 33° Baumé Standard.							
	1-10.	1-15.	1-20.	1-30.	1-40.	1-80.	1-100.	1-120.
25°	7.6	11.4	15.2	22.7	30.3	60.6	75.8	90.9
26°	7.9	11.8	15.8	23.6	31.5	63.0	78.8	94.5
27°	8.2	12.3	16.4	24.5	32.7	65.5	81.8	98.2
28°	8.5	12.7	17.0	25.5	33.9	67.9	84.8	101.8
29°	8.8	13.2	17.6	26.4	35.2	70.3	87.9	105.5
30°	9.1	13.6	18.2	27.3	36.4	72.7	90.9	109.1
31°	9.4	14.1	18.8	28.2	37.6	75.2	93.9	112.7
32°	9.7	14.5	19.4	29.1	38.8	77.6	97.0	116.4
33°	10.0	15.0	20.0	30.0	40.0	80.0	100.0	120.0
34°	10.3	15.4	20.6	30.9	41.2	82.4	103.0	123.6
35°	10.6	15.9	21.2	31.8	42.4	84.8	106.1	127.3

* Diseases and pests of Queensland fruits and vegetables—Veitch and Simmonds.

Spraying and Dusting Apparatus.

The type of apparatus required for any particular area will depend partly on the nature of the crop, and partly on the area to be treated.

For small garden or nursery areas, hand dusters and sprayers are obtainable at low cost, while a range of machines up to large power plants, sufficient to do any class of work, are quoted by a number of manufacturers.

When spraying with poisons which are only held in suspension in the fluid, such as Arsenate of Lead and Paris Green, an agitator is required to keep the mixture in constant movement and maintain an even strength of spray.

Advice on these matters will be freely given to any one desiring information; when inquiry is by letter, the fullest information should be given on the nature of the crop to be treated—low or high, and if the latter, the range of height—area, &c.

DISEASES OF PIGS.

By G. F. Gee, H.D.A.

Pigs kept under clean conditions, receiving a balanced ration, and provided with dry, draught-proof sleeping quarters, are susceptible to very few serious diseases.

Most diseases can be traced to bad housing, badly-drained land upon which they run, or a ration which is unbalanced, i.e., the per cent. of proteins to carbohydrates and fats, in the ration being fed, is either too high or too low.

Provided that all these factors are given proper attention and the strain of pigs kept are the right type, little difficulty will be experienced in bringing the pigs to maturity in the shortest possible time.

It must be remembered that when a young pig becomes affected with a disease of heavy infestation of parasites, its growth is seriously hampered, and it is rarely worth while attempting to rear it to maturity, as the time taken and the extra food consumed makes it uneconomical.

Following is a list of the more important diseases to be met with by the pig breeder.

Contagious Pneumonia.

This disease causes heavy losses among pig breeders, and once established in a piggery is highly infectious, and spreads rapidly from affected to healthy pigs.

It is caused by a bacillus. The organism responsible can remain alive for several months under favorable conditions, but is easily killed if due care is given to hygiene, and disinfectants used. Pigs of the weaner or store type are usually affected.

Symptoms of the disease are as follows:—

Pigs affected have a high temperature and have great thirst, with a tendency to lick up anything wet. They become sleepy and dazed, and lose all inclination to eat. The gait becomes unsteady, and often the hind legs wobble. The pigs seek quietness, rest, shade and water. A sticky discharge appears from the eyes, to which dust adheres, and the eyes may become glued together. The pigs become emaciated, the ribs and spine becoming prominent and the flanks tucked up.

Diarrhoea and constipation usually alternate, the foeces are discoloured, sometimes contain blood, are putrid and usually adhere to the buttocks. Ulcers may appear in the mouth and a state of pneumonia is present. The animal has fits of dry coughing, and sits on its haunches breathing very rapidly and shallow. There is a heavy pumping movement of the body, which gives the popular name of "Pants" to the disease. Red spots may appear on the body, especially on the underline, ears, neck, breast, and on the abdomen, where it runs underneath the groin. These are more readily noticed on white pigs than on pigs of a darker colour.

Post-mortem inspection shows the lymph glands to be slightly darker than usual, and the lung has a marbled or mottled appearance.

Predisposing causes of the disease include exhaustion, cold or continued wet weather, unbalanced rations, contaminated water supply and general insanitation.

Prevention and suppression of the disease consists in taking the following precautions:—

Keep any new or visiting stock separate and under observation for at least four (4) weeks.
Isolate all sick pigs.
Disinfect all sties, houses, &c.
Undertake sanitary measures daily.

Swine Fever.

As far as is known, this disease is not present in the Territory, but when once introduced may rapidly wipe out large numbers of pigs in a very short time.

It is an extremely contagious, virus disease (i.e., caused by an ultra microscopic organism) favoured by insanitary conditions and improper feeding. It usually affects suckers or stores up to three (3) months of age, but rarely affects older pigs. Death may take place in as short a time as two to three hours.

The temperature rises rapidly, and may go as high as 106°-107°. The pulse and heart rate become very quickened, while the respirations are quick, increased and shallow. The pig may also exhibit a short, dry cough, and be greatly affected by prostration, often bleeding from the nose, due to excessive coughing. Red spots similar to those caused by contagious pneumonia may also appear. These are due to the action of the virus organism on the nervous system.

The pigs become constipated or otherwise, have a tendency toward tympany (bloating). Death usually then follows.

Method of infection may be either by ingestion or respiration, but more usually by ingestion.

A common cause is the feeding of uncooked meat from a diseased animal to healthy animals. The period of incubation may range from one to three weeks from time of ingestion till the first symptoms are noticed.

The disease may be spread by—

(1) Contact with affected pigs or material.
(2) Sound pigs occupying sties previously occupied by affected pigs.
(3) Introduction of boars and sows for breeding purposes.
(4) Germs carried from one piggery to another by attendants, &c.
(5) Birds (crows, &c.) and flies may carry the germs from an affected piggery.
(6) Stock may carry the germs on their feet.
(7) Prevalence of rats.
(8) Contact with any discharge from an infected pig.

Post-mortem lesions show very little, although blood spots may be noticed in the musculature and kidneys, while the lymph glands are usually darker than usual.

There is no effective remedial measure, and prevention by proper attention to hygiene and suitable rations is the only thing.

Inoculation may be practised, but an inoculated pig, due to the method of inoculation, becomes a carrier, so that all pigs in a district must be inoculated. In addition, up to three (3) per cent. may be lost.

Tuberculosis.

This may be regarded as a serious disease of pigs in the Territory, and many have been seen suffering from it, some badly affected.

The disease is caused by pigs ingesting material from an infected source, as milk or meat. It may also be caused by inhalation, but ingestion is the more common method of infection.

The most common glands affected are those of the head and throat, the glands of the digestive tract are next affected, followed by those of the lungs, while the spleen may often be affected. Occasionally, the bones and even the udder and mammary glands become infected. The pigs become unthrifty, or there may be no outward signs of the disease. If infection is suspected, the pigs should be tested by tuberculin, using the Opthalani test, which gives indication of the presence of the disease.

Post-mortem examination shows the lymph glands to be enlarged, and containing a grey, gritty pus. It is very easy to determine the presence of tuberculosis on post-mortem inspection; therefore, all pigs killed for human consumption should be examined for presence of the disease.

The glands inspected are the submaxillary and the precrural lymph glands. The submaxillary are found one on the point of each jaw, and are cut on to from inside the carcass. The precrural are situated one in each groin, and if these are found to be affected the whole carcass should be condemned. If only the submaxillary are affected, then the head should be condemned.

The main source of infection of tuberculosis to the pig is cattle. Where possible, pigs should not be allowed to run in the same paddocks as cattle, and all milk, fed to pigs, should be sterilized before feeding.

All slaughterhouse and household refuse should be well boiled before being given to pigs.

Poultry may also transmit tuberculosis to pigs, and for this reason the two should not be run on the same ground. Tuberculosis in fowls is most easily recognized by enlargement and sponginess of the bones.

All houses and feeding places should be regularly disinfected to prevent the possibility of spread of the disease. There is no known remedy for tuberculosis; prevention is the aim.

All pig flesh should be well cooked before being consumed, as the organism is destroyed by prolonged high temperatures. It is considered that much of the tuberculosis in the Territory is caused by the consumption of undercooked pig flesh which appears to be the usual method in most parts.

Anthrax.

This disease in pigs is caused by the same organism that causes anthrax in other animals, but it affects pigs differently, except that death usually takes place very rapidly.

The pig has a fever of up to 106° F., there is a swelling in the throat due to the bacilli being located in the lymph glands there, and the face swells up and the eyes appear to sink.

Pressure from this swelling causes short, difficult, rapid breathing, and owing to the distress, the animal gets diarrhoea and finally chokes.

Post-mortem inspection shows little, except swollen lymph glands.

The carcass of a beast which has died from anthrax should never be opened up, but should be burned on the spot without being moved. An alternative is to bury the carcass at least 6 feet deep, as earthworms can convey the spores to the surface if not buried deeply enough. Spores can exist from fifteen to twenty years under favorable conditions.

Suppurative Otitis.

This disease is most common in young pigs, and is marked by the peculiar carriage of the head and unsteadiness of gait, the part affected being the ear.

The ear is divided into the outer, middle and inner ear. The outer ear collects the sound waves and transmits them to the drum. The middle ear is on the other side of the drum, and it exaggerates the sound waves, which are then passed to the inner ear. This is connected with the brain.

A tube, known as the Eushachian tube, connects the middle ear to the nose, and this serves to maintain equal pressure on both sides of the drum. Mucous and other discharges from the ear also pass down the tube to the nose.

When suppurative otitis occurs, an abscessed condition is set up in the middle ear, while the outer ear is not affected. This interferes with equilibrium and sense of direction by breaking down the maintenance of equal pressure. Being situated in the middle ear it is practically impossible to treat it.

The head is rotated to one side, and is often twisted. In bad cases the drum may burst, and there is a pussy discharge from the ear. There may be often a discharge from the nose which is a form of nasal catarrh.

There is a possibility of the disease being contagious, although this has never been proved, but it is advisable to isolate any affected pigs.

Pigs in any condition may be affected by the disease, and when affected the hair may lose its lustre, and the skin may become scurfy; but this is not always the case.

The only treatment to be adopted is to syringe out the external ear with a weak solution of hydrogen peroxide.

Heat Apoplexy.

This condition is more likely to affect fat pigs, and only occurs in hot, sultry weather, and in pigs subject to the direct rays of the sun.

The condition consists of convulsions in the pig due to pressure within the brain. The blood vessels become dilated, but still intact, so that recovery is rapid, or the blood vessels may become ruptured, which brings about death.

Prevention, as far as possible, by good management, feeding and hygiene, should be aimed at. The action of the bowels should be kept under observation, and purgatives administered when necessary. Glaubers salts (3–4 tablespoons per 100 lb. live weight) should be given, olive or linseed oil (4–8 oz.), or castor oil (2–4 oz.) are all satisfactory.

Where possible, if symptoms are shown, hose the pig down or throw buckets of water over him, being careful to wet the head first and then the rest of the body.

Abortion.

This condition in sows may be either sporadic or contagious, due to a bacillus. The bacillus, however, has not yet been proved to be identical with that causing contagious abortion in cattle.

Predisposing causes of sporadic abortion include—

Insufficient exercise, which causes overfatness and a toxaemia which causes abortion.

Incorrect feeding of pigs; a necessary portion of the ration is missing.

Feeding indigestible foods, or pigs becoming constipated.

Feeding too much fat to pigs, especially household scraps not cooked.

Driving pregnant sows hard, or long journeys, rough handling, or crowding together in sleeping quarters.

Debilitating diseases, as pneumonia or swine fever.

Once a sow has commenced to abort (i.e., swelling of the vulva or dropping in the hams) it is practically impossible to prevent it. A quarter (¼) to one (1) teaspoon of laudanum per 100 lb. live weight may help in some cases. If the sow is constipated give her a drench of 3-4 tablespoons of Glauber salts in water per 100 lb. live weight.

Preventive treatment lies in correct management, and feeding, quietness for pregnant stock, segregation of stock into sties, and the maintenance of clean, hygienic surroundings.

Catarrh.

This disease is also known as "snuffles". It is an inflammatory condition of the mucous membrane of the respiratory parts of the head—the nasal cavity, frontal sinus, &c.—causing an increased supply of lymph, which blocks up the apertures and causes snuffles.

The pigs are affected by a short dry cough due to the distress and the inflammation of the larynx and pharynx, which causes laryngitis and pharyngitis. The condition extends down the trachea and turns to bronchitis, which causes the cough to become quicker and more rapid. If the lung substance becomes affected the condition gives rise to pneumonia.

The disease is caused by wet, exposed, unhygienic conditions, especially draughts and cold winds, or chills due to incorrect flooring. There is always a tendency towards catarrh in continued wet weather.

All affected pigs should be isolated and the food should be correctly balanced, nutritious and not constipative.

If the pig becomes constipated, dose with olive or linseed oil (4–8 oz.) or castor oil (2–4 oz.).

Chlorate of potash at the rate of half (½) teaspoon in water for 100 lb. live weight, may also be given in the drinking water.

Scours in Young Pigs.

This condition is usually due to the sow's milk, the fault being either in feeding or the management, or even a diseased condition of the sow.

If the latter is the case it is necessary to take the young suckers away from their dam.

Too much fat in a young pig's ration will also cause scouring, as will unhygienic conditions, which rapidly bring on diarrhoea.

In treatment, the first essential is to remove the cause, and to pay particular attention to management and feeding.

Prepared chalk and powdered charcoal mixed in equal quantities, and given at the rate of one (1) drachm in the feed will relieve the condition.

Very good results have been obtained by diminishing the amount of feed given to the sow and cutting out all greenstuff from the ration, it being replaced by a little whole dry maize. With this treatment suckers have been cured of this condition in two to three days.

Gastritis.

This is an inflammatory condition of the stomach due to the ingestion of fibrous foods, sand or poisonous substances as brine, arsenic or phosphorus.

The pig shows signs of great uneasiness and loss of appetite. It attempts to vomit, and stands with its back arched, tail drooped and ears back. A fever is present, and there is evidence of great thirst. After two or three days the pig either becomes constipated or has diarrhoea; or if the condition persists, the two alternate.

Treatment lies in good nursing and tempting the pig with easily digested swill. Add half an ounce (½ oz.) epsom salts or half an ounce (½ oz.) hyposulphite of soda, daily to the drinking water, which will keep the temperature down. In addition, give castor oil, one ounce (1 oz.) per 100 lb. live-weight, in milk, three (3) times daily, till the bowels function normally.

If the pig has diarrhoea, give one (1) drachm chlorodyne and 15–20 grains baking soda in milk, several times daily till the condition ceases.

Soapy water enemas will also help.

If the gastritis is due to brine poisoning, in addition to other symptoms, the pig usually froths at the mouth, races round bumping himself, and may even go into convulsions.

In this case an emetic is necessary, so give 15 grains zinc sulphate in water. Follow this with olive or linseed oil, 4–5 oz. per 100 lb. live weight. Add one (1) drachm laudanum and chloradyne to the oil and repeat this sedative four or five times daily, in milk.

If the gastritis is due to phosphorus, on no account give oil, but give either one (1) drachm turpentine or half (½) drachm of copper sulphate, in a flour gruel.

Mammitis.

This is a germ infection of the udder and is brought on by contact with dirty floors and pens, or cold damp quarters. It may also be caused by overfeeding a sow of high milk production.

The udder becomes swollen, inflamed and tender. In advanced cases it becomes hard, swollen and lumpy or lobulated, and even containing pus.

The condition can be prevented by avoiding the cause—strict hygiene in the pens and careful attention to the sow's rations.

If from over milk-production, reduce her feed and give an increased amount of salt in the ration, which will have the effect of drying her off.

Relief may also be given by massaging the udder with an embrocation made up of—Camphor, 1 part; soft soap, 1½ parts; turpentine, 13 parts; boiled water, 4½ parts.

The soap is dissolved in the water, and the camphor in the turpentine, the two solutions mixed and well shaken.

Sow Eating Young.

This condition can usually be traced to improper feeding, the ration usually being deficient in protein, so that the sow is meat hungry.

It is marked by an extremely feverish state and abnormal appetite after farrowing; the sow may even become ferocious toward her attendants.

To overcome the possibility of a sow eating her young after farrowing, it is essential to balance her ration properly during pregnancy, seeing that she receives sufficient protein, by feeding meat meal if necessary, to make up for the extra drain on her system.

With a sow inclined to eat her young, it may be wise to remove the pigs from her immediately after farrowing, for a few days, except at suckling time, when she is carefully watched.

If the abnormality becomes habitual, it is wise to dispose of the sow.

MIXING PIG FOOD.

When pig food has to be mixed by hand, whether wet or dry, much labour can be saved and better results obtained by mixing in the right way. The water or swill that is used in slop-feeding must always be put first into the receptacle, be it bucket or tub, and the meal measured into it in such quantity that when all is mixed together a creamy consistency is obtained. A flat paddle is the best tool for mixing, and it should be kept quite clean. When more than one dry ingredient is used it is better to add each one separately to the slop and to stir it in well before putting in the next.

Unless each kind of food is well mixed in, the ration will not be balanced and some pigs may get too much of one ingredient and not enough of another. Particular care should be taken with highly concentrated stuff like fishmeal, which is used in a small quantity, and must therefore be very thoroughly incorporated. This can best be accomplished by putting it in first, adding the next smallest quantity of ingredient next, and keeping the largest to the last.

In mixing dry food it is better to reverse this process, the ingredient which forms the greater bulk of the mixture being first spread out thinly on an even floor. A thorough turning of the pile should be given as each ingredient is added, taking care that the shovel goes beyond the centre of the heap each time. Dry food cannot be turned too often, and one should not be satisfied until on picking up a handful one finds that it is impossible to do so without getting a proportion of each substance used without an excess of any. A flat-tined fork is a useful implement for mixing dry food, turning the heap first with this and then finishing off with the shovel.

INVESTIGATIONS ON SOME NATURAL FOREST PRODUCTS IN NEW GUINEA.

By R. E. P. Dwyer, B.Sc.Agr.

This article is concerned with a valuable phase of the activities of the Department of Agriculture, which is not generally realized in this Territory. In this connexion some recent findings concerning a few selected examples of native products are considered worthy of publication. It is conceded, however, that some of the information obtained was not encouraging from the commercial aspect.

No. 1.—*Parinari laurina* (= Kusta Nut in New Guinea and Makita in Fiji).—Sir Arthur Hill, Director of Kew, has pointed out[8] that the above name is now employed in place of *Parinarium laurinum* which was used as the botanical name of this species until quite recently. He has also supplied some valuable information concerning the economic possibilities of utilizing the fruits of this species.

Parinari (*Parinarium*) is a genus of trees belonging to the family *Rosaceae* and found in the tropics generally. There are several species of this genus in the Malay Peninsula, Netherlands Indies, South Sea Islands (including New Guinea, Papua and the British Solomons) Philippines, Fiji and North Australia. According to Burkill,[2] oil from the seeds of several African and Brazilian species is expressed.

P. glaberrimum, Hassk, found in Malaya, has an oily seed. This is also found in New Guinea according to Schumann and Lauterbach[14] also *P. arramense* has an oily seed and probably other species have too.

A species *Parinari Hahlii,* Warb, from Ponape, Caroline Islands, was examined by Professor Mannich[11] in 1902, and it was stated that "Fett ist in den nüssen nicht enhalten," i.e., "There is no fat contained in the nuts." Tannins were found to be present in the fruit.

Parinarium cormybosum Miq. (*P. Griffithianum*), Benth in Hook, is recorded by Schumann in the Flora of Kaiser Wilhelms-land,[15] as being found in Augusta Station and Lagerburg on the mainland of this Territory. He mentions its distribution in the South Seas and New Guinea and Papua, and also refers to its existence in North Australia. It is also found in Java, Borneo and the Philippine Islands. According to Whitford[18] this is one of the best timber trees of this genus. *P. Griffithianum* is present in New Ireland according to Father Peekel, but is not so common as *P. laurina.*

The *Parinarium glaberrimum* was collected from the mainland and also one of the outlying islands. There is the possibility that *Parinarium myrsinoides* described by Schlecter from New Caledonia and that *Parinarium insularum* may be found here, though they are, as far as known, not recorded.

In a recent work Hill[7] has shown "that with two exceptions in all other species of the genus, a close-fitting stopper or cork seals the orifice of the seed cavity. On germination the plugs or stoppers are forced out and ejected like corks from a bottle. Two species of *Parinari* have been noticed which do not show this stopper mechanism. *P. glaberrima Hassk.* (*P. laurina* A. Gray) from the Malayan region is one of these, it has much larger fruits than is usual in

the genus; they contain, however, only a single seed, which consists chiefly of the much convoluted, pink, fleshy cotyledons; the radicle splits the fruit open through the scar of the pedicel, but there is no pore or stopper."

It also would appear from this note that *P. glaberrima* is the new name for *P. glaberrimum* which is now regarded as a synonym of *P. laurina*.

Burkill's notes on *P. glaberrimum* are quoted (probably synonymous with *P. laurina*) almost verbatim.[2] He states that "this is a tall tree which occurs in Java, Borneo and eastwards in the Pacific, while once it has been obtained from the Malay peninsula in Perak. The timber is hard, very heavy, but not durable in contact with the ground (according to Schneider Bur. For. Philippines). Rumpf gives several uses for the kernel in Amboina. He says *inter alia* that it arrests diarrhoea; and that a paste of it is used for coating the wood of boats that have been attacked by Teredo or ship-worm."

According to Heyne,[6] Greshoff found 31 per cent. of oil in the seeds. This observation is most interesting as it means that fruits of this species would be worthy of further investigation. Attempts are necessary to get a true botanical identification of the species present in this Territory, and also to collect fruits of the species mentioned here.

On the understanding that the fruits of *Parinari laurina* contained a valuable drying oil the Director of the Imperial Institute, London, very kindly submitted specimens of fruit from New Guinea to a detailed chemical examination. The findings are given verbatim under a separate heading as supplied in a report to this Department.

The following remarks on the Kusta Nut as supplied by Sir Arthur Hill,[8] in answer to an inquiry from here indicated that the local product was at least worthy of the chemical investigation which he suggested:—

"*Parinari laurina*.—The kernels of this species have recently attracted a certain amount of attention on account of the drying oil they contain, reputed to be not unlike tung oil, and the oil has been the subject of chemical investigation in more than one quarter. It is no doubt the drying properties of the oil which render the masked kernels suitable for stopping holes in canoes and fixing spear-heads by the natives of New Guinea, as stated.

Little appears to be known regarding the potential commercial value of the seeds. In this connexion the following remarks from the Director of the Paint and Varnish Research Station at Teddington, near London, where a small sample of seeds from Fiji was recently examined, may be of interest:—

> 'With regard to the possibility of using this material within the industry, the question is probably largely one of economics. The amount available was too small to carry out any useful experiments of a practical nature on its application, but the oil was found to body up very easily, and to form a solid gel, like tung oil, but with far greater rapidity. It dried up to a hard film. If such oil were manipulated alone, it might present difficulties, which could, however, be overcome.
>
> Probably if the oil could be produced cheaply, it could be absorbed within the industry, but there is no great chance of a ready-made demand.'

In the Kew Museum collections there are seeds of this species from Fiji, where they are said to be used for scenting coco-nut oil. We are not aware that the qualities of this seed have been investigated from the perfumery standpoint."

W. D. Francis, Botanist at the Botanic Museum and Herbarium, Brisbane, identified specimens of fruits sent to him from this office, in 1935, and originally collected from New Hanover by Mossman, Inspector and Instructor at Kavieng, as *Parinarium laurinum*. Francis stated in his reply that "the natives of Fiji

obtain from the seeds, called 'Buri Nut' or 'Makita' a much esteemed perfume; they also heat the kernels up into a kind of putty which is used for stopping holes in canoes and for fixing spear heads." The kernel is used as a putty by natives in this Territory for similar purposes, but it is not, as far as known, used for preparing a perfume. In Fiji it is said that the perfume is used for scenting coco-nut oil which is used for anointing purposes. It seems that no commercial uses for this perfume are so far known.

Father Peekel, of the Catholic Mission, Ugana, New Ireland, who is also a well-known botanist, kindly supplied the following note:—

"Regarding the genus *Parinarium* I know of only two species here. The common *Parinarium* is *P. laurinum* A. Gr.; the fruit is ovoid, and one celled. The seeds are used, everywhere by the natives, to fill up the fissures of their canoes. The native names are as follows:—Katita, katite, tite, or of similar form. The second species is *P. Griffithianum Benth.* The fruit is oblong and two celled. I have a specimen of this in my herbarium, but the tree is not so common as *P. laurinum.*"

It is of interest to note that in Fiji some local varieties of Makita (*Parinari laurina*) are existent. Parham[1] records that the following types were collected in 1934, viz., "*Makita damu*", "*Makita leka*", "*makita dina*" and "*makita salusalu*". It was not stated whether these are varieties or sub-species. This varietal variation would suggest that there would be considerable variation in the production of fruits and contained oils. Such variation, combined with the greater amount of acid decomposition which occurred on the long voyage to England from New Guinea, might quite well account for the differences in oil content recorded between this and fruits from other sources. A search for varieties or sub-species of the kusta nut has not yet been made by this department in New Guinea. If at any time it is considered that the product is worth further investigation this would provide a promising line to pursue.

The kusta nut has been the subject of some inquiry from New Guinea residents. Mr. E. R. Miller, owner of Tsalui Plantation, Lavongai (New Hanover), stated that the trees grow prolifically in the vicinity. It was queried whether the nuts contained any substance of commercial value. The information was also given that Mr. Draper, of Nanianne Plantation, on one occasion forwarded some of these nuts to Brisbane, where the pulp was analysed and was reputed to contain an excellent lacquer.

Mr. J. H. L. Waterhouse kindly collected a sample of kusta nuts, for despatch to England, from a situation close to the native school at Nodup, Rabaul, and also supplied the following notes:—

"It was hoped to secure about a hundredweight of the nuts, but the commodity is much harder to procure than previously imagined. The quantity forwarded should prove enough for small experiments.

The kernel only is used—grated and applied raw to leaks or crevices in canoes after which wood ash is applied. The natives state that without the addition of the ashes the putty is not strong or effective ("ogor") which fact may be helpful in determining its uses."

It was suggested that the outer covering be investigated.

The tree is believed to be a rather shy bearer, but is fairly widely distributed in this Territory. W. A. Mossman, Departmental Inspector, found it difficult to collect fresh nuts, as they germinate quickly in the undergrowth, while the kernel is inclined to disintegrate quickly under rain forest conditions.

The Director of the Imperial Institute,[7] referring to the notes supplied by Mr. Waterhouse, stated—

"We have not investigated the possibility of using the grated kernels, as this would not be a practical issue in the United Kingdom. It is, moreover, not feasible to suggest any commercial use to which the husks of the fruits could be applied, except the possibility that they might be of use in the manufacture of industrial charcoal. This point, however, would not be worth investigation unless large quantities of fruits were available and the kernels themselves were disposed of as oilseeds."

Conclusions.

Among the factors which would militate against the commercial exploitation of the fruits are—

(*a*) the apparently very limited supplies;
(*b*) the statement that the kernels keep badly.

Parinari Laurina Fruits from New Guinea.

Results of Chemical Investigation by The Imperial Institute (31*st August*, 1936).

The sample, which is the subject of this report,[8] was forwarded to the Imperial Institute by the Assistant Director, Royal Botanic Gardens, Kew, in July, 1936, being originally received from the Department of Agriculture, Territory of New Guinea.

Description.

The sample, which weighed 3½ lb., consisted of reddish-brown, roughly oval fruits, varying in size from 2½ inches long by 1¾ inches in diameter to 3½ inches long by 2¾ inches in diameter. The fruits, as received, were composed of fibrous husk from ¼ to ½ inch thick, enclosing a kernel varying in colour from pale purple to chocolate and in consistency from fairly hard to hard. In the case of some kernels, part of the outer surface was covered with a light brown skin.

Results of Examination.

The fruits were submitted to examination with the following results:—

Table.

Fruits—	
Average weight of a fruit	76.2 grams.
Husk	52.2 per cent.
Kernel	47.8 „ „
Oil, expressed on entire fruits	5.7 „ „
Kernels—	
Average weight	36.4 grams.
Moisture	11.4 per cent.
Oil, in kernels as received	12.0 „ „
Oil, expressed on moisture-free kernels	13.6 „ „

The oil extracted from the kernels with light petroleum was a pale buff fat of soft consistency. It oxidizes very readily in the air at ordinary temperatures forming a substance which is gelatinous at 100 degrees C., and is not soluble in the unchanged oil. The oil was examined with the following results, which are shown

in comparison with those obtained by Tsujimoto and Koyanagi[17] for the fat of *Parinarium laurinum* (*Jour. Soc. Chem. Ind., Japan*, 1933, *Vol.* 36, *suppl. binding p.* 110):—

	Present Sample.	Fat of *Parinarium laurinum*.
Specific Gravity at 100° C./15.5° C.	0.9025	0.9379 (*a*)
Refractive Index at 40° C.	1.5429	1.5610 (*b*)
Melting point	37.1° C. (*c*)	49–50° C.
Acid value	33.8	1.31
Saponification value	193.7	186.8
Iodine value (Wijs, 1 hr.), per cent.	202.8	214.1
Unsaponifiable Matter, per cent.	1.2	1.15

(*a*) Density at 50° C/1° C. (*b*) At 50° C. (*c*) Open tube method.

The foregoing results show that the kernels of these *Parinari laurina* fruits contained only a very low percentage of oil. The oil belongs to the "drying" class of fatty oils. It has been shown by Tsujimoto and Koyanagi, *loc. cit.*, and Farmer and Sutherland,[3] *Journ. Chem. Soc., June*, 1935, p. 759, to contain as one of its components a highly unsaturated fatty acid, the presence of which would account for the high iodine value and high refractive index.

Remarks.

It is unlikely that it would be remunerative to offer kernels of the quality of those in this sample of fruits as a commercial oil-seed, owing to the low yield of oil which they furnished. A much higher yield of oil, viz., 44 per cent., has been recorded by Farmer and Sutherland (*loc. cit.*) for the kernels of this species (country of origin not stated). It is also improbable that the oil could be profitably produced in the Territory for shipment to the United Kingdom especially as it possesses the disadvantage of oxidizing very readily in the air at ordinary temperatures; the expression of the oil from the kernels would therefore have to be carried out under special conditions.

In addition to the low oil content of the kernels, the fact that supplies of the fruits are very limited, and that the kernels are stated not to keep well, render the prospects of commercial utilization unpromising. It is possible that the low yield of oil in the kernels examined may be due in part to deterioration if this sample has aged, and that fresh kernels might contain a higher percentage.

This species and other closely related species, some of which are found in New Guinea, have been the subject of investigations by forestry officers in other countries as a timber product. Burkill (*loc. cit.*) and Ridley[12] in Malaya and Whitford[18] in the Philippines are amongst the authors who have discussed the timber possibilities of this group.

Ridley describes *Parinarium griffithianum*, Benth, as a large tree 70 to 80 feet tall with deep green leaves and white flowers, but not very abundant in Malaya. Wood, red with light markings, grain medium, fairly hard, splits very slightly

in drying, durable, weight 49 lb. 8 oz. per cubic foot. He says that according to Van Eden, this is a good timber giving beams 5 inches to 6 inches square. Habitat usually near the sea.

Whitford (*loc. cit.*) says that this is the only tree of the *Rosaceae* of commercial importance in the Philippines, where it is known as Liusin. His comments regarding the wood are that "the sapwood is creamy white in colour; the heart-wood is light reddish brown, very hard, extremely difficult to saw, fine and usually straight grained. It is very durable in contact with salt water. Liusin is especially valuable for piling and is also used for ship-building and house-posts. Other species of the genus *Parinarium* produce wood indistinguishable from Liusin.

Burkill[2] quoted Foxworthy[4] as stating that all the Malayan species of *Parinarium* (including *P. griffithianum*), seem to furnish wood of similar quality. It is pink or reddish in colour, very hard; heavy, fairly durable, but very little used. The wood is sufficiently good to be suitable for posts especially in salt water, but it is subject to dry rot. It is not ordinarily found in large sizes. In some places the wood of various species is not used, or used only for charcoal, on account of its extreme hardness. It seems that these remarks largely apply to New Guinea forests as in most parts the distribution of trees is scattered.

Parinarium laurinum=*Parinari laurina* from the forestry point of view, was described by Lane Poole[10]. A specimen from his collection No. 810 is in the department's herbarium as collected from the Mavelo River, Papua.

A small to medium tree 3 feet in girth and 30 feet high. (One authority states that this tree may grow 30 metres high.)

Leaves.—Simple, alternate, on swollen, brown, tomentose petiole (hairy leaf stalk), ¾ inch long; blade 5 inches to 10 inches by 1½ inches to 2 inches; lanceolate somewhat oblique, acuminate, Venation prominent, stiff, glabrous and thin.

Fruit.—A very hard, rough, woody fruit, ovoid in shape when ripe 3 inches by 2 inches. When green a flattened ovoid shape. Woody shell 5-16 inch thick; inside a convoluted kernel 2 inches by 1½ inches.

Bark.—One-eighth of an inch thick, brown finely lined, inner bark reddish.

Wood.—Sap white 1 inch, heart light brown. Axes firmly.

Rays.—Very indistinct, 390-400, sinuous around if not broken by pores which cover a width of up to five rays. Indistinct on longitudinal sections. Pores—900 to 2,000 in irregularly scattered clumps; single. Soft tissue. Very fine lines link up the rays; 250 to the inch.

General.—A reddish brown wood with a dense grain. Cuts hard, weight 52 lb. per cubic foot.

Remarks.—The shell of the fruit is grated upon a stem of pandanus and the gratings are used to make caulking for canoes.

According to Schumann and Lauterbach[14] this species was first described by A. Gray[6] (in Unit. Stat. Explor. Expedit. of Bot. Wilk. Exp. Vol. 1, page 490) and it has the following distribution:—Fiji Islands, Solomon Islands, Island of Bougainville, Admiralty Islands (Manus).

The author comments that it is also moderately plentiful on the whole of the Bismarck Archipelago, and is stated to be particularly abundant on Lavongai (New Hanover) Island.

It would appear that it would not be worth while to continue these investigations until some more definite market is available for oils derived from *Parinari*. It is regrettable that there are features other than the actual oil content of the fruits, which mitigate against the use of the product for commercial purposes.

One potential use, however, is the utilization of oil-bearing species of *Parinari* for schemes of re-afforestation in the tropics, where this becomes necessary. In that case it would be necessary for a local chemist to examine each individual variety and species, until those with the highest yield, oil content and best timber possibilities are isolated.

It is intended to discuss the possibilities of exploiting some other natural forest products in future publications of the *Agricultural Gazette*.

ACKNOWLEDGMENT.

The department is greatly indebted to Sir Arthur Hill, Director, Royal Botanic Gardens, Kew, and to Sir Harry Lindsay, Director of the Imperial Institute, South Kensington, London, for their courtesy and help in carrying out these investigations on the fruits of *Parinari laurina*. The collaboration of Father G. Peekel, of Ugana, New Ireland; Mr. J. H. L. Waterhouse, of Nodup, New Britain; and of Mr. W. A. Mossman, Inspector and Instructor, stationed in New Ireland, both in collecting specimens and providing comments is gratefully acknowledged.

LITERATURE CITED.

1. Annual Bulletin of Divisional Reports, Department of Agric., Fiji, p. 56, 1934.—(Refers to collection of varieties by Parham, B.E.V.)
2. Burkill, I. H.—A Dictionary of the Economic Products of the Malay Peninsula, vol. II. (I-Z) pp. 1165-1168. Pub. Crown Agents for Colonies, London, 1935.
3. Farmer and Sutherland (quoted 8).—Journ. Chem. Society, June, 1935, p. 759.
4. Foxworth.—Philippine Jour. Sci. C.2, 1907, p. 386.
5. Gray, A.—Unit. Stat. Explor. Expedit. of Botany. Wilk. Exp., Vol. 1, p. 490.
6 Heyne, K—Nutt, Plant. Ned. Ind. ed. of 1927, pp. 696-8.
7. Hill, A. W.—Reprint Annals of Botany—New Series—Vol. No. 2, April, 1937, pp. 239-256.
8. Correspondence on *Parinari*.—From Director, Royal Bot. Gard., Kew, England.
9. Imperial Institute (Director Sir Harry Lindsay).—Results of chemical investigations, August, 1936, South Kensington, London.
10. Lane-Poole, C.E.—The Forest Resources of Papua and New Guinea, Rept. Govt. of Com. of Aust., 1925.
11. Mannich, T.—Results of Analyses of *Parinari Hahlii* for "Kolonial Wirtschaftliche Komitee". Tropenpflanzer, Jahrg VI., 1902, pp. 370-371.
12. Ridley, H. N.—Flora Malay Penins. (Polypetalae). Pub. L. Reeve and Co., Vol. I., pp 666-71, London, 1922
13. ——— Agric. Bull. Straits and F.M.S. 1, 1902, pp. 144-45.
14. Schumann, K., und Lauterbach, K—Die Flora Der Deutschen Schutzgebiete in Der Sud-see. Page 341, Leipzig, 1901.
15. Schumann, K., Hollrung, M.—Die Flora von Kais. Wilhelm Sel—Asher, Berlin, p. 93, 1889.
16. Schlecter, R.—Flora New Caledonia—Beitrage Zur Kenntnis der Flora von Neu-Kaledonien, p. 133, 1905.
17. Tsujimoto and Koyanagi (quoted 8).—Jour. Chem. Soc. Ind. Japan, 1933, Vol. 36, Supp. binding p. 110.
18. Whitford, H. N.—The Forests of the Philippines, Part 11, The Principal Forest Trees, Bull., No. 10, p. 34, 1911.

PROGRESS OF NATIVE AGRICULTURE IN THE MADANG DISTRICT.

By Colin C. Marr, Inspector and Instructor.

Introduction.

In his report,* Colonel Ainsworth pointed out the importance, in fact, the essential necessity, of the development of native agriculture as a means of raising the status of the native.

The terms of the Mandate, "to promote to the utmost the moral and material well-being of the natives", if they are to become more than a mere empty literal form, must be translated into action, and to this end the development of native agriculture as recommended by him is the first and most obvious step.

Colonel Ainsworth advocated a policy of agricultural development, under which the natives will gradually become producers, and so help to increase the exports of the country, and at the same time improve their own material well-being. (Para. 34.)

In para. 64, dealing with the Agricultural Department, he said: "I consider that the Department should be responsible for instruction and advice in connexion with the cultivation of food and other economic crops by the natives, and that such instruction form the main and, for a time, the only line of industrial education undertaken by the Administration".

In para. 181, he stated, "The Education Ordinance, *inter alia,* provides that the Administrator may establish education in agriculture, and I suggest that such education be started without delay".

Again, in para. 185, he comments: "The greatest educational force is, and will be, example and industry, and in the case of the New Guinea native that example and industry, for some years yet to come, must be tillage of the soil, which is the oldest form of industry known to man".

In view of the foregoing recommendations, the Administration, through the medium of the Department of Agriculture, has, during more recent years, re-adjusted its policy so that, at the time of writing, we find an instructional staff of officers composed almost entirely of graduates of an Australian university or agricultural college, patrolling the many districts in the Territory. Instruction is given in improved methods of agriculture, particularly with regard to rotation of crops and the necessity of cessation of such primitive methods as the disastrous "shifting agriculture", so commonly practised by all tribes throughout the Territory.

The mere introduction of new food crops for cultivation will not suffice, in the present conditions of the native population, to meet the requirements of the situation. The disinclination or apathy, too often present, must be dispelled, and under the best conditions, where the natives are eager to learn, they need instruction and tuition, and more than anything, practical demonstration.

This will in the end be overcome when cultivation is extended over wider areas and crops are grown in greater variety. At the same time the native population has to accustom itself to the new foodstuffs, to provide storage for the crops harvested, and generally to advance toward the betterment of an agricultural people.

* Report by Colonel John Ainsworth, C.M.G., C.B.E., D.S.O., on "Administrative Arrangements and Matters Affecting the Interests of Natives in the Territory of New Guinea, 1924."

At present native cultivation is practically confined to coco-nuts (*Cocos nucifera*), *taro* (*Colocasia esculentum*), yams and mammies (*Dioscorea spp.*), bananas and plantains (*Musa spp.*), sugar cane (*Saccharum officinarium* and *Saccharum robustum*); and to a lesser extent, varying with the locality, "aibika" (probably *Abelmoschus manihot*), "pit" (probably *Saccharum arundinaceum*) and papaia (*Carica papaya*). In the first instances cited the crops are all of long-term habits, that is, planting takes place one year and the crops come into bearing in the course of two, three, four or more years. The effect on village life is that one season's work in clearing and planting, with the stimulating and invigorating effect that all such industrious effort brings, is followed by several years of apathy during which little is done. To inculcate some real agricultural instinct in the native population, it is essential that they should be taught the cultivation of annual crops, where the seasonal operations of tilling the land, sowing the seed, and harvesting the crops occur regularly.

There are other crops in view for introduction and cultivation, in conjunction with accessory crops, which are necessary to counteract failure of any one crop in the schedule. Two crops are in view, namely, rice on the coastal areas, and soya-beans in the recently controlled higher-altitude hinterland.

The revenue of many countries in the world is dependent largely on the export of its native produce harvested. The corollary to a large export trade is a considerable revenue to Administration, whether derived from export tax, import duty, or head tax, and under the financial stringency existing in the Territory, this consideration is important both from the point of view of the original cost in introducing new crops, and its probable ultimate cost. The results of this policy should more than justify the original outlay.

Under the policy of native agricultural development, the natives are required to grow crops which, if the object of the policy is to be obtained, will result in the creation of a surplus of agricultural products for export.

This will apply generally throughout the Territory, but not in the Rabaul district, where the natives have, through the process of absorption, become industrialists, and are not beholden to agriculture for their livelihood to any great extent.

Crops Generally.

The shortage of grain crops—other than maize—and the native custom of subsisting almost entirely on root-crops, indicates that other cereals should be introduced into the native dietary for supplementary reasons.

Rice has been tried out in the Rabaul district with moderate success, but climatic and adverse soil conditions combined to produce rather disheartening results. Notwithstanding, however, one Paramount Luluai (or Head-man), has continued to plant annually sufficient rice to meet the needs of his family, who find no difficulty in hulling the grain with a hand pestle and mortar sufficient for their needs as required. The grain is not as full as that produced in other parts of the Territory, and it is confidently expected that further experimentation with this particular cereal will yield more encouraging results.

During Dr. Bryce's period as Director of Agriculture in this Territory, 6 tons of selected seed maize of the varieties of Hickory King and Red Hart Flint were imported from the Department of Agriculture in South Africa. The whole consignment was fumigated before despatch from South Africa, and it arrived in this

Territory in excellent condition. The seed was distributed amongst the natives through the District Office, to plantations through the Expropriation Board, and individually to missions, private planters, and natives, as requests were received. The Hickory King variety was confined to the Bismarck Archipelago, and the Red Hard Flint to the New Guinea mainland and the Solomon Islands. The results were not an unqualified success, the Red Hard Flint variety seemingly being the better of the two.

The introduction of seed into any new country with new conditions of soil and climate is always attended by some uncertainty. It can be easily followed, therefore, that the work of acclimatization and selection of suitable types assumes a position of some importance, and the necessity of continuous observation under the conditions afforded by an experimental station is demonstrated.

In view of the diversity of soils and of the variety of climate obtaining between the several districts of the Territory, it is evident that intensive experimentation is warranted in each district. To date only one experimental or demonstration plantation is in existence, and that is at Keravat, situated in the New Britain district, 30 odd miles from Rabaul; but the results obtained thereon cannot be logically assumed to be applicable elsewhere in the Territory.

The Madang district, particularly the hinterland embracing the Ramu, Wahgi and Purari valleys, which appear to hold great possibilities in both grazing and the cultivation of higher-altitude crops such as cinchona, tea, coffee, and soya-beans, is sorely in need of an experimental station close to the township of Madang and within the limits of travel to the average planter in the district.

Approximately two years ago, the Director of Agriculture recommended the establishment of a station in the Upper Ramu area for the purpose of experimentation with various tropical and sub-tropical crops. An officer of the Department of Agriculture was sent to this area, which at the time was situate in the Morobe district, and the results obtained appear to be most promising and warrantable of expansion. Since this station was established, this portion of the hinterland has been transferred to the Madang district. It is confidently expected that, with the addition of a station on the coastal area working in conjunction with the inland station, increased developmental work would result.

Rai Coast.

During the past two years the Administration, to consolidate Government influence, has posted an officer of the District Services at Saidor, on the Rai coast, south of Madang township, and about 60 miles by airline. This move was brought about in view of recent hostilities amongst inland tribes.

A suitable site was chosen as a base, centrally situated, and with good soil conditions. An airport has been constructed alongside the base, thus bringing Madang within 35 minutes by air.

Whilst on patrol in this area in the early part of this year, opportunity was taken of visiting several portions of the hinterland under the guidance of Mr. Patrol Officer Greathead, for the purpose of making a brief agricultural survey of the country.

Intense interest was shown by the natives in agricultural instruction, and the greatest co-operation afforded by the District Services representative, who expressed the keenest interest in all matters pertaining to agriculture.

All coco-nut groves, native-owned, in the district were found in a clean and orderly condition, and practically free of pests and diseases.

The common belief throughout the Territory that coco-nut palms on the Rai coast are stunted, and give a poor yield, is unfounded. Many areas of palms are as healthy as those elsewhere in the Territory, and were estimated to be yielding at the rate of 1 to 1½ tons per hectare per annum. Unfortunately, little forethought by natives has been exercised in the past in the selection of suitable sites for coco-nut areas, but it is probable that they were compelled to utilize whatever land was available close to each village site, owing to the hostile nature of their neighbours.

Generally speaking, it may be safely stated that, on the whole, the soil conditions on the Rai coast are not up to par with those of the rest of the Territory, excepting perhaps Gazelle Peninsula, the south coast of New Britain, and portions of the Wewak coast.

Whilst at Saidor Base, plans were drawn for laying out the station correctly with avenues, gardens and an orchard.

The following seed, which was sent out from the Botanical Gardens, Rabaul, and planted in bamboo pots under shade, will be transplanted out in the field when ready:—

Coffea robusta.

Cassia multijuga (avenue tree).

Thevetia neriifolia (Allamanda hedge).

Murraya exotica (hedge resembling privet).

In addition to the above, the following fruit trees were planted to establish an orchard in the district:—

Brazilian cherry.
Cherry guava.
Rambutan.
Avocada pear.
Soursop.
Mandarin.
Mango.
Root cuttings of seedless breadfruit.

The soil conditions at Saidor Base, being of a deep, well-drained alluvium, are excellent. Amongst a quantity of vegetables recently received from this station was a pumpkin weighing 56 lb., whilst a bag of maize resembling Manning Silvermine (cross between Iowa Silvermine and Manning or Macleay White) equalled any seen in Australia.

A quantity of vegetable seeds obtained from a well-known Australian nurseryman was decently distributed in the district, particularly amongst the hill tribes of the Rai coast and hinterland.

The seeds introduced include—

Lettuce (Mignonette).
Cabbage (Enkhuizen Glory; Succession; Earliball).
Kohl Rabi (Early Purple).
Tomato (Burwood Prize; Bonny Best).

Potatoes, eschallots and carrots, previously introduced to the higher levels on the Rai coast, have shown remarkable adaptability, and will eventually merge into the native dietary system.

Agriculture—General.

The following is a report on the agricultural activities in the Madang district for the period 1st July, 1936, to 30th June, 1937.

Rainfall.—The average rainfall over 20 years is 136.26 inches. During the period, the total rainfall registered at the Meteorological Station, Madang, was 154.02 inches, the heaviest falls being recorded in February, November. and December.

Plantations.—Copra is the basic primary product of the Madang district, although extensive additions to existing cocoa areas have taken place over the last twelve months.

The total area under cultivation in the district is 12,608 hectares, but several applications for land have been received in respect of the Rai coast sub-district, and it is expected that, during the ensuing year, extensive developmental work will result.

The planting of coco-nuts and cacao by one planter on Kar-kar Island was carried out on a fairly large scale, whilst another plantation was commenced on Baga-bag Island.

The Agricultural Inspector and Instructor was able to visit most plantations, and it is expected that more frequent visits will be paid in the near future.

Stock.—No serious diseases were reported, and apart from a minimum of tick on cattle, and swamp-cancers on horses, general good health throughout the district is noted.

Rattan Cane.—Samples of rattan-cane from the mainland and Kar-kar and adjacent islands were despatched to the Director of Agriculture for tests of resiliency and comparison with rattans from other countries, with a view to the future marketing of this commodity.

Derris Root.—Several bales of this medicinal insectifuge in raw root stage of various lengths were forwarded to the Director of Agriculture, for rotenone content comparison with similar root of other countries, with a view to the possible marketing of this product.

Coco-nut Groves.—Extensions to grove areas on the Rai coast have been reported by the field staff. This revival of interest in an industry of primary importance to the Territory as a whole is pleasing, and can be attributed to—

(1) the recent improved prices in copra; and
(2) the sudden activity in the Rabaul district during the past twelve months, whereby natives have been encouraged by the Administration to prepare and market their own copra.

Natives who have completed their contracts of service with employers in Rabaul, on returning to their villages on the Rai coast, are now settling down, and with the above in view are preparing large areas of land preparatory to planting up coco-nuts. Where medium-sized groves already exist, driers are being erected, and copra will be produced in the near future.

Every assistance and encouragement is being given by the Administration, and arrangements will be made for the marketing of this produce on their behalf, as the Rai coast is rather isolated with no trading facilities available.

Unusual interest and activity has been shown by the Paramount Luluai of Kar-kar Island in extending the grove area of his village from 20 hectares to approximately 90 hectares, within the last twelve months. Every assistance has been accorded by the manager of the adjoining Kululi Plantation, and in addition to coco-nuts, a small area of cacao has been established under his guidance and supervision. Other than this area no further plantings are recorded on the island.

The Agricultural Officer of the district completed a patrol of the Rai coast area, extending some 60 miles over the Madang-Morobe border, and in addition to the inspection of plantations, advice was accorded natives regarding the control of pests and diseases affecting their coco-nut groves and native foods.

Manam Island.—Owing to the severe nature of the eruption occurring on this island in October and November, 1936, the annual tobacco crop—on which the inhabitants rely for revenue—was so severely damaged as to be of no commercial value whatever.

Extensive damage also resulted from falling ash and grit (scoria), on to the leaves of food crops such as taro, bananas, &c., whilst similar crops situated at higher levels near the rim of the crater were rendered useless through scorching. The peppering, however, merely delayed the maturity of the crops, but, being later than customary, trading with the mainland natives was lost.

Saidor Base.—The grounds flanking this new Administration emergency airport have been systematically laid out with lawns and suitable avenue trees introduced from the Botanical Gardens, Rabaul, and a small orchard of tropical fruit trees is now being established.

On the maturity of these trees, seed or cuttings will be available for distribution to the local planters and native populace in the area.

Bogia Base.—Should an officer of the District Services be stationed in this area, it is intended that similar agricultural activity will eventuate as at Saidor Base.

Madang Township.—Further avenue planting in the township was conducted with a flowering tree, botanically known as *Peltophorum ferrugineum.* Varieties of tropical fruit trees were planted in the grounds of several Administration bungalows.

Native Foods.—The staple food of the Madang district natives at the present time is taro and yam, the only exception occurring in the Lower Ramu valley, where sago palm (sac sac) forms the bulk dietary.

Except on Manam Island, no food shortage occurred in the district.

Sweet corn can almost be regarded as a staple food, as it is to be seen in nearly every native garden, growing between taro, yam, mammies, aibeka, bananas, pit and sugar cane.

Irish potatoes, carrots, parsnips, eschallots, cabbages, parsley, lettuce, kohl rabi, tomatoes and radishes have been introduced to many villages above 2,000 feet altitude, and have taken well amongst the natives.

It is hoped that before long Madang township will be supplied regularly with vegetables.

Root cuttings of a seedless type of breadfruit tree (*Artocarpus spp.*) have recently been introduced to the district through the Department of Agriculture, and have been distributed amongst the natives.

A quantity of fruit trees, including Avocada pear, rambutan, mandarin, lime, sour-sop and custard apple has also been sent to higher inland villages.

DERRIS FOR DOG TICKS.

When derris powder is applied to ticks already attached to a dog the ticks do not immediately die, but on the following day they will all be dead and dried up. After applying the powder to the dog ticks may get on it and re-attach quite soon, but if they get on the dog within three days after the powder has been applied they will die without engorging. To make a derris powder wash, add one heaped tablespoon of the powder to one gallon of water in which one tablespoon of soap flakes has been dissolved. Mix thoroughly. After washing, the dog should be exercised to drain off the surplus fluid, or this may be taken off by drying roughly. The wash, like the powder, does not kill ticks instantaneously or prevent others attaching, but will kill the latter for three days after bathing.

PAPAWS (OR PAPAYAS.)

(CARICA PAPAYA.)

By G. H. Murray, Director of Agriculture.

A fruit common to the Territory, but not appreciatetd as it should be, is the papaw or papaya, known botanically as *Carica papaya*. Indigenous to the West Indies and Central America, it has spread throughout the tropics and is now wild in the bush of this Territory, the seed apparently having been distributed by birds. Although growing to a height of 15 to even 30 feet, it is hardly worthy of being called a tree, and might more correctly be described as a tall herbaceous plant, and is dioecious in habit, i.e., having male and female blossom on different plants. It is of rapid growth, ripe fruit being borne in slightly less than twelve months. The plant is at its best from its first to third or fifth year, though it will frequently bear for several years, but the fruit usually deteriorates in quality with increasing age. It bears no lateral branches, but frequently forms divided erect stems. A "self-sown" plant alongside the offices of the Department of Agriculture, which has received no attention, is about 30 feet in height, has divided stems and has been bearing a large crop of fruit for at least a couple of years.

The fruit is somewhat variable in form, being commonly spherical or round. A few years ago, at the Demonstration Plantation, Keravat, there was a well-flavoured variety, weighing about 6 to 7 lb. each and obscurely angled, like some forms of rock or musk melons, but it deteriorated in quality with age. There are also elongated forms up to about 20 inches in length, and weighing as much as 20 lb., hence the fruit is sometimes known as "tree melon". The inside cavity of the fruit is usually filled with wrinkled seeds about the size and shape of pepper corns and when soft and green have a peppery flavour which is not unpleasant to some palates. There is also an almost seedless form which is generally considered to have the finest flavour and it is certainly the pleasantest to prepare for the table.

A form recently introduced to the Demonstration Plantation, Keravat, from Hawaii, is round and small, sufficient for one or two persons, well flavoured and is considered better for table use than the large size. The latter, however, would, no doubt, be more suitable for issue as pig feed, and even to native labourers, whose palates may not be quite so sensitive as those of Europeans.

The fruit can be put to many uses, although principally favoured as a breakfast dish. As a crystallised fruit it is good, but without a very distinctive flavour. It can be used in a salad sliced with lettuce, boiled green in the same manner as summer squash. It can also be used for pickles, preserves of different kinds, jellies and pies. As a jam, prepared with some Davidsonia plums (a wild, acid, purple coloured fruit in North Queensland scrubs) in place of lemons, it is particularly attractive in appearance and flavour, and I have no doubt any ingenious housewife could find other equally attractive methods for its preparation.

The plant has digestive properties, long recognized in the tropics, where it is a common practice to rub the juice over tough meat to make it tender, and old fowls are frequently wrapped in *papaya* leaves, bruised, if I remember rightly, and allowed to remain overnight before cooking.

The fruit also contains a milky juice known, when dried, as papain, which has pronounced digestive properties, having the same use as animal pepsin. This juice is collected by making longitudinal incisions in the fruit and collecting it in non-metal vessels. The hands of the collectors should also be protected and absolute cleanliness is essential. It is customary to have a small quantity of water in the vessel into which the milky juice or latex is collected. As the liquid falls into the water it coagulates and is dried on trays, formed of muslin or calico, stretched on light wooden frames. The production of papain is a minor industry, conducted mainly by peasants in some West Indian islands, Ceylon and Philippines, and can hardly be recommended for planters in this Territory, except for their wives and daughters who should find it an occupation combining pleasure with profit.

It is a plant, however, that should receive greater attention by planters in this Territory, not only for their own use, but as food for their labourers and pigs. It is also a particularly suitable plant for growing in a fowl run, as it provides sufficient shade for the birds, besides, of course, yielding good crops of fruit. It is one of the plants that could be planted between rows of young coco-nuts, with other subsistence crops. Though requiring little attention when once established, and its cultivation is easy, seedlings of the better types require attention in their earliest stage. Seeds should be sown in well prepared nursery beds or seed flats, and will germinate in two to six weeks, according to freshness of seeds and climatic conditions. When 7 or 8 inches high they should be transplanted 10 feet apart each way and shaded until established in their new position. If the weather is showery, there should be no losses, but to avoid any risks, the leaves, except those at the top of the plant, may be snipped off without removing the stems.

Papaya Recipes.

Papaya Cocktail.

Cut papaya in dice and serve in glasses with cocktail sauce and chipped ice. Or serve with orange, lemon, or lime juice, and little sugar in same manner.

Papaya Salad No. 1.

On a strip of peeled papaya lay small bits of pomelo and orange. Serve with mayonnaise on separate plates, and garnish.

Papaya Salad No. 2.

Cut papaya in cubes and add eight small onions and five pieces green celery chopped fine. Serve with boiled dressing.

Papaya Whip.

To 1½ cups papaya pulp add juice of 1 lemon, ½ cup sugar, and beat into 2 stiffly whipped whites of eggs.

Papaya Pickle.

Make a syrup of 1 measure sugar and ½ measure vinegar. Add a few whole cloves and peppercorns and 2 measures of half-ripe papaya cut into small pieces. Boil until tender.

Orange and Papaya Marmalade.

To 1 measure papaya allow ½ measure oranges. Wash oranges well. Squeeze out seeds and juice. Put skins through a meat chopper and add to the juice, strained free of seeds. Add papaya pulp cut in small pieces (without rind) and boil all together; then add as much sugar as pulp. Boil again for 15 to 20 minutes.

Papaya—Flavoured Gelatine Dessert.

½ box gelatine.
½ cup cold water.
juice 1 lemon.
1 cup boiling water.
1 cup papaya pulp.
½ cup sugar.

Soak gelatine in cold water five minutes. Dissolve the sugar in the boiling water; add the gelatine and strain. When cool, add the papaya and lemon juice. Place on ice to harden.

Papaya and Ginger.

Make a syrup of 1 measure sugar, ½ measure water, some finely sliced dried ginger, and a few slices of lemon. Add 2 measures half-ripe papaya sliced lengthwise, which has been previously simmered in water until clear but not broken.

Papaya Pie.

2 eggs.
1 cup papaya pulp.
½ cup butter.
1 cup sugar.
juice ½ lemon.

Make a bottom pie crust and bake. Cream butter and sugar. Add beaten eggs, lemon juice, and papaya. Pour into pie crust and bake. Make a meringue of whites of eggs and 2 tablespoonsful sugar. Place on pie and brown in oven.

Papaya Sherbet.

Mix 4 cups papaya pulp with 2 cups sugar and juice of 2 lemons and freeze.

Stewed Papaya No. 1.

2 cups diced papaya.
½ cup sugar.
¼ cup water.
Juice of 2 lemons.

Cut papaya in dice and stew with sugar, water and lemon juice ½ hour. Serve in sherbet glasses as a first course for luncheon or a dessert. Can use 4 oranges in place of lemons.

Stewed Papaya No. 2.

Cook in the same manner as No. 1 with ½ cup sugar and only enough water to keep from burning. Serve as vegetable.

Baked Papaya.

Cut papaya in halves lengthwise. Add a little sugar and orange, lime, or lemon juice, or a little cinnamon in place of the juice. Bake 30 minutes and serve immediately on taking from the oven. This is a vegetable.

THE VEGETATIVE PROPAGATION OF CACAO.*

By E. E. Cheesman, Imperial College of Tropical Agriculture, Trinidad, British West Indies.

It is noteworthy that all the investigators contributing to the perfection of the budding technique in different countries were inspired by the advantages to be derived from the cultivation of uniform types of cacao, in place of the heterogeneous seedling populations which are still the rule. Some mentioned earlier bearing as an additional point in favour of budded trees, but all stressed uniformity, and especially uniformity of high yielding power, as the great desideratum.

In quest of uniformity all attempted, quite rightly, to adapt to cacao, horticultural methods long established for temperate orchard crops; but in quite recent years temperate orchard practice in this respect has again moved ahead. Researches, in which the East Malling Station has taken a leading part, have shown that uniformity of yield and of other characters in temperate fruit trees depends on uniformity of rootstock as well as uniformity of scion. There is no reason *a priori* to suppose that these findings will not apply to cacao, but rather the reverse.

For this reason, when in 1930 a Cacao Research Scheme was launched at the Imperial College of Tropical Agriculture, it was felt necessary to approach the problems of vegetative propagation from a new angle. There were many problems relating to budding still awaiting solution, but it was decided to concentrate attention, so far as the propagation side of the programme was concerned, on efforts to raise cacao trees vegetatively *on their own roots.*

The numerous problems of stock-scion interactions could the more profitably be deferred for later attack because in the absence of clonal rootstocks the most promising instrument for their solution was not yet available. A summary of the results achieved and of the present outlook is the object of this paper, but, in order to explain the terminology which must be employed, a brief description of the mode of branching of the cacao tree must be given first.

Branching of the Cacao Tree.

A young cacao seedling growing healthily produces a single vertical unbranched stem, on which the leaves are arranged in a $\frac{3}{8}$ spiral, and which later forms the main trunk of the tree. After a variable time, and presumably when it has attained a certain physiological condition not yet defined, the terminal bud divides into three, four, or five, which grow out into oblique or almost horizontal branches (Fig. 1). The whorl of branches so formed is known as the fan or by the Trinidad term jorquette (pronounced horkette), the latter name being preferable, because the word fan or fan-branch can then be used for the individual limbs of the jorquette without danger of confusion. The fan branches have their leaves in two ranks, and bear secondary branches of higher orders, all with leaves in two ranks.

* Extracted from *Journal of the Imperial College of Tropical Agriculture*—Trinidad.

At a later stage a vertical branch arises from the main trunk just below the jorquette. Since it arises on old wood, there is difficulty in determining its exact origin, but it is probably axillary. This branch is known as a chupon; it has its leaves in a spiral, and it repeats exactly the behaviour of the seedling axis, growing up through the jorquette and in due course branching into a second jorquette some feet higher. A third and fourth tier may be added to the tree in the same way. The arrangement is often obscured in old trees by loss of the lower branches by reduction of the vertical part of one "storey" so that two jorquettes arise from almost the same point, or in other ways, but it can usually be traced on careful examination.

As the tree grows older, it nearly always produces from the base of the trunk, at or near ground level, additional chupons (also referred to as "suckers", "water-shoots", or "gormandizers") and if left untended may develop into a clump. In cultivation these basal chupons are most commonly cut out, though some planters like to leave two or three. If the original tree is showing signs of disease or senility, it is usual to allow a strong chupon to grow, and when it is in a condition to replace the old trunk to cut out the latter instead. For this reason "age" in cacao fields is a complex subject, since an old tree, said to be of a certain age, may have been renewed (so far as the parts above ground are concerned, and probably in roots as well) several times since the actual planting.

Normally chupons do not branch, except when they make their jorquettes but they may be induced to do so by bending them over or cutting them back, and when the axillary buds are thus stimulated into growth they give rise in every case to branches of the same type, i.e., to chupons. Fan branches on the other hand branch freely, and their axillary buds likewise normally produce shoots like themselves, i.e., fan branches of the second or higher orders. If, however, fan branches are cut hard back they will sometimes produce chupons behind the cut. Moreover, it is by no means uncommon in the field to find chupons arising from fans, and although the physiological equivalent of pruning, in the shape of a wound or canker, can often be found as the cause, such is not invariably the case.

The so-called "dimorphism" of cacao branches is thus clearly marked, yet by no means absolute and there seems to be a certain plasticity of behaviour in both kinds of buds. Buds on fan branches (fan buds) especially seem able to give rise to either fans or chupons, according to their physiological state, and shoots may be found on fan branches having a spiral phyllotaxis below and a two-ranked arrangement above. Axillary buds on chupons are less plastic, but physiological factors must certainly determine the height at which the terminal chupon bud produces its jorquette, since that height varies without any apparent morphological or genetic reason.

The practical importance of the dimorphism in propagation lies in the fact that the entire habit of the vegetative progeny depends on the type of branch or bud used. Thus in the early grafting experiments, fan branches were inarched on seedlings held in bamboo pots near the tree, and Jones describes his grafted plants as branching a few inches above the point of union and forming bushy specimens. In the budding method described as used in Jamaica and Haiti, trees were pruned to provide vigorous chupons for budwood and the result was that the budded progeny developed a main trunk. The same applies to Stahel's technique, in which chupon buds are recommended as preferable. In Trinidad,

however, fan buds have usually been employed, and as a result budded plants can be recognized at a glance by their lack of trunk, and by their spreading two-ranked branches, which need some training to make a symmetrical tree. It is to be noted that whereas there is always an abundance of fan material available on a healthy tree, there is very often under plantation conditions, little or no chupon material to be had without recourse to manipulation. Exactly the same considerations apply in propagation of scions on their own roots.

Propagation by Cuttings.

The rooting of cacao cuttings has possibly been achieved, though unrecorded, many times in different countries, but it has never previously attracted attention as an important contribution to the technique of crop improvement. Since the end of 1930, however, a systematic survey of the possibilities of the method has been made by E. E. Pyke, working in these laboratories, and the conclusions here given are based entirely on his researches. Detailed accounts have appeared elsewhere and only a summary will be attempted.

The work began with a general survey of all possible means of vegetative propagation, excluding budding and grafting. This included trials with hardwood and softwood stem-cuttings and root-cuttings, and soon demonstrated beyond doubt that between those the greatest hope of success lay in the use of softwood. By "softwood" is meant shoots that are mature but which still retain their leaves, and which are set to generate a root-system without removal or loss of those leaves; in actual texture such shoots are semi-hardwood. The success with this kind of cutting was of such an order that there appeared to be no possible economic advantage in pursuing investigations with hardwood, and subsequent work was devoted to standardization of method.

The second year's work established several principles. In the first place it showed an important connexion between the physiological condition of a tree and the behaviour of cuttings taken from it. Old trees and trees grown without shade are alike unsuitable for supplying cuttings. The general appearance of shoots likely to root well is now known, but much physiological research remains to be done before the constitutional features of such material can be defined. In the second place comparisons were made between chupon cuttings and fan cuttings, which showed little difference in ability to root, but marked differences in the type of rooting and subsequent growth. In both, the roots push horizontally, through the cortical tissues just above the callus but whereas in fan cuttings they continue to grow almost horizontally for some centimetres, in chupon cuttings they usually turn vertically down as soon as they emerge from the stem. In fans, the terminal bud, if present, usually grows out, together with several lateral buds, sometimes low on the stem, and the shoots tend to spread obliquely. In chupons, on the other hand, either the terminal bud, or in its absence a single lateral near the top of the cutting, grows out into a vertical leading shoot. The differences are illustrated by Fig. 2. The chupons, as might be expected, approximate more closely to seedlings in their behaviour, and the importance of that fact will be indicated later.

The essence of success with softwood cuttings lies, as every horticulturist knows, in keeping the leaves on until roots are formed, and to that end careful control must be exercised over both the water-content of the rooting medium and

the humidity of the air above. Illumination is also important, since much of the carbohydrate used in root-formation is presumably manufactured by the cuttings after they are set in the propagator. Temperature under Trinidad conditions needs no elaborate control, and none was attempted, since the object of the researches was less to discover academically optimum conditions than to establish the simplest technique consistent with practical results.

Full details of the propagating frames used and of the environmental factors studied are given by Pyke (loc. cit.). In average batches of cuttings, 50 per cent. root within three weeks, and good batches finally show 90 per cent. or more of successes. These figures justify the claim that a practicable technique has in fact been found. Subsequent treatment needs care if the rooted cuttings are to be successfully established in the field, but presents no very great difficulties.

Propagation by Layering.

Stooling and layering were tried simultaneously with the experiments on cuttings, and with equal success.

Aerial layering, or marcotting, in which ringbarked branches are surrounded by a ball of moist soil in sacking, has been found possible with cacao in Trinidad, Ceylon and Java, and is illustrated by van Hall (loc. cit). It is, however, a tedious method and for large-scale work possesses no apparent advantages over the setting of cuttings.

Pyke obtained excellent results by pegging down seedlings about 18 months old in the surface of the soil. Basal chupons of older trees, if they occur in a suitable position and are at the right stage, can be treated similarly. Under such treatment several of the axillary buds push out into vigorous chupon branches, and if they are then moulded up with soil they develop in a few months a strong root-system with one or more main roots running vertically down like tap-roots. Earthing-up must be deferred until the buds have made some growth, because cacao buds apparently will not burst when covered, and all attempts with covered layers failed. Secondary layers were at a later date made from the first with equal or even greater ease.

The observations are still incomplete in the sense that established cuttings have not yet been layered, that step being on this year's programme, but there appears no reason why chupon cuttings at least should not behave exactly like seedlings in this respect. Fan branches similarly laid down have so far given rise to fan-type layers, and fan cuttings may be expected to do the same. It is in layering of fans, however, that the plasticity of the buds assumes importance. It is most probable that by cutting hard back after rooting, or by some other manipulation, chupons can be induced on fan layers. Work is at present being directed towards finding the appropriate treatment for converting fans into chupons with certainty.

The possible advantages of layering lie chiefly in the ease of the process, and the fact that constant daily attention is not required by a layer-bed, as it is by a propagating frame set with cuttings. On this account the layering technique may prove more adaptable to estate routine and provides a means for the planter to bulk up an approved clone from rooted cuttings initially supplied by an experimental station. The possible disadvantages are the length of time required for rooting and the rather large space taken up by a layer nursery as compared

with a seedling nursery. Much remains to be discovered about the minimum time in which layers can be induced to root, and also about the number of rooted branches which can be obtained per unit length of stem laid down. Until these points are determined the method can neither be recommended for commercial use, nor accurately compared with the cutting technique in efficiency and practicability. Still, from the point of view of practical nursery multiplication, the outlook is the more promising for the existence of these alternative methods.

Stooling by a method similar to that used for Malling apple stocks has been tried, but so far has given results inferior to those from layering, chiefly because the shoots seem to need ring-barking to induce deep rooting, and the extra handling involved has no compensating advantage. It remains to be seen whether older stools will behave differently, and no final pronouncement on the relative merits of the two methods is yet possible.

Established Potentialities.

With the striking of cuttings and rooting of layers added to the previously established method of budding, there is now at the disposal of the research worker an almost complete range of possibilities of producing any kind of tree he chooses. A tree selected in the field by the plantbreeder as worth clonal multiplication may be grafted or budded on a seedling stock, or cuttings or layers may be taken from either its fan branches or its chupons, according to the circumstances, the facilities and the type of material most readily available on the tree. Once established in the experiment station, any type of tree can be converted into almost any other. Grafts or buddings can be subsequently layered or used as a source of cutting. Chupon-type plants will always produce sooner or later a jorquette of fan branches. The only gap in the chain is the absence of a sure method for obtaining chupons at will on fan-type plants, and it has been shown that this problem does not seem by any means insoluble. In short, isolation of any desired clone *on its own roots* becomes a matter of routine, and the main question next for solution is, which of the several methods of propagation available can be most advantageously adapted to the raising of planting material on a commercial scale. This question, however, involves at least three subsidiary ones of the greatest importance, which must be shortly discussed.

Outstanding Problems.

Ruling out grafting, which by the consensus of opinion of previous workers is less convenient than budding if seedling stocks are to be used, and ignoring any possible differences between cuttings and layers as means of propagating clones on their own roots, there are still six distinct kinds of vegetatively propagated cacao trees which now need careful study and comparison. They are illustrated diagrammatically in Fig. 3, which represents, from left to right:

Type IA, fan bud on seedling stock; IB, chupon bud on seedling stock.
Type IIA, fan bud on clonal stock; IIB, chupon bud on clonal stock.
Type IIIA, fan layer; IIIB, chupon layer.

The three major questions to be answered, in order of importance and urgency, are; (i) Should the root-system be of seedling or of vegetative origin? (Type I versus Types II and III) (ii) Should the root-system and the scion

be of different genotype or identical? (Types I and II versus Type III.) (iii) Should the scion be of fan or chupon origin? (Sub-type A versus sub-type B throughout). Only experiment can provide the answers, and it may well provide different answers under different sets of conditions. There are, however, a number of considerations bearing on each of the questions which must be reviewed even at the present stage, because they indicate the relative magnitudes of the issues involved.

(1) Root-systems.

The drawbacks of seedling stocks for temperate fruit trees are too well known to need more than mention. They arise from the fact that the parent trees from which the seedlings are raised are heterozygous, so that the seedlings themselves vary in constitution one from another, and the composite trees of which they form part after grafting or budding must likewise vary. The variations in yield and in other physiological behaviour of uniform scions when united with such variable stocks are of great economic significance, and it has come to be realized that if orchard material is to be truly standardized, stocks raised vegetatively must be used.

Similar drawbacks of seedling stocks for cacao are at present only assumed by analogy. Seedling cacao stocks are indubitably heterogeneous, and the argument by analogy is justifiable as a working hypothesis until disproved. A direct demonstration is difficult, first because there is so little budded cacao of which records have been kept, and secondly because there have until now been no clonal stocks to serve as standards of comparison. What little direct evidence there is does not contradict the hypothesis. Still, the direct demonstration must be provided before further work can be well and truly founded on a scientific basis.

On the other side of the account, there is a strong prejudice in many quarters in the tropics against trees on non-seedling root-systems. It is said that the absence of a tap-root makes them liable to fall in wind and otherwise militates against their efficiency. Such an argument must be respected and put to experimental test. That it may be true, yet only half true, is shown by Fig. 2, illustrating the essential differences which may arise among vegetatively induced root-systems themselves. At the present it seems likely that cacao stocks raised from fan cuttings or fan layers might be genuinely open to objection, whilst those raised from chupon cuttings or chupon layers might not. Steps are being taken immediately to compare both types very carefully with seedlings, but it must inevitably be some years before conclusive results can be obtained, and meanwhile other investigations must be pushed ahead on the presumption of an answer favorable to clonal stocks.

(2) Composition of Tree.

Assuming for the purposes of argument that vegetative stocks can be proven better than seedlings, the question at once arises whether budding remains any longer necessary or desirable. Budding of selected scions on selected clonal stocks would be directly analogous to the most advanced practice in temperate fruit culture, but it need not necessarily prove ideal for cacao, and this is a case where argument from analogy can easily be carried too far.

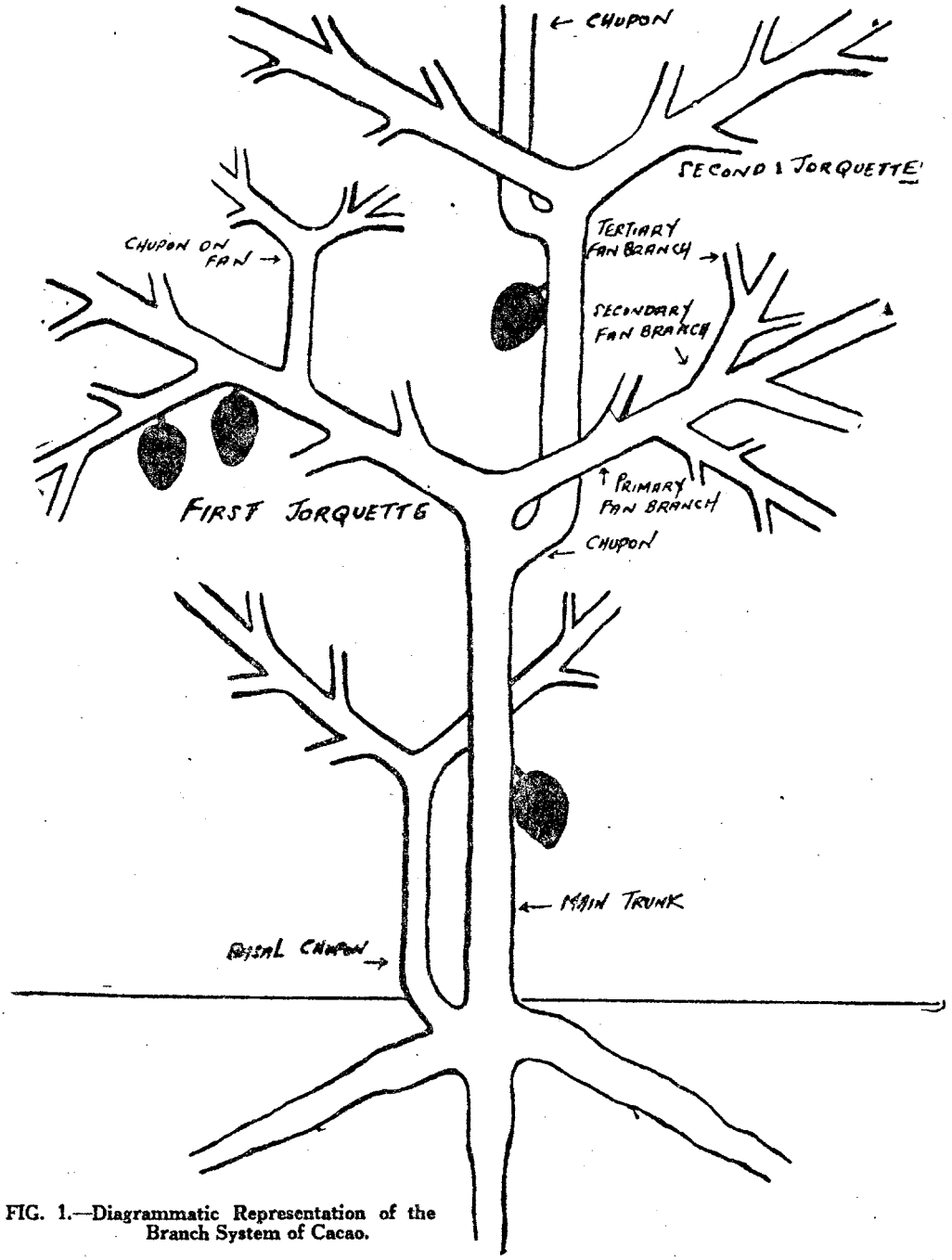


FIG. 1.—Diagrammatic Representation of the Branch System of Cacao.

Cacao trees selected for propagation will usually be selected primarily for high-yielding power, and only secondarily for qualitative characters of the fruit. In this respect they are not quite comparable with fruit varieties, which have probably in most cases been selected primarily for non-yield characters such as

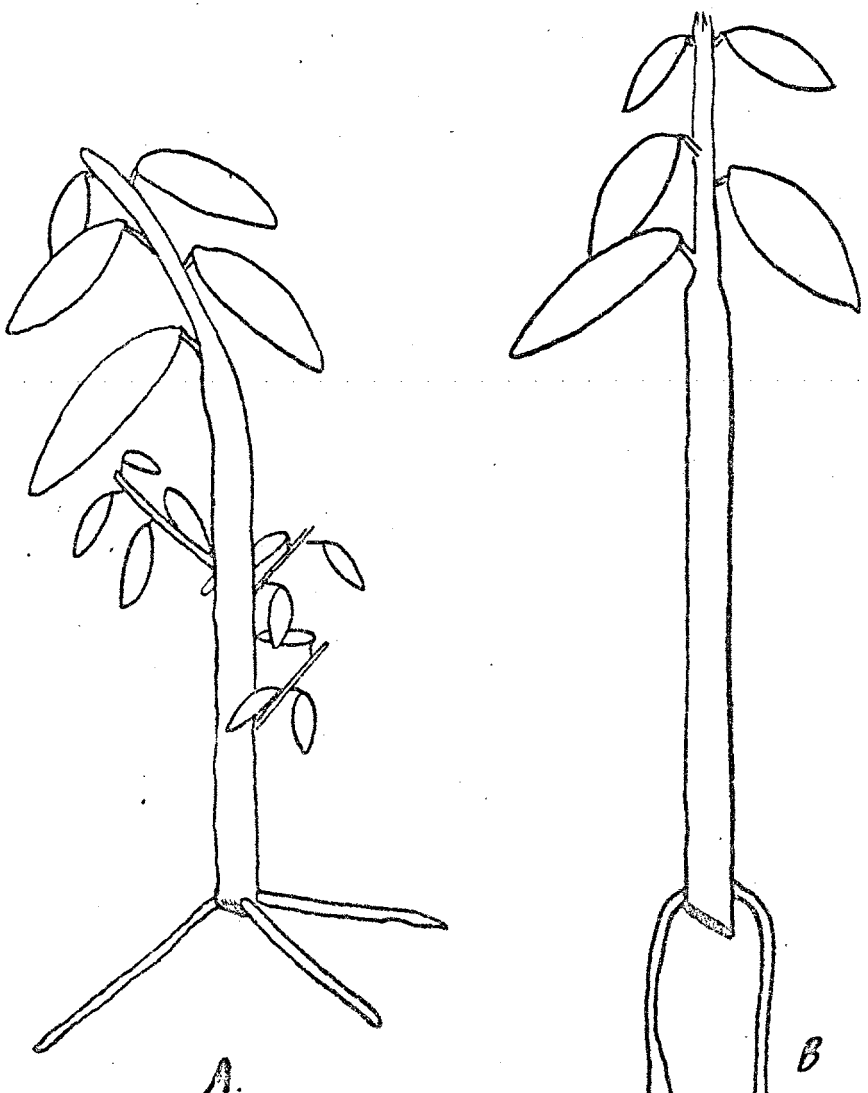


FIG 2.—A—Typical Fan Cutting.
B—Typical Chupon Cutting. (New growth only shown; old leaves omitted for simplification of diagram.)

flavour, texture, or size of the individual fruit, and only secondarily for yield per tree. The high-yielding cacao tree must have a root-system capable of supporting its yield; and if cuttings or layers from it regenerate a root-system of similar type, the main object of vegetative propagation will be attained.

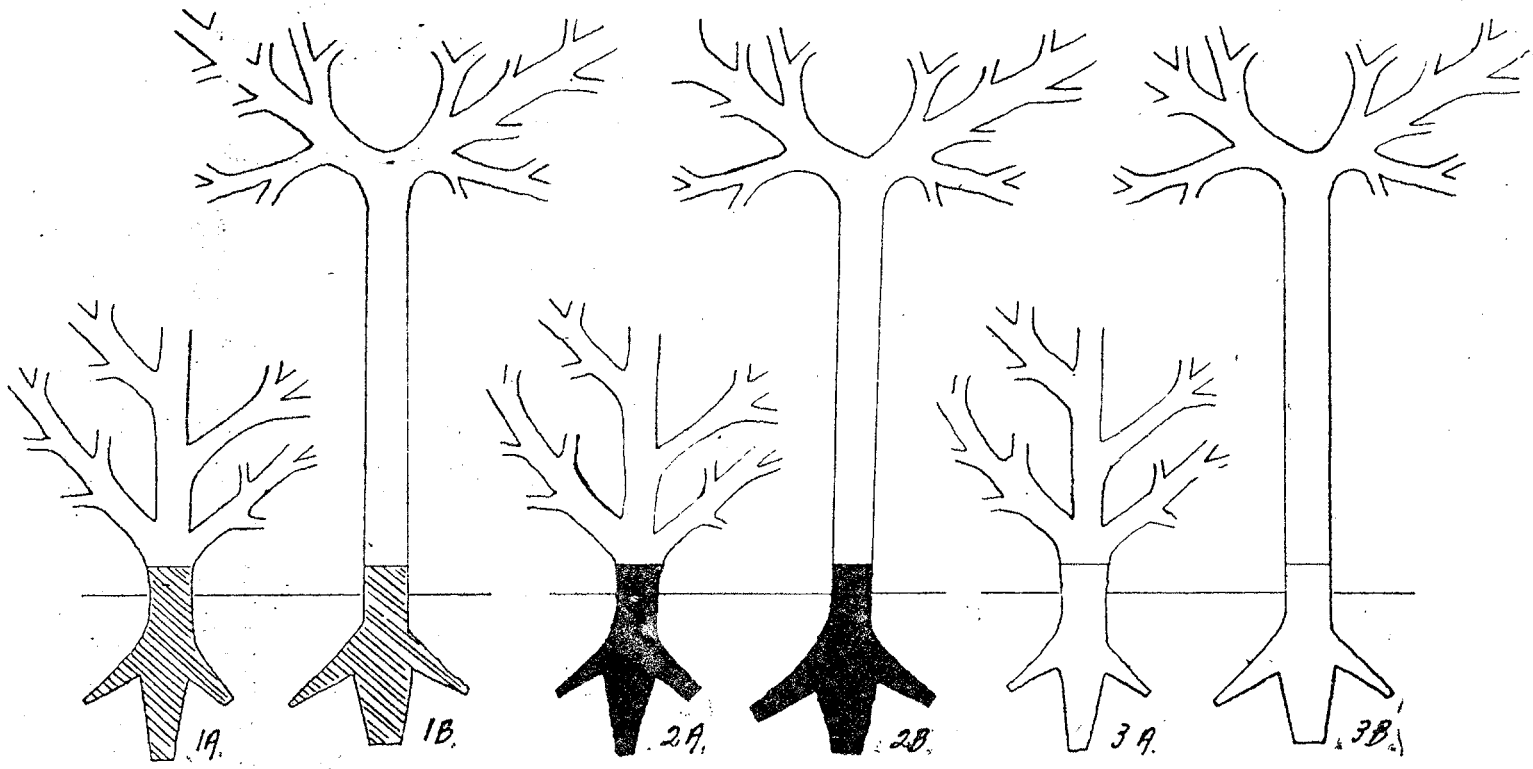


FIG. 3.—Types of vegetatively propagated Cacao trees:
1. Budded on seedling stock. A. Fan bud. B. Chupon trees.
2. Budded on clonal stock. A. Fan bud. B. Chupon bud.
3. Unworked. A. Fan cutting or layer. B. Chupon cutting or layer.

It is not overlooked that a scion good on its own root-system might give even better results than its parent if placed on another; neither have the possible uses of different stocks to change the habit of the scion been forgotten. Dwarfing stocks, for example, might be very valuable for "filler" trees in laying out new plantations at a wider spacing of the "permanent" trees. There is, indeed, scarcely any limit to the amount of research which will be needed into the interaction of stocks and scions in cacao culture, now that clonal stocks are available for accurate studies.

At the same time there is a factor of quite another kind which cannot be excluded from this part of the discussion, and that is disease. Canker (caused by *Phytophthora Faberi* Maublanc) is one of the most destructive of diseases of cacao, and causes incalculable losses. It is one of the advantages of the seedling cacao tree that, should the main trunk or jorquette be badly attacked, the whole system can be regenerated by allowing a basal chupon to grow, and it has been pointed out above that this practice is regularly followed. A budded tree naturally cannot be regenerated in similar fashion, because if a basal chupon grows it is of the stock and not the scion variety. A tree from a layer, however, will behave in this respect like a seedling. The natural regenerative power of the cacao tree is a valuable economic asset not shared to the same extent by the majority of species usually budded or grafted, and may possibly prove the deciding factor between "foreign" and "self" root-systems, at least in many districts where canker is especially rife.

(3) Branch-systems.

It has already been hinted that if layers (Type III) should ultimately prove the most satisfactory means of propagation, as on the balance of available evidence seems not unlikely, the choice between fan and chupon material for multiplication is likely to be decided by the nature of the respective root-systems. If, however, trees of Type I or Type II prove preferable, the question of branch-systems will add itself to the more urgent ones already discussed.

On account of the cauliflorous habit of cacao, if a main trunk is required on a budded tree it must be obtained from a chupon bud set low on the stock. The alternative method of budding high with a fan bud and allowing the stock to form the trunk is impracticable, because the stock would then bear fruit, and the crop would be only partly derived from the scion variety. Consequently, the choice of bud seems to be essentially a choice between presence or absence of a main trunk, and this would appear to depend more upon the tastes of the planter and the kind of cultivation he intends to give the trees than upon fundamental botanical considerations. Sub-types Ia and Ib are already both grown on a small scale with success, and whilst there is undoubtedly scope for experiments to compare the two, the problem seems both less urgent and less difficult than either of the two foregoing.

INSECTS THAT RIVAL MAN.

By A. W. Haslett (Reprint John O' London's Weekly, 20/8/37.)

Somewhere about three-quarters of a million kinds of insects are known to science. They are also more numerous than all other animals put together, so that it has been said, and with good reason, that they are really a dominant type of life on earth at the present time. We can claim, it is true, that we can protect ourselves against the more noxious varieties and make commercial use of others—for example, the honey bee and the silkworm. But the degree of protection achieved is woefully incomplete.

The United States, which seems to have a passion for such statistics, estimates that insects still, in a normal year, take a 10 per cent. levy of all human efforts at food production—and a single insect, the cotton boll weevil, is blamed for taking 15 per cent. of the entire cotton output of the southern states. On the other side, it might be argued that yellow fever and malaria—both mosquito-borne diseases—have been largely brought under control, and that the same is true of quite a number of plant pests.

The Civilization of the Ants.

If insects deserve (and secure) attention from their importance, many of them are also of interest in themselves. It is the latter claim which Mr. A. Hyatt Verrill has chiefly stressed in *Strange Insects and Their Stories* (Harrap, 10s. 6d.). "Among them," he writes, "we find nearly every art, industry and phase of human activity duplicated. There are insect masons, carpenters, weavers, divers, aviators, and bridge builders. There are insect soldiers and sailors, insect miners and farmers, insect basket makers and engravers, insects who keep cattle, and insects who have slaves," and, if we put the word "cattle" in quotation marks, it is all true. The reference is to the habit of certain ants of keeping little aphid insects for the sake of their "honey dew," the aphides being all but literally milked and, in some cases, kept in underground "stables" and deliberately fed by the ants during cold weather.

Even more strange are the ant farmers of South America, which make hanging gardens in trees, and cultivate plants which have never been otherwise found. Presumably, they have either been grown by the ants for so many millions of years that distinct species have evolved, or else the original wild plants have disappeared. But of the fact, apparently, there can be no doubt.

How Wasps Ripen Figs.

Then there is "the insect magician who gives us figs"—who alone is capable of bringing Smyrna figs to development and, in the process, commits suicide and forfeits its own prospect of parenthood. The story came to light from the effort of a San Francisco newspaper in the 'eighties to introduce Smyrna fig cuttings into California. The cuttings grew, but instead of big, luscious figs, little wizened buds were the only produce—until a Government expert was sent out to Smyrna to investigate. Here he was struck by the native habit of carefully gathering quantities of inedible wild figs and hanging them on strips in the orchards "to keep away evil spirits." They were so emphatic that this was important that he decided to wait and watch. And here is the answer.

Figs, strictly speaking, are flowers rather than fruit, and require fertilization, when apparently already in the fruit stage, before they will further develop. This is done naturally for the wild caprifigs, by little wasps, which burrow their way in through the "eyes" of the figs and lay their eggs inside. When the young wasps emerge in the orchards they fly unhesitatingly to the cultivated figs, force their way hopefully inside, and then finding the figs unsuitable come out again without laying any eggs and fall helpless and wingless to the ground. The one result of their sacrifice is that the cultivated figs are fertilized. And only by importing fig wasps and wild figs, together, into California, could Californian figs be made to fruit.

Saved by Ladybirds.

From California, too, comes the story of the saving of the orange groves there by the Australian ladybird "Vedalia." This was a case of pitting insect friend against insect foe. The cottony-cushion scale insect, known to have been accidentally introduced from Australia, was decimating the Californian plantations—although reports from Australia showed that, in its native country, it did little or no damage.

An investigator was therefore sent to Australia to discover what it was that kept the cottony-cushion scale in check. He came back with a pretty red and black Vedalia. In six months "they had spread all over southern California and had made such inroads on the scale army that the withered, dying orange trees put forth new leaves and began to bloom once more," and within a year the scale insects were under control.

Mr. Verrill might have told, too, of the prowess of "*Cactoblastis cactorum*," Australia's guest-insect from Brazil, which has already helped Australia to reclaim more than three million acres of agricultural land from the notorious prickly pear. The story, in this case, goes back to 1787, when Captain Phillip, who was in command of the "first fleet," as Australians later came to call it, called at Brazil on his way out.

The Insects were Lost.

There, so it is said, he took on board a supply of cochineal insects, thinking he would like to have a home-made red dye for his red-coats and with the insects he took also a number of cactus plants, prickly pear, on which the insects feed. Unfortunately, the cochineal insects were lost in transit, but the prickly pear—which had merely been incidental—safely arrived.

However, the story of its introduction was known, and so when the original consignment had grown to cover 60,000,000 acres—an area larger than the whole of Britain—it was to Brazil that search parties were sent. "*Cactoblastis*," a name now famous in Australia, has proved the best recruit.

But in a book so packed with odd and varied information it would be unfair to complain of omissions. A more valid criticism is of the manner of appeal—to wonder, and again to wonder—through artisans and mimics, ogres and giants, sawyer beetles and ethereal dragon flies, grave and gay, for the whole length of an evening's reading. The wonder, of course, is there. But it should be taken rather as a series of cocktails, than as a single meal—or else diluted with intervening courses of more solid fare. Apparently Mr. Verrill himself realizes the need. He expresses the hope, at the end of his book, that readers will be encouraged to delve more deeply. He might, with advantage, have met them—quarter way.

THE PRACTICAL APPLICATION OF METEOROLOGY TO AGRICULTURE.*

The subjoined account of the way in which meteorology is applied to agriculture in Europe is of especial interest to New Guinea.

Climatology.

(*a*) General Application of Climatology in the Improvement of Crops.

Weather forecasting is not, as generally thought, the only branch of meteorology which can be useful to agriculturists. There is a second—climatology—of which many agriculturists are unaware, which can, however, render them considerable service. A precise knowledge of climate, that is to say, of the meteorological elements not solely of the air in which we live, but of the air at the surface of the soil and in the soil, can play a capital part in agriculture for the following reasons:—

(1) It will help to increase yields by facilitating the choice of varieties of crops best adapted to the climate; varieties resistant to cold in the east, or drought in the south; early varieties in regions where the heat of July causes "burning" to be feared; varieties of which the critical periods (earing of cereals for example) coincide to the maximum of probability with favorable meteorological phenomena.

(2) It affords a powerful aid in the application of preventive treatment against fungus diseases. Two kinds of conditions are needed for the development of these diseases—those favorable for the fungus and those predisposing the plant to disease. High temperatures, drought, and a high exposure to sunlight are factors propitious to fungi attacking the plant, which is already weakened by a partial withering of its tissues; they form, on the contrary, a powerful obstacle to the development of the propagative organs of the fungus, whose existence they menace. On the other hand, a soft and humid weather favorable to the fungus produces the maximum of turgescence in the tissues of the plant, which is thus better able to resist fungus attack. In order to produce an epidemic it is necessary that these two opposite kinds of conditions must immediately succeed each other, leading, in the first place, to predisposition of the plant to attack, and then to the development of the fungus before the plant can react. Thus at the beginning of the warm weather the plants wither in the day time; now if, in the course of the night, temperature is lower and a mist is produced (an element propitious for the propagation of fungus spores) the fungus attacks the plants, which will not have had time sufficiently to regain their turgescence and the epidemic will break out. On the basis of these data, and from the observation that potato blight always travels from west to east, one can, in

* Translated and summarized by Mr. W. R. Black (Ministry of Agriculture and Fisheries, U.K.) from an article by Mons. J. Sanson (Chief of the Climatological Service of the French National Meteorological Office) in *La Grande Revue Agricole*, March, 1928, and reprinted from *The Journal of the Ministry of Agriculture*, (Great Britain) for October, 1928.

certain conditions of temperature and humidity, and with observation posts judiciously placed, announce the probable advance of this disease in a given region and advocate the necessary preventive treatment.

(3) It will sometimes allow measures to be employed to counteract certain atmospheric phenomena which are particularly dangerous at certain times of the year—use of artificial clouds against spring frosts, formation of societies intended to prevent or insure against hail.

(4) It will assist the rational use of manures. It is known, for example, that lack of water in arable soil impedes nitrification. In very dry regions the extensive use of easily soluble manures may remedy this to a certain extent. In districts with abundant rainfall, where fungus diseases and storms are particularly to be feared, dressings of potassic and phosphatic manures will be increased. These same manures will induce vegetative activity in regions where winter cold and spring frosts lead to the risk of damage to advanced crops. The climatology of the country will be also utilized to fix the dates of spreading manures; for example, the application of potassic manures will be the earlier the drier the climate, that of nitrogenous manures on grass will be carried out as far as possible on dry days at the end of February when rain is imminent. Liming and marling will be done in the dry periods of autumn.

(5) It is indispensable when new crops are tried. Thus, in France, an increase in the area under sugar beet is very desirable. Before this crop is grown in certain departments, their climatology must be known; in particular, whether the distribution of average quantities of rain over the summer months will permit of the advantageous acclimatization of this crop. Sugar is produced as much through the water in the soil as from the carbonic acid in the air. Evaporation from the leaves of beet is considerable, and may reach 350,000 to 500,000 gallons of water per acre, corresponding to a rainfall of about 20 inches, which must be spread over half a year (May to October). It must be ascertained, therefore, that the rainfall can satisfy the need of this crop for water.

(6) Finally, certain meteorological data can be instanced which are of service to agriculturists, e.g., the monthly and annual distribution of rainfall and the amount of maximum falls in the case of the construction of cisterns; the system of winds in the case of the installation of a mill or an airwheel; and extremes of temperature, duration of frosts and their intensity, in the case of heating in glass houses.

(*b*) Study of a Particular Climatological Factor, e.g., Influence of Rain in Agriculture.

Among the climatological phenomena having an important effect on agricultural production, rainfall seems to take first place, and it seems useful by way of example to study, in some detail, the role of rainfall in agriculture.

The amount of rainfall is expressed in inches, a precipitation of 1 inch corresponding to 4.7 gallons of water (i.e., 47 lb.) per square yard, i.e., 22,500 gallons per acre. In France, the average quantity of rain received annually varies according to district, the minimum in the neighbourhood of Paris and the maximum in the neighbourhood of the mountains.

Fertilizing Effects of Rainfall.—The physical and chemical effects of rainfall are well known. Minerals in the soil are rendered soluble, without which they cannot be utilized for the formation of plant tissues. It is, also, through rainfall that fermentation indispensable to plant life takes place in the soil. There is one point to which particular attention must be called, namely, the fertilizing effect of rainfall due to the ammoniacal or nitric nitrogen which it contains in quantities far from negligible. Determinations carried out in France and Belgium have shown that rain contains, on the average, .0002 per cent. of ammoniacal nitrogen and .00007 per cent. of nitric nitrogen. Winter rainfall is, in general, richer in nitrogen than summer rainfall. It is seen that rain brings in an average year some 13 lb. of nitrogen per acre in the region of Paris, and more than 26 lb. in the wetter districts of the country. In Germany and in Italy, the average quantity of nitrogen brought per acre by rainfall has been found to be about 10 lb., and in England about 7 lb., of which three-quarters are ammoniacal nitrogen and one-quarter nitric nitrogen, while, in the United States, it is as large as 20 lb., of which 13 lb. are ammoniacal nitrogen and 7 lb. nitric nitrogen. Rainfall is about ten times richer in nitrates in tropical regions than in temperate climates. The proportion of ammonia is also much higher, which explains the luxuriant vegetation on certain African soils which, from their composition, would be considered as poor. These quantities of nitrogen furnished by rain are much superior to those given in manures, especially in France.

Thus, in some degree, rainfall supplies manure, but the reverse is sometimes the case, and manure can, at least in part, replace water. In order, for example, in the case of wheat, for the plant to manufacture 1 gram of dry matter it has been established that 0.53 pints of water are necessary in unmanured soil and only 0.35 pints in the same soil with average manurial dressings. The transpiration of cereals is, in fact, diminished by the use of manures, and, varying with the dressing of the latter and the nature of the soil, the quantity of water required to produce 33 bushels of wheat per acre, weighing 71 lb. per bushel, has been reduced from 24 inches to 8 inches.

Disadvantages of Excessive Rainfall.—(1) Potash salts are retained by the absorptive power of the soil and suffer only insignificant losses from rainfall. No loss is to be feared so far as concerns soluble phosphatic manures. It is different, however, with nitrates, which are in danger of being lost in drainage water through abundant rainfall in autumn and winter. This point must, however, not be exaggerated. The loss of nitrates in the sub-soil is much less rapid than is often imagined; thus after a rainfall of half an inch, it was found that nitrate only descended a few tenths of an inch in the soil, while the humidity produced by this rain falling on a dry soil had penetrated in one day to 2½ inches. Further in warm weather nitrate may be brought back quite quickly by capillarity from a considerable depth to the surface. Nitrate 10 inches deep in the soil was thus returned to the surface in a fortnight. During this season, capillarity causes the water in the soil to rise to replace that lost in evaporation. This water brings

with it dissolved products deep in the soil, products which thus come to be concentrated in the neighbourhood of the roots of plants. Too deep a burying of nitrates following rain need not be feared when the manures are applied in spring, even if they are ploughed or harrowed in. As, however, nitrates are subject to denitrification in very humid soils, it is advisable, where too heavy rains or a high humidity are to be feared, to replace nitrates by ammoniacal manures. Sulphur, and, above all, lime, are lost through rainfall in larger quantities than any other manurial element. Losses of lime, naturally more important in rainy climate than in a dry district, attain on the average in France 3 to 4 cwt. per acre per annum; in very rainy years they have even reached 4¾ cwt. The practice of liming is, therefore, absolutely necessary, as lime is an indispensable element in the nutrition of plants equally with nitrogen, phosphoric acid, and potash.

(2) Soils which are too wet, i.e., which contain more than 40 per cent. of their weight of water, are, in general, impermeable to air, and thus any gaseous exchange between the soil and the atmosphere is rendered impossible. There results a stoppage of respiration of plant roots, leading to asphyxiation of the plants and a lowering of the temperature of the soil harmful to their growth. The water (which is a bad conductor of heat) remaining in the top layers of the soil is not replaced by air, and, in consequence, these layers, although superficially warm in spring, cannot transmit this warmth to the lower layers, which remain cold. There results, among other things, from this lack of warmth, the impossibility of production of carbonic acid gas in the soil, an indispensable element in the development of the plant, as a complement of carbonic acid gas in the atmosphere. Soils which are too wet lack air and are cold, but it is possible by drainage to aerate and warm them. Experiments have shown that the average temperature of a drained soil can be 6 degrees Centigrade higher than that of an undrained soil.

(3) The substances necessary for the nutrition of plants, concentrated in the neighbourhood of the root hairs, penetrate these latter with the soil water by capillarity and endosmosis and ascend through the plant cells under the impulse of these forces. Their ascension and their absorption are considerably increased by transpiration, which leads to the consumption of an enormous quantity of water compared with that strictly necessary for the tissues. Thus fertilizing elements from the soil reach right to the leaves. If the soil is too dry, transpiration is greater than absorption and plants wither, but, if the soil is saturated, the plants are "gorged" with water and their vegetative apparatus is developed to the detriment of their reproductive apparatus. In this latter case, in effect, the substances in the soil are diluted to too large a degree with liquid, and, since the roots can only absorb a certain volume of water, the plants are deprived of a certain amount of their nutrients, notably phosphates, without which it is impossible for them to live normally. On the other hand they have other nutrients at their disposal in greater quantity, particularly nitrogen brought down in the rainfall. There results an exaggerated growth of the vegetative organs, a diminution of precocity, and a marked tendency to the invasion of fungus parasites. This can be remedied by increasing the potassic and phosphatic dressings.

(4) The year 1927 showed once more that, while abundant summer rain has not always a bad effect on the quantity, it has on the quality of the crop. For wheat, in particular, it has been established that rain at harvest does not lead to the germination of the grain in the sheaf unless accompanied by a sharp fall

in temperature such as is produced at the time of a storm. Such fall of temperature is not an obstacle to germination as one would be tempted to think, but, on the contrary, the determining cause. The damage to the crop is the greater the longer the temperature remains below the normal after rainfall; and inversely the damage is the smaller the more rapidly the thermometer regains the average for the season. In regions where rainfall is abundant during the months of July and August, it is to the interest of farmers to select varieties of wheat which are resistant to this special effect of summer rains.

Correlation Between Rainfall and the Yield of Wheat.

The preceding considerations show the important part played in agriculture by rainfall. It has long been known (it is found for instance in the Bible) that harvests are intimately dependent on rainfall. For the central region of France, in particular, the following rules have been drawn up on the relation between rainfall in the quarter April, May, June, and the yield of the wheat crop:—

(1) If the rainfall during these three months is below average, the yield will be above average so long as the temperature is not more than 1 deg. C. above the average. If the temperature is more than 1 deg. C. above average, the crop is damaged by burning.

(2) If the rainfall during these three months is above average, the yield of wheat is below average.

Analogous conditions have been found in the north of Italy and in Ohio, where a diminution of rain in the spring is accompanied by an increase in the yield of wheat. On the contrary, in the south of France and the southern part of the Italian Peninsula, the effect of rainfall is quite the opposite.

PHASES OF THE MOON, 1938.

RABAUL.

January—		
2-New moon	4.58	a.m.
10-First quarter	12.13	a.m.
16-Full moon	3.53	p.m.
23-Last quarter	0.9	p.m.
31-New moon	11.35	p.m.
15-Perigee	12.0	noon
27-Apogee	4.0	p.m.
February—		
8-First quarter	10.33	a.m.
15-Full moon	3.14	a.m.
22-Last quarter	2.24	p.m.
12-Perigee	4.0	p.m.
24-Apogee	11.0	a.m.
March—		
2-New moon	3.40	p.m.
9-First quarter	6.35	p.m.
16-Full moon	3.15	p.m.
24-Last quarter	11.6	a.m.
11-Perigee	6.0	p.m.
24-Apogee	7.0	p.m.
April—		
1-New moon	4.52	a.m.
8-First quarter	12.10	a.m.
15-Full moon	4.21	a.m.
23-Last quarter	6.14	a.m.
30-New moon	3.28	p.m.
5-Perigee	2.0	p.m.
21-Apogee	3.0	a.m.
May—		
7-First quarter	7.24	a.m.
14-Full moon	6.39	p.m.
22-Last quarter	10.36	p.m.
29-New moon	Midnight.	
2-Perigee	11.0	p.m.
18-Apogee	7.0	p.m.
31-Perigee	3.0	a.m.
June—		
5-First quarter	2.32	p.m.
13-Full moon	9.47	a.m.
21-Last quarter	10.52	a.m.
28-New moon	7.10	a.m.
15-Apogee	4.0	a.m.
28-Perigee	11.0	a.m.
July—		
4-First quarter	11.47	p.m.
13-Full moon	1.5	a.m.
20-Last quarter	10.19	p.m.
27-New moon	1.54	p.m.
12-Apogee	7.0	a.m.
26-Perigee	9.0	a.m.
August—		
3-First quarter	12.0	noon
11-Full moon	3.57	p.m.
19-Last quarter	6.30	a.m.
25-New moon	9.17	p.m.
8-Apogee	1.0	p.m.
24-Perigee	3.0	a.m.
September—		
2-First quarter	3.28	a.m.
10-Full moon	6.8	a.m.
17-Last quarter	1.12	p.m.
24-New moon	6.34	a.m.
5-Apogee	3.0	a.m.
20-Perigee	10.0	p.m.
October—		
1-First quarter	9.45	p.m.
9-Full moon	7.37	p.m.
16-Last quarter	7.24	p.m.
23-New moon	6.42	p.m.
31-First quarter	5.45	p.m.
2-Apogee	9.0	p.m.
16-Perigee	6.0	p.m.
30-Apogee	5.0	p.m.
November—		
8-Full moon	8.23	a.m.
15-Last quarter	2.20	a.m.
22-New moon	10.5	a.m.
30-First quarter	1.59	p.m.
11-Perigee	2.0	p.m.
27-Apogee	1.0	p.m.
December—		
7-Full moon	8.22	p.m.
14-Last quarter	11.17	a.m.
22-New moon	4.7	a.m.
30-First quarter	8.53	a.m.
9-Perigee	11.0	a.m.
28-Apogee	5.0	a.m.

(Apogee.—The point in the moon's orbit farthest from the earth.)
(Perigee.—The point in the moon's orbit nearest the earth.)

CALENDAR FOR 1938.

JANUARY.						
Sunday	..	2	9	16	23	30
Monday	..	3	10	17	24	31
Tuesday	..	4	11	18	25	..
Wednesday	5	12	19	26	..	..
Thursday	..	6	13	20	27	..
Friday	..	7	14	21	28	..
Saturday	1	8	15	22	29	..

FEBRUARY.						
Sunday	..	6	13	20	27	..
Monday	..	7	14	21	28	..
Tuesday	1	8	15	22	..	..
Wednesday	2	9	16	23	..	..
Thursday	3	10	17	24	..	..
Friday	4	11	18	25	..	..
Saturday	5	12	19	26	..	..

MARCH.						
Sunday	..	6	13	20	27	..
Monday	..	7	14	21	28	..
Tuesday	1	8	15	22	29	..
Wednesday	2	9	16	23	30	..
Thursday	3	10	17	24	31	..
Friday	4	11	18	25	..	..
Saturday	5	12	19	26	..	..

APRIL.						
Sunday	..	3	10	17	24	
Monday	..	4	11	18	25	
Tuesday	..	5	12	19	26	
Wednesday	..	6	13	20	27	
Thursday	..	7	14	21	28	
Friday	1	8	15	22	29	
Saturday	2	9	16	23	30	

MAY.						
Sunday	..	1	8	15	22	29	..
Monday	..	2	9	16	23	30	..
Tuesday	..	3	10	17	24	31	..
Wednesday	4	11	18	25	..	..
Thursday	..	5	12	19	26	..	..
Friday	..	6	13	20	27	..	..
Saturday	..	7	14	21	28	..	..

JUNE.						
Sunday	..	5	12	19	26	..
Monday	..	6	13	20	27	..
Tuesday	..	7	14	21	28	..
Wednesday	1	8	15	22	29	..
Thursday	2	9	16	23	30	..
Friday	3	10	17	24	..	..
Saturday	4	11	18	25	..	..

JULY.						
Sunday	..	3	10	17	24	31
Monday	..	4	11	18	25	..
Tuesday	..	5	12	19	26	..
Wednesday	..	6	13	20	27	..
Thursday	..	7	14	21	28	..
Friday	1	8	15	22	29	..
Saturday	2	9	16	23	30	..

AUGUST.						
Sunday	..	7	14	21	28	
Monday	1	8	15	22	29	
Tuesday	2	9	16	23	30	
Wednesday	3	10	17	24	31	
Thursday	4	11	18	25	..	
Friday	5	12	19	26	..	
Saturday	6	13	20	27	..	

SEPTEMBER.						
Sunday	..	4	11	18	25	..
Monday	..	5	12	19	26	..
Tuesday	..	6	13	20	27	..
Wednesday	7	14	21	28	..	..
Thursday	1	8	15	22	29	..
Friday	2	9	16	23	30	..
Saturday	3	10	17	24	..	..

OCTOBER.						
Sunday	..	2	9	16	23	30
Monday	..	3	10	17	24	31
Tuesday	..	4	11	18	25	..
Wednesday	..	5	12	19	26	..
Thursday	..	6	13	20	27	..
Friday	..	7	14	21	28	..
Saturday	1	8	15	22	29	..

NOVEMBER.						
Sunday	..	6	13	20	27	..
Monday	..	7	14	21	28	..
Tuesday	1	8	15	22	29	..
Wednesday	2	9	16	23	30	..
Thursday	3	10	17	24	..	..
Friday	4	11	18	25	..	..
Saturday	5	12	19	26	..	..

DECEMBER.						
Sunday	..	4	11	18	25	
Monday	..	5	12	19	26	
Tuesday	..	6	13	20	27	
Wednesday	..	7	14	21	28	
Thursday	1	8	15	22	29	
Friday	2	9	16	23	30	
Saturday	3	10	17	24	31	

Extract From "Summary Report, Resolutions, and Reports of Committees" issued in connexion with the Fourth British Empire Forestry Conference—South Africa, 1935.

Tropical Forestry in Relation to Agriculture.

The importance of close co-operation between forestry, agricultural and other services, in promoting the general welfare of a country, was stressed, particularly in regard to the control of shifting cultivation with its attendant destruction of forests and all the evils that it entails. Such co-operation is already effective or is developing in some countries, e.g., the Gold Coast, Mauritius and Nyasaland.

In Nyasaland, excellent progress has been made by putting into effect the village forest scheme (explained in a paper) which puts reserved forest areas under control of the village headmen and gives the people a direct interest in them. All co-operative schemes must go hand in hand with education and demonstration in modified agricultural and pastoral methods to prevent loss of soil and to maintain the fertility of the land. Co-operation between forest, agricultural and other officers is necessary in the first instance in assigning areas for forestry and agricultural purposes respectively, so that environmental conditions required for specific crops such as cocoa, rubber, clover, &c., may be safeguarded. Each service has its special knowledge to contribute to the end that the best and most enduring results may be secured. Without the help given by forestry, the agricultural possibilities of a land decrease and may ultimately disappear.

Forestry also enters very definitely into the solution of the tsetse problem. In high forest, though tsetse may be present, animals are immune or tolerant; where forests have been destroyed there are found peak regions of fatal incidence of trypanosomiasis. In the control of this pest, co-operation by many sciences including forestry is essential.

Shifting cultivation, though usually a bad master, can be made into a good servant as exemplified in the "taungya" system which, when properly applied in the formation and regeneration of forests, serves the ends of both forestry and agriculture. Stress was laid on the fact that foresters should always be ready to step out of their own province in order to help agriculture, and to combat any prejudice that might exist to the effect that forestry has no application in agricultural or pastoral pursuits. The appointment of experts trained in the science of vegetation, to act as liaison officers between forestry and agriculture, was considered to be well worth consideration.

It was pointed out that timber exploitation in the tropics is generally somewhat speculative and that a selective technique is usually most appropriate in the exploitation of rain forests in the moist tropics both on silvicultural and on economic grounds. Highly mechanized methods of exploitation entail high capital costs and highly paid labour for operation and maintenance of mechanical transport. The view was expressed that where labour is cheap and efficient, it is not economical to go in for elaborate mechanization and that simple extraction methods which rely largely on hand labour for the operation of tramways, slides, &c., will prove more satisfactory and economical.

LEGISLATION.

THE COMMONWEALTH OF AUSTRALIA.

PAPUA AND NEW GUINEA BOUNTIES.

No. 35 of 1937.

AN ACT TO PROVIDE FOR THE PAYMENT OF BOUNTIES ON CERTAIN GOODS THE PRODUCE OR MANUFACTURE OF THE TERRITORY OF PAPUA AND ON CERTAIN GOODS THE PRODUCE OR MANUFACTURE OF THE TERRITORY OF NEW GUINEA.

[Assented to 16th September, 1937.]

BE it enacted by the King's Most Excellent Majesty, the Senate, and the House of Representatives of the Commonwealth of Australia, for the purpose of appropriating the grant originated in the House of Representatives as follows:—

1. This Act may be cited as the *Papua and New Guinea Bounties Act* 1937.

2. This Act shall commence on the first day of January, One thousand nine hundred and thirty-eight.

3. There shall be payable out of the Consolidated Revenue Fund, which is hereby appropriated accordingly, the bounties specified in this Act.

4.—(1.) The bounties under this Act shall be payable on the goods, the produce or manufacture of the Territory of Papua or of the Territory of New Guinea, which are specified in the Schedule to this Act, on importation into the Commonwealth for home consumption therein, provided that—

(*a*) the goods are imported either within the period prescribed in the third column of that Schedule or within the period prescribed in the Schedule to the *Papua and New Guinea Bounties Act* 1926-1936; and

(*b*) the goods have been imported direct from the Territory in which they were produced or manufactured.

(2.) The bounty payable in respect of any goods specified in the first column of the Schedule to this Act shall be payable at the rate specified in the second column of that Schedule opposite to the name or description of those goods.

5. Bounty under this Act shall not be payable—

(*a*) to any person other than the exporter or his authorized agent;

(*b*) in respect of any goods which are not of good and merchantable quality; or

(*c*) in respect of any goods upon which bounty has been paid under the *Papua and New Guinea Bounties Act* 1926-1936.

6. Every claimant for bounty under this Act in respect of any goods shall produce—

(*a*) a certificate signed by the principal officer of Customs at the port of shipment in the country of export that the goods are the produce or manufacture of the Territory of Papua or of the Territory of New Guinea, as the case may be; or

(*b*) such other evidence of the origin of the goods as the Minister requires.

7. The Minister may, in relation to any claim for bounty under this Act, require such information as to the correctness of any certificate produced under the last preceding section, or otherwise, as he deems necessary.

8. No person shall—

(*a*) obtain payment of any bounty under this Act which is not payable;

(*b*) obtain payment of any bounty under this Act by means of any false or misleading statement; or

(*c*) present to any officer or other person doing any duty in relation to this Act or the regulations any document, or make to any such officer or person, any statement, which is false or misleading in any particular.

Penalty: One hundred pounds or imprisonment for twelve months.

9.—(1.) A return shall be prepared not later than the thirty-first day of August of each year, and shall be laid before both Houses of the Parliament within thirty days after its preparation, if the Parliament is then sitting and, if not, then within thirty days after the next meeting thereof.

(2.) The return shall set forth in respect of the preceding financial year and in respect of each class of goods produced or manufactured—

(*a*) the number of persons, firms or companies to whom bounty under this Act has been paid;

(*b*) the total quantity on which bounty has been paid; and

(*c*) the total amount of bounty paid.

10. The Governor-General may make regulations, not inconsistent with this Act, prescribing all matters which by this Act are required or permitted to be prescribed, or which are necessary or convenient to be prescribed, for carrying out or giving effect to this Act, and in particular for prescribing penalties not exceeding fifty pounds for any breach of the regulations.

THE SCHEDULE.

First Column. Goods.	Second Column. Rate of Bounty.	Third Column. Period of Bounty.
1. Cocoa Beans, raw, whole or broken ..	1½d. per lb.	Ten years from and including 1st January, 1938
2. Cocoa Shells, raw	1½d. per lb.	Ten years from and including 1st January, 1938
3. Fibres, viz. :—		
(*a*) Manila and Sisal Hemp and other hard fibres known commercially as hemp, as determined by the Minister	£6 per ton	Ten years from and including 1st January, 1938
(*b*) Coir	£3 per ton	Ten years from and including 1st January, 1938
4. Sago, not packed for household use ..	1d. per lb.	Ten years from and including 1st January, 1938
5. Beans, Vanilla	2s. per lb.	Ten years from and including 1st January, 1938
6. Bamboos and Rattans, unmanufactured (including clouded)	£4 per ton	Ten years from and including 1st January, 1938
7. Spices, Unground, viz. :—Nutmegs, Mace, Pepper, Cloves and Ginger	1½d. per lb.	Ten years from and including 1st January, 1938
8. Other Spices, unground	½d. per lb.	Ten years from and including 1st January, 1938
9. Kapok	2d. per lb.	Ten years from and including 1st January, 1938

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EDITORIAL.

In this issue results are given of preliminary tests with insecticides against *Sexava spp.* (coco-nut tree-hopper). Since this was written the power dusting machine has been received and field trials will be proceeded with as soon as possible, but as it will be some time before these can be completed, the results referred to are published at this stage to show the line of investigation that has been started.

The value of coco-nut improvement by seed selection is dealt with at length and it is generally recognized that in these times of specialization in agricultural practice and keen trade competition, the most careful attention to detail is essential in order to obtain the best from agricultural pursuits.

A contribution on the dwarf coco-nut has been submitted by Mr. Hall, Madang District, and we would welcome further articles, of agricultural interest to the Territory, from other correspondents.

MEASURES FOR CONTROL OF COCO-NUT TREE-HOPPER (SEXAVA SPP.)

By John L. Froggatt, B.Sc., Entomologist.

Measures for the control of any pest must necessarily depend on its mode of living and propagating, and its general habits. In order to make the measures discussed readily understandable, it may be desirable to first give a very brief recapitulation of the life history and habits of the coco-nut tree-hopper (*Sexava spp.*).

The adults and nymphs live in the head of the palm, sheltering on the under-surface of the foliage and feeding principally at night. From about 6.30 p.m. the females crawl down the trunks to the ground (a few may volplane down) to deposit the eggs, which are laid singly just under the surface of the soil. The adults then re-ascend the palm by crawling up the trunk. The eggs take from 49 to 107 days to hatch (average 70 days); the young hoppers (nymphs) emerge mostly at night and ascend the palms within, at most, 24 hours after emergence. These pass through a series of "moults" (six for the male and seven for the female) occupying a period of 78–117 days for the male (average 92.4 days) and 90–124 days for the female (average 100.9 days). The adults mate after about two to three weeks and eggs are deposited about five to seven weeks after reaching the adult stage. Epiphytic growths on the trunks of palms are often favoured sites for egg deposition.

The early-stage nymphs are not the voracious feeders that the fifth to seventh instars and adults are.

In elaborating methods of control, for any insect pest, the economics of each case must of necessity be an all-important guide to measures recommended or undertaken.

During the depression period when copra was barely, if at all, paying expenses, only those lines of attack, requiring the minimum expenditure, warranted special attention. Foremost amongst these was—

Biological Control

or the use of other insects which prey on or pass their developmental stages within the body of some stage of the host.

Minute wasp parasites of the eggs were found on New Hanover in 1930, but failed to breed under laboratory conditions. This was later identified as *Doirania leefmansi.*

In 1933, the egg parasites, *Leefmansia bicolor* (*Encyrtidae*) and *Doirania leefmansi* (*Trichogrammatidae*) were introduced into the Manus District from Amboina. The former bred up freely in captivity, but colonies of the latter got weaker and weaker and finally were liberated on the chance that they might establish themselves in the field.

The egg parasites of *Sexava* known to occur in this Territory have been recorded in the *New Guinea Agricultural Gazette,* Volume 3, No. 2,

Parasite breeding over an extended period has shown that *Leefmansia bicolor var.* is very easily bred in captivity. *Doirania leefmansi* has proved difficult to breed in the field laboratory, yielding comparatively weak colonies. The *Mymarid sp.* although breeding freely in the field has failed to develop through even a single generation in the laboratory.

The results achieved in establishing *Leefmansia bicolor* have varied in different parts of the Territory. Within three months of starting regular liberations from the field laboratory, it has been recovered from the field; in some parts it has maintained the generations very successfully, and in others where this has not been so marked, other procedures are now being adopted to test out the influence of increased ground shade and windbreaks.

Biological control, where successful, although slow in attaining its object, calls for very little expenditure of either money or labour, in most cases.

Tanglefoot Bands.

Bands of tree tanglefoot around the trunks of the palms have been tested out, and with one preparation large numbers of first, and to a lesser extent, second stage nymphs have been "trapped", the bands remaining tacky for about four months. This might have economic possibilities in the early stages of an outbreak in a restricted locality, but is too expensive on a large scale.

Use of Insecticides.

With the greatly increased value of copra and the maintaining of a fair price, other methods warranted detailed study; foremost amongst these was the use of insecticides, which could be applied in either of two ways, spraying or dusting.

Spraying requires a large volume of soft water, and a high-power spraying outfit. In many parts, owing to the coraline nature of the soil, soft water is very difficult to obtain in quantity, quite apart from the cost of cartage of such. Salt water has been tested but has not proved satisfactory.

Dusting on the other hand requires no water, although requiring a power machine, but one much less expensive than a corresponding spray outfit.

During long leave in 1936, extensive inquiries were made by the writer, in England, and information obtained from the United States of America, on the latest types of dusting machines, and finally an English machine was selected, equipped with a four-stroke, six horse-power engine, which was ordered early in 1937.

Meanwhile laboratory cage trials were instituted with a number of insecticides, both arsenical and non-arsenical (derris and pyrethrum) to ascertain those which promised the best results in the field. Cages were made of copra-bed wire about 3 feet high and 2 feet in diameter, in which fresh coco-nut foliage was suspended and a number of *Seseva*, collected at night, was placed. The dust was then applied by means of a hand-dusting machine, and the number of deaths recorded over a period of three days. In each series, one cage was untreated, to act as a control.

The insecticides comprised both proprietary and experimental preparations supplied to the Entomologist by the manufacturers from England, Australia and America, for testing in connexion with this work.

The arsenicals comprised arsenate of lead (several different brands), calcium arsenate and Paris green.

The non-arsenicals comprised various preparations of derris (as pure powder, and total extractives, diluted with an inert filler) and pyrethrum; of this group both proprietary and experimental preparations were used.

The results with the former were very consistent; 5 per cent. of the insecticide (slaked lime being the dilutent) gave an average kill of 80 per cent. with arsenate of lead, 87 per cent. with calcium arsenate, and 90 per cent. with Paris green, deducting a common factor with the controls. On the other hand, the non-arsenicals gave very variable results, even with the same preparation, ranging from 48 per cent. to 59 per cent. under the same conditions.

At the date of writing, the power-dusting machine has not been received, but on receipt, field trials will be instituted with arsenate of lead and calcium arsenate; in these trials data on the quantity of insecticides per acre, time taken to dust a given area, number of treatments for control, &c., will be worked out.

Such a method of control would in no way interfere with the course of biological control, but would rather tend to supplement it.

Without the application of insecticides the following measures will have to be adopted:—

1. Lighting of fires to give a volume of hot smoke between the rows of palms, having a line of boys to collect and destroy the adults and nymphs coming down from the palm heads.

2. Collection of *Sexava* at night; the number of females collected at these times is greatly in excess of that of males, and prevention of deposition of numbers of eggs is thus brought about.

3. Collection of *Sexava* eggs.

4. Turning over the surface soil by hoes, &c.; in this way eggs are exposed to predators and are destroyed partly by dessication and partly by deep burying.

Poison Bait.

Paris green and bran baits have been tried both in the heads of the palms and on the ground. This method, although very successful with the ground-frequenting locusts, was of no value at all with these tree-frequenting species.

Other Suggestions.

These have included the use of flame-throwers, and aeroplanes. The former have proved themselves of great value on the swarms of young locusts on the ground, but the *Sexava* belong to a family that have totally different habits and do not swarm in this way. To use flame-throwers to destroy the eggs would require a considerable heating of the soil and probably result in damage to at least the roots of the palm close to the surface.

Aeroplanes.

Where there are very large compact areas of any one crop, aeroplanes have been reported to be successful for some insects. But again economics come into the question with copra, which is a comparatively small return per acre for any

costly measure of control. Moreover, the *Sexava* shelter on and feed from the lower surface of the foliage and can be reached more readily and cheaply from the ground than from the air.

Moreover, in the dusting trials it has been found that a high percentage of kill was obtained where the "hoppers" had fed on fresh foliage but had crawled over dusted edges and so got a very small amount of the poison on legs and antennae, which were cleaned through the mouth. Thus dusting from the ground will powder the insects as well as the foliage.

WEEVIL PESTS OF COCOA.

By John L. Froggatt, B.Sc., Entomologist.

Two species of weevils, or "snout beetles," have been bred from cocoa trees, one being a pest of economic importance.

Pantorhytes Plutus, Oberth.

The adult beetle is about three-quarters of an inch in length, head, thorax and hind third of elytra (wing covers) and under surface of body and legs, black; one medium green stripe and one lateral green stripe on each side of thorax, and black portion of elytra marked with green stripes or spots. The snout is short and thick.

The point of attack may be anywhere on the stem or branches, a fork in between branches being especially favoured, heavy gumming arising at every site of infestation.

The eggs are laid in the bark, apparently singly, for only one larva is found in each channel. The grubs tunnel along the soft, woody tissue just under the bark, which is ultimately killed over the site of infestation, leaving a ragged opening, and seriously affecting the branch attacked. As a general rule the channel is more or less straight, but especially in cases of attack in a fork the branch may be completely girdled and the centre of the fork bored into.

The adults feed on both the bark and leaves, but more on the former. A trial was made on one plantation of spraying young trees, on which the beetles were very prevalent, with arsenate of lead, and the manager reports that the pest has been very considerably reduced by this means.

A trial was also made with paradichlor-benzene introduced into the channels, but proved a failure in killing the grubs, the mass of gum apparently hindering sublimation of the chemical and preventing penetration of the fumes into the head of the channel.

Pantorhytes plutus, the green cocoa weevil, has been collected in several parts of the Territory, but has only been recorded as a pest on portions of New Britain.

Diplerous larvae are nearly always present in the gum, but are apparently only scavengers.

Orthorrhinus Patruelis, Pasc.

This weevil has been bred from a small green branch of a cocoa tree, but is apparently not numerous. The adult beetle is dark brown in colour, and about half an inch in length; the surface of the elytra is rough and the snout of moderate length.

ARTIFICIAL CONTROL OF INSECT PESTS.

By B. A. O'Connor, B.A., B.Sc.Ag., Assistant Entomologist.

In a previous article in this *Gazette*,* biological control of insect pests was dealt with, and it was stated that, where this method could be successfully employed, it was ideal. However, most insect pests can be controlled only partially, or not at all, by parasites, and in these cases, artificial methods must be used. These may be roughly classified under two heads, preventive and curative, though there is a good deal of overlapping. The former are of course to be preferred to the latter, other things being equal.

Preventive methods may be grouped as follows:—

(*a*) Quarantine.

(*b*) Cultural.

(*c*) Use of resistant strains.

(*d*) Repellents and lures.

(*a*) *Quarantine.*—The object of quarantine regulations is, of course, to keep out of a country or district pests which do not already exist there, and which, if introduced, would cause damage to property. Most countries in our day have stringent quarantine laws covering a large range of insect pests, and these laws are frequently administered in a drastic fashion. An example of the application of domestic quarantine in the United States of America will serve to show how severe is the legislation enacted to restrict the spread of an insect pest which is a great potential danger.

Several years ago, it was discovered that the Mediterranean fruit fly, a destructive pest mainly of stone fruits, had made its entry into the fruit-growing areas of Florida, despite quarantine laws designed to keep it out of the United States of America. A large staff, totalling 70 entomologists, was immediately sent to cope with the danger, supported by large numbers of workers and a huge vote of money from Congress. It was realized that should this insect spread throughout the huge fruit-growing areas of Florida, it would cause immense loss, as it had done in the Mediterranean countries and elsewhere, including Australia. Fifteen thousand acres of orchard and virgin land were quarantined, including all areas where there was any likelihood of the fly having spread, and in this area, every fruit, wild or cultivated, was destroyed, though only a very small proportion was fly-infested. These measures were apparently successful in combating the menace, and Florida thus holds the record of being the only country where the Mediterranean fruit fly has become established and has been wiped out.

There are various opinions as to the effectiveness of quarantine of imports from other countries, some well-informed observers contending that the money spent in policing the regulations is largely wasted, and that it would be better spent on a concentrated campaign to wipe out each pest after it had been introduced from abroad. This is a very doubtful contention, for such a policy would necessitate prompt information as to the occurrence of any such insect, information which might easily not be forthcoming until too late. It would seem that a country or State with few points of entry should have an excellent chance of keeping out unwelcome insect visitors, and there is always the second line of defence if the pest

* See *New Guinea Agricultural Gazette*, Vol. 4, No. 1, January, 1938, p. 13.

does manage to penetrate the outer barriers. Western Australia has had signal success in excluding the codlin moth, present in the other States of the Commonwealth. The import of pome fruits, which the codlin moth attacks, is forbidden, but on about a dozen occasions the moth has become established in the apple orchards of the south-west. Nevertheless, it has been invariably wiped out, thanks to a rigid system of orchard inspection and quarantine of affected areas. In no other country has this pest been controlled once it has made its entrance. Immunity from the ravages of the insect means many thousands of pounds annually to Western Australia, and pays over and over again for the cost of enforcing quarantine regulations.

(b) Cultural Methods.—In the control of many insect pests, it has been found that correct cultural practice, and in some cases, special cultural methods, can play a big part. Such activities as the cleaning up of trash and stubble, or the burning over of harvested areas, are common-places of good farming for many crops. In the case of the rhinoceros beetle, a local pest of coco-nut palms, similar action is taken. It has been found that the destruction of surplus decaying vegetable matter on a plantation checks the activities of this insect, destroying its favourite breeding grounds. Similarly, wheat crops sown on weedy ground in Australia are subject to plagues of certain species of cutworm, whereas this trouble is avoided by utilizing clean fallow for sowing the crop. There are many such instances, all indicating that correct methods of agriculture can do much to limit the increase of injurious insects.

Ploughing and cultivating are useful also in that they expose insects living in the ground to the weather, and to the attacks of birds and other natural enemies, and also sometimes make the condition of the soil unsuitable for the development of these insects. On the outer fringe of the farming areas in Western Australia, for instance, much trouble has been experienced from the plague locust. This insect lays its eggs in hard, bare patches of ground, and the abandonment of many farms during the depression period provided large areas of cleared land suitable for this purpose. Ring-barked paddocks which had not been ploughed were also favoured breeding grounds. The only way to forestall a plague of locusts is to plough up the ground where the eggs are laid, exposing them to the sun, wind and natural enemies. Similar action would, no doubt, be useful in the case of the coco-nut tree-hopper (*Sexava spp.*) in this country, were ploughing and cultivating practicable, and in line with the cultural practice generally adopted.

Manuring has also been used to counteract the ravages of insect pests, as for instance in the case of the shothole borer of the tea plant in Ceylon. This borer girdles the branches with its gallery, and they frequently break off, causing considerable loss. However, it has been found that by the application of certain manures, chiefly nitrogenous, the plants are made more robust, and the loss of branches is considerably reduced.

Another practice which is often resorted to is the planting of "trap crops". These are favoured food plants of the pest which it is feared will attack the main crop. The trap crops are planted around the commercial crop, and are sown earlier, so that they reach maturity more quickly. When they are heavily infested by the noxious insect, trap crop and pest are destroyed, and thus a large number of insects which would otherwise have attacked the main crop are diverted and killed.

(c) *Use of Resistant Strains.*—Much work has been done on the breeding of plants which will resist the attacks of insects, and some good results have been obtained. Various methods are employed, including continued selection of the most resistant plants in a succession of crops, cross-breeding of two different varieties, and grafting of prolific but susceptible varieties on to a resistant stock. For instance, the Northern Spy apple has been freely used as a stock on to which commercial varieties are grafted, the Northern Spy being resistant to the attack of woolly aphis, which feeds on the roots as well as the aerial portions of the tree. Similarly, resistant stocks have been employed against the vine louse, *Phylloxera vastatrix*. Little has been done in the breeding of resistant animals, but one of the recommendations of students of the sheep maggot fly problem in Australia is that an effort should be made to breed out the wrinkles in the neck of the merino. The rancid grease collecting inside these wrinkles stimulates the fly to deposit its eggs there, and makes a suitable environment for the maggots. The wrinkles are, of course, the result of a deliberate breeding policy designed to increase wool production.

(d) *Repellents.*—Repellents usually take the form of chemical substances obnoxious to the insect pest concerned, though occasionally a crop is surrounded by a belt of some other crop distasteful to the pest, thus preventing the latter from approaching the threatened plants. Such a system is used against certain species of army-worm (caterpillars which attack in mass formation) in Australia. A protective barrier of oats, which the caterpillars dislike, is grown round the crop of wheat, which would be destroyed in an amazingly short time if the army-worms could gain access to it. Chemical repellents are frequently used to protect stock against the attacks of such irritating insects as stable-flies, blow-flies and buffalo-flies. The repellent, which may be a preparation of tar oil or crank-case oil, is sprayed on the animal, and helps to give it relief from its annoying enemies. A common practice in Australia is the "jetting" of sheep, that is spraying an arsenical solution under strong pressure in and around the crutch of the animal, to ward off the attacks of the sheep maggot-flies. This is supposed to derive some repellent action from its checking of bacterial action in the grease and dirt which fouls the wool, but it of course has the important effect of killing newly-hatched maggots which attempt to feed in the wool.

Other repellents go hand in hand with the forecasting of insect outbreaks. Some very effective work has been done in forecasting, the basis of the scheme being close observation of meteorological and other factors which favour the multiplication of the pests. When these have been tabulated for a number of years, and correlated with the activities of a pest, it is sometimes possible to predict the advent of destructive hordes, and thus provide an opportunity for the timely employment of preventive measures. In Australia, much is hoped from this system in the control of apple thrips, a destructive pest which every now and then assumes plague proportions, and may cause the total loss of the apple crop of a whole district. It is proposed to use repellent sprays on the apple buds when an attack is predicted, and thus keep the thrips off sufficiently long to allow fruit to set.

Attractants, though working in a way diametrically opposite to that of the repellents, are designed to produce the same effect, that is to keep insect pests away from a threatened plant or animal. Trapping of fruit-flies and blow-flies is

carried out extensively in Australia, the principle being the same in each case. A lure is placed in a trap, from which the insect, once it has entered, is unable to escape. Decaying meat is used to attract the blowfly, and various aromatic substances for the fruit-fly. Baits, also, are laid for fruit-flies, consisting of molasses and water containing a small quantity of poison. The bait is sprayed here and there on the leaves of the fruit tree, and the flies which are attracted to it sup up the fluid and are killed.

A method of prevention which has been experimented with locally against *Sexava* is "banding", that is, applying a band of adhesive material, somewhat similar to tanglefoot, to the trunks of palms in an area affected by the tree-hopper. The tests were made in Manus, where the great majority of the eggs of the insect are laid in the ground, the object of the bands being to trap any young *Sexava* which attempted to ascend the trunks of the palms after hatching from the eggs. During a period of between four and five months, the average catch per palm amounted to over 600. It must be remembered that the experiments were carried out in a very badly affected area, where the numbers of *Sexava* were huge. If an area of palms were treated in the early stages of an outbreak, it is possible that the bands might effect successful control. Similar bands give good results in Australian orchards.

The methods of artificial control which may be classed as curative, consist of the poisoning of the insect pest by spraying, dusting, fumigation and dipping. Spraying and dusting of plants attacked by insects are by far the most common methods of pest control, and generally give good results. In some cases, of course, it is not economically possible to use these methods, because the value of the crop is not sufficient to pay for the plant and materials necessary. However, orchardists and truck-crop growers throughout the world use vast quantities of materials in regular spraying and dusting programmes, and though the cost is considerable, the outlay is repaid many times over by the increased yield of crops. In the eastern States of Australia, for instance, apple trees have to be sprayed several times annually, in order to reduce the ravages of the codlin moth. Spraying for some purposes may be slightly cheaper and more thorough than dusting, while the latter has the advantage of mobility of plant and speed of application.

Some of the materials used kill by being ingested by the insect with its food, and setting up internal poisoning. Others, the "contact" insecticides, asphyxiate the insects on to which they are sprayed, while a third type, such as extracts of derris root, kills in both ways. The type of spray or dust used depends mainly on the feeding habits of the insect concerned. Some orders of insects, such as the *Hemiptera* (bugs, aphids, &c.), feed by inserting a long proboscis into the tissues of their plant or animal host, and sucking up the juices. Other orders, such as the *Coleoptera* (beetles) chew their food, while the *Diptera* (flies) include those which sup up surface fluids, as well as sucking species. A poison spray applied to the surface of foliage is of no use against a sucking insect, as it obtains its food from inside the leaf, so in this case contact insecticides are used. Some of the best known of these are oils, nicotine, derris and resin and soda washes. For the chewing type of insect, internal poisons are used, and arsenical preparations predominate, though the desire to employ something less dangerous to man and the higher animals has encouraged the use of derris, and various fluorides and fluosilicates. Some insects can be killed by internal poisons even though they may not ingest these

with their food. Among such are cockroaches and our local coco-nut tree-hopper (*Sexava spp.*). These pests have a habit of cleaning themselves by passing their feet and antennae through their mouths, thus removing any adhering particles of dust. Hence, if a poison dust is projected on to them, they frequently absorb a lethal dose in this way. This method is frequently used against cockroaches, sodium fluoride, which is non-poisonous to humans, being freely dusted in cracks and crevices and other haunts of the 'roaches. As the insects pass through the dusted area, a number of particles adhere to them, which they clean off later with fatal results. With such a wary feeder as the cockroach, this method is probably superior to any other.

It is hoped that successful control of *Sexava* will be obtained by dusting affected palms, and in this connexion many laboratory experiments have been carried out to ascertain the lethal effect of various dusts. At present, it appears that calcium arsenate possesses the best combination of cheapness and efficiency, and it has been shown by experiment that it kills the tree-hopper through both the cleaning habits and the feeding of the pest.

The practice of dipping probably needs little description here, as most people know of the regular dips given to sheep and cattle to control lice and so-called tick in the former, and tick in the latter. These dips are arsenical preparations, and experience has proved them to be most effective, so much so that legislation compels their use

Finally, there is the widely used control measure of fumigation. This is commonly employed against the pests of stored products, such as grain weevils, dried fruit moth and numerous others, and is also a standard method of controlling household pests and the scale insects attacking citrus trees. For stored products, the commonly used fumigants are carbon bisulphide, chlorpicrin, and hydrocyanic acid gas, while the last-mentioned substance is employed for citrus tree fumigation and house fumigation practically to the exclusion of all others. Hydrocyanic acid is sold in the form of powder, which, on exposure to damp air, gives off the gas. Fumigation of citrus trees is carried out under special gas-proof tents, and is an operation calling for knowledge and care. It is done at night, so that the air will be damp and the heat of the day avoided, but dew must not be present on the leaves, otherwise the gas dissolves in the dew, causing severe burning of the foliage. Of recent years, vacuum fumigation has been increasingly used with stored products such as grain, where difficulty might be experienced in securing a thorough distribution of the gas throughout the bulk of the material. Where vacuum fumigation is used air is drawn out of the space to be fumigated, and the fumigant is then liberated, and is drawn into the most inaccessible spots by the partial vacuum created. This ensures that fumigation is thoroughly carried out.

LOCAL TIMBERS FOR PLANTATION BUILDINGS, AND NOTES ON NON-INDIGENOUS HARDWOODS.

By G. E. Bliss.

The exports of timber from this Territory have advanced rapidly in the last two years and now form a valuable addition to the territorial income. These exports, however, are all in the form of logs and the imports of milled building

timber are still considerable. During each of the last two financial years timber was imported to the value of over £11,000, and to this must be added the heavy cost of freight and handling. There is also a large quantity of furniture imported which might be made locally.

It seems possible that, as far as Rabaul and other main ports are concerned, it may always be cheaper to import timber; the obstacles to the establishment of saw-mills sufficiently large to cope with the demand are considerable. Two main drawbacks are:—

Firstly, lack of pure stands. With the exception of small areas of kamerere in New Britain and the *araucaria* belts in the highlands, the New Guinea bush is very mixed forest, rarely containing as much as 10 per cent. of any one species.

Secondly, lack of virgin country. Nearly all the New Guinea bush has been and is being marred, from the timber-getter's point of view, by the shifting cultivation and wasteful methods of the kanaka. The native obtains such timber as he requires in the sapling stage; uneconomically and often, unfortunately, before it is old enough to bear seed and regenerate itself. Matured timber trees are useless to him and in making new clearings for food crops he rings these, with axe or fire, or fells them. He leaves, however, such trees as bear edible fruits and it is fortunate that these include such useful timber species as "Tun", "Talis", and "Lup". These methods, combined with the lighting of hunting fires, have, in the course of generations, greatly altered the rain-forests of the country and gradually converted a large portion of them into kunai land, maintained as such and further extended by seasonal burnings. The remaining forest land has also suffered radical alterations and now consists very largely of secondary growth interspersed with food-bearing trees; a type of country which is, as a rule, not very suitable for the large-scale saw-miller.

It is, however, a type of country which is generally capable of providing ample supplies for the limited needs of a plantation and this article is written in the hope of assisting those planters who may be interested in producing their own timber. Many planters already do so; there are several plantations in this Territory on which all the buildings have been constructed from native woods. But there are also many plantations, surrounded by suitable bush, where all building material has been imported.

Owners and managers of such plantations may have been influenced by the theory that the cost of the necessary equipment would render local production uneconomic. Extensive and expensive machinery is not necessary for milling on a small scale. Logs can be pit-sawn where felled into slabs up to 6 or 7 inches in thickness and brought in by road or water to a small plant consisting of a 24-in. circular saw bench, a power planer and a heavy duty oil engine of about 3 b.h.p. Total landed cost of such equipment should not exceed £150.

The cost of building timber on plantations is generally allotted under two heads, viz., construction and maintenance, the latter including minor alterations and improvements. The writer, who admits to a lack of building and costing knowledge, estimates the first as averaging well over £1,000; and the second at about £100 per annum. The latter item alone, if approximately correct, should warrant an attempt at local production.

The following include some of the more common timber trees of the Territory: many of these are now being exported to Australia for the manufacture of plywood and veneers. Some of them are too small to interest the exporters but are

nevertheless, sufficiently large for plantation requirements. Their pidgin names are given, where possible, as a means of identification.

Intsia (Afzelia) bijuga—"Kwila".—This timber is too well known to need description. Makes an excellent, though heavy, furniture wood.

Pometia pinnata—"Towan" or "Tun". Another well-known timber, not quite as hard and durable as "Kwila", but easier to work. Rots quickly in the ground unless well tarred.

Eucalyptus naudiniana—"Kamerere".—Grows only in New Britain, but is worthy of introduction to other parts of the Territory. It, and *Eucalptus deglupta* (which occurs in the Celebes and the Philippines and is held by some botanists to be identical with the local species), are the only eucalypts which thrive at sea-level in the tropics.

Calophyllum inophyllum. Common on nearly all the beaches of the Territory; unfortunately, its habit of growth makes it difficult to secure timber of any length. It is a very popular boat-building timber in Malaya.

Vitex cofassus—"A-sang" or "Sang".—A hard, straight-grained, brown timber with yellow sapwood; has been described as "New Guinea Teak".

Dracontomelon spp.—"Lup".—Large, heavily buttressed trees with edible fruits. Yield fair wood.

Albizzia spp.—"Poun-poun". Several of the indigenous *Albizzias* yield good hardwood; the commonest, *Albizzia procera*, is generally found among and in competition with kunai (*Imperata cylindrica*) and should be very useful in re-afforesting kunai land. It is rather small for a milling timber but makes good round posts which last well in the ground.

Hibiscus tiliaceus—"Mungas". A small tree which is readily recognizable by its hibiscus type of flower which is yellow with a reddish-purple centre. It is generally found, like *Calophyllum*, on or near beaches and has much the same gnarled growth. The sapwood is perishable, but the purplish brown heartwood is tough and durable.

Canarium spp.—"Galip".—Yield a moderately hard wood which, however, seems very liable to insect attack and is not very durable. Moreover, the trees, being valued for their fruits, are not readily available. However, their long, straight boles supply good lengths of timber, which, suitably treated, should be useful for ceilings and inside work.

Octomeles sumatrana—"Erima".—A large tree with a long, buttressed bole. Provides a rather soft, light wood, nicely grained and suitable for all interior work.

Glochidion sp.—There is, apparently, no pidgin name for this tree; it may be recognized by a furrowed, grey bark and a small fruit which contains a number of red, wedge-shaped seeds attached to a central core. Yields a hard, tough, reddish timber.

Terminalia calappa (and other *Terminalia spp.*)—"Talis".—These are common throughout the Territory and are conspicuous for the autumn-tinting of their foliage just before leaf fall. They yield a good, durable timber, elastic and easily worked, but since they also bear an edible nut it is, as in the case of Galips, difficult to purchase the trees from natives.

Heritiera littoralis.—Has been called "Looking Glass Tree" and is recognizable by the reflecting sheen on the lower side of the leaves. Generally found on or near beaches and yields a tough, hard, dark-brown timber; unfortunately, the tree is often gnarled and low branching.

Alstonia spp.—"Ai-ting".—This genus, which may be distinguished by its panicles of white, scented flowers and the latex which can be obtained from leaves and bark, is represented by three (possibly more) species in New Guinea. One, *Alstonia scholaris*, yields a soft wood which is not recommended for anything but case-making, but there is another species, possibly *Alstonia longissima*, which yields a hard, very durable, cream-coloured wood.

Pterocarpus indicus.—This is one of the best of the New Guinea hardwoods; other species of this genus yield "Padauk" which is exported in large quantities from Burma and the Andaman Islands. The local species is a large tree with yellow flowers borne on axillary racemes and the fruit is a round, single seeded, winged pod. The timber varies from pale yellow to red, and is considerably lighter than "Kwila" or "Tun". Makes an excellent furniture wood. Has no pidgin name, but the following local names may assist in its identification:—E-Yoh (Gasmata), Sae Lupae (Aitape), Surum (Wosika dialect of Karkar, Madang), Saiko (Nakanai), Tangi (Manam and Lower Ramu).

The above list is, of course, by no means complete. Different districts vary largely in their range of timbers available and local knowledge and the local natives will, no doubt, be able to suggest other trees worthy of trial.

Afforestation is generally, by reason of its long-delayed returns, a concern of companies and governments rather than individuals, but some planters may be interested in the planting up of non-indigenous hardwoods. The following notes are based, mainly, on observations of trees introduced to, and growing in, the Botanic Gardens, Rabaul. Most of the trees mentioned below are growing as specimen trees and have, therefore, larger girths than they might have attained in a timber plantation, although they have, however, been handicapped by the poor pumice soil of Rabaul. An asterisk (*) indicates that seed can be supplied.

Teak (*Tectona grandis**).—This is not really suited to the damp, non-seasonal climate of New Guinea, but the trees in the Botanic Gardens (now about 28 years old) flower and seed freely and have girths up to 7 ft. 9 in.

Mahogany (*Swietenia mahogani* and *Swietenia macrophylla**).—These are doing well. One of the latter, planted about 1910, has a girth of 6 ft. 5 in.; the former, planted ten years ago, girths up to 3 ft. 11 in.

East Indian Walnut (*Albizzia lebbek**).—This yields a good hardwood which has been used as a substitute for walnut. It is a quick grower and was planted in Rabaul as an avenue shade tree. Unfortunately, it has proved liable (as have many of the *Leguminosae*) to attack by fomes.

Trincomalee Wood (*Berrya cordifolia**).—Only one specimen of this is present in the gardens. It has a girth of 3 ft. 2 in. at eight years old.

Crabwood (*Carapa guianensis*).—This is also represented by a single specimen which has apparently suffered some damage in its early stages of growth. Planted in 1932, it now has a girth of 20 inches.

Spanish Cedar (*Cedrela odorata**).—This appears to flourish here; trees planted 28 years ago now show girths up to 7 ft. 4 in.

The above are timbers with an established commercial reputation. The following, which are not so well known, are all good hardwoods which have proved suited to local conditions:—

*Tamarindus indica** (Tamarind).
*Artocarpus integer** (Jakfruit).
*Adenanthera pavonina** (Bead Tree).
*Cassia fistula** (Indian Laburnum).
Filicium decipiens.
*Lagerstroemia flos-reginae** (Indian Lilac).
*Michelia champaca** (Champak).
*Myroxylon balsamum** (the source of Balsam of Tolu).
Pericopsis mooniana.

Dipterocarpus grandiflorus, which provides the "Apitong" which is imported into this Territory from the Philippines, has never been tried here, but should do well.

Trees planted for timber should be grown as far as possible under forest conditions. Specimen trees and trees planted in avenues may grow more quickly, but they generally branch too low and fail to form long straight boles.

KAMARERE (*EUC. DEGLUPTA* (*NAUDINIANA*)).

By C. E. Lane Poole, Inspector-General of Forests, Canberra.

In New Britain kamarere (*Euc. deglupta* (*naudiniana*)) occurs as a very fine riverine type thriving best in pure stands on the alluvium in a valley which is flat enough to be subject to annual flooding in the height of the rainy season which in New Guinea occurs in the north-west monsoon.

The species come under the category of a giant gum, for it towers to a height of 240 feet, and yields timber both in size and quality which rivals that of the great gums of Australia.

After the undergrowth has been removed, a stand of kamarere resembles in appearance the mountain ash forests of Victoria (Australia). The trees shed their bark in the same way, and, although the colour of the boles is darker—sometimes purplish—the species are very much alike.

The crowns of the kamarere, however, carry more spreading foliage, and the leaves do not hang down straight like the more sclerophyllous of the eucalyptus species, but spread out straightly. The leaves are, moreover, of less leathery texture.

The volume of timber yielded by the kamarere may be gathered from the following measurements of a tree felled some time ago for the Korindal Mill in New Britain:—

1. Log, 20 feet in girth, 8 feet long.
2. Log, 18¼ feet in girth, 16 feet long.
3. Log, 15 feet in girth, 18½ feet long.
4. Log, 14 feet in girth, 19½ feet long.
5. Log, 13 feet in girth, 18½ feet long.
6. Log, 12½ feet in girth, 29½ feet long.
7. Log, 11½ feet in girth, 18½ feet long.

The length of the eight logs into which the millable portion of the tree was cut measured 136½ feet, and the solid content of the logs was calculated at 2,120 cubic feet or 25,419 superficial feet. The volume of timber recovered after milling these particular logs is not known, but, owing to defects, it would probably not exceed one-third of the total.

A survey was made of an area of 14 acres which was chosen as being a patch of timber that could be taken as fairly representative of the timber lands at Korindal in New Britain. Other species besides kamarere were on the area, and details of measurements were taken of these trees as well. The table set out below gives an excellent idea of the volume of kamarere timber yield on the area:

Species.	Number of trees.	Cubic Contents.			Percentage.		
		Total.	Per tree.	Per acre.	Trees.	Cubic feet.	Trees to acre.
Eucalyptus naudiniana ..	103	185,408	1,800	13,243	85.8	98.6	7.5
Pometia pinnata ..	5	646	129	46	4.2	0.13	0.3
Dracontomelum mangiferum	10	1,716	171	122	8.3	0.9	0.7
Celtis sp.	1	202	202	14	0.85	0.1	0.07
Vitex cofassus	1	210	210	15	0.85	0.1	0.07
Total	120	188,182	..	..	..	..	..

Realizing that it was possible that the species would succeed equally well in other countries, seed was obtained and despatched to many different places, including India, Africa, West Indies, Federated Malay States, Philippine Islands, Palestine, British Honduras and Mauritius.

While many failures were experienced, results in many places have been such as to show that the species is likely to become established and prove an equally valuable timber tree in its new setting as in its native habitat. A tree planted out as a seedling at Port of Spain, Trinidad, British West Indies, in 1928, when measured in November, 1936, eight years later, had attained a height of 65 feet and a girth of 3 ft. 10 in., whilst another planted the same year was of about the same height, but with a girth of 4 ft. 9 in. Others planted at the same time were 55 feet (24-in. girth) and 50 feet high (19-in. girth). Seedlings planted out in 1935 were 6 feet to 8 feet at the end of the first twelve months.

At Burma, India, trees reached a height of 17 ft. 6 in. in twelve months.

The Forest Research Institute of Kepong, Federated Malay States, reported that trees in eight years from planting out had attained girth measurements of up to 18½ inches.

Reports from Africa are equally encouraging. Seedlings planted out by the Forest Department at Uganda in 1934 a year later were 2 feet high, and, while one tree only gained 5 feet in height in the next twelve months, a companion tree added to its stature to the extent of 25 feet, due, no doubt, to the more favorable situation.

The Forest Department at Kenya has a tree which, at four years from planting out, was 30 feet high, and the trunk at breast height measured 17½ inches.

Many of the experimental plantings have been so highly successful that further supplies of seed will be distributed with a view to permitting further sowings to be made.

It is a matter of interest that it has been found that kamarere has successfully withstood 4 degrees of frost, and also that trees have succeeded on upland country as well as under riverine conditions.

METEOROLOGICAL DATA, KIETA.

By B. G. Challis.

The town of Kieta, situated 6° 13′ S., 155° 39′ E., on and in the hills about the western and southern shores of Kieta harbour on the east coast of Bougainville Island, is the principal administrative centre of the Kieta District. The harbour is extremely well sheltered from prevailing winds, especially in the north-west season, by the protecting nature of the surrounding country, which is extremely mountainous. These mountains extend to the north, west and south of the harbour and reach from 1,000 to 3,000 or more feet above sea level within five to ten miles from the town.

Above the 3,000-ft. altitude, about six miles from the sea, rain falls almost every day and mists and fogs are common, while at lower altitudes nearer the sea the rainfall is not so heavy but is more or less seasonal. In Kieta itself the force of winds is greatly reduced by the high mountains surrounding the harbour, and consequently the temperature there is hotter than in more exposed localities; and for the same reason the rainfall in the harbour is also affected. The average annual rainfall for the past 21 years is 119.19 inches.

Sea-planes could descend on and ascend from the harbour safely, and there is a small privately owned aerodrome just outside the southern boundary of the town.

The basic rocks round Kieta give rise to a stiff clay soil except on the sandy foreshores. In some cases, close to Kieta the foreshore is higher than the land at the base of the foothills where water tends to collect. The country rock comes close to the surface and there is a good deal of erosion as for example in Toberoi some six miles away. The surrounding gullies contain talus materials which have fallen from the higher hills behind.

The Government Geologist, Mr. N. H. Fisher, M.Sc., reports as follows on the geology of this district:—

"The topography of the inland portion of Bougainville is exceedingly rugged. Mountains rise to a maximum height of 10,000 feet and in general the country consists of streams occupying steep-sided gorges between mountain ridges. In

many places, some near Kupei gold-field (six miles from Kieta), sharp peaks or knots occur with nearly vertical, bare rock faces. The mountainous country is bordered by a coastal flat usually a few miles wide on the north-east side of the island, while on the south-west, at Empress Augusta Bay, this coastal flat comprises an extremely large tract of country which is separated from the Moroni, Punkuna area by a series of river gorges. In the upper reaches of the Kavarong, a reasonable extent of river flats and terraces are found. Climate at Kupei is generally warm in the morning, wet in the afternoon and cool at night . . .

At Kieta itself a tuffaceous conglomerate occurs in association with a porphyritic augite andesite."

The rainfall is high and evenly distributed throughout the year; there being practically no difference between wet and dry seasons. The north-west season is from October to February and the south-east season from March to September. The annual average relative humidity for 9 a.m., 3 p.m. and 9 p.m. readings is 79, 78 and 84 per cent. respectively.

Unfortunately, apart from the Government Station at Kieta, rainfall data is not available on the Island of Bougainville except at Hakau Coffee Estate some forty (40) miles north of Kieta, on the east coast.

The Department of Agriculture would welcome rainfall records from plantations prepared to furnish such meteorological records in this district.

Rainfall records at Kieta and Hakau are set out in the following tables:—

MONTHLY AND YEARLY TOTALS OF RAINFALL AT KIETA DISTRICT (IN POINTS).

STATION—KIETA.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Total.
1917 ..	1,388	1,150	3,387	1,056	1,327	604	1,655	1,005	1,255	959	1,529	732	16,933
1918 ..	1,298	683	1,733	814	756	987	1,304	1,537	1,274	741	678	502	12,307
1919 ..	407	736	790	1,738	550	882	557	822	869	817	684	873	9,815
1920 ..	1,286	921	1,001	549	1,060	1,911	1,377	322	388	1,177	1,034	952	11,978
1921 ..	1,040	1,027	1,475	1,069	585	1,950	2,231	598	1,595	1,352	1,044	1,870	15,836
1922 ..	1,557	1,157	885	2,161	730	1,214	517	194	884	1,125	980	1,124	12,528
1923 ..	819	825	1,148	723	1,513	1,431	698	830	759	602	1,144	997	11,537
1924 ..	1,656	553	*	*	202	249	489	1,087	1,766	872	*	*	*6,874
1925 ..	479	603	1,352	2,243	698	980	519	2,029	914	776	710	133	11,436
1926 ..	902	558	388	1,434	1,128	447	1,278	1,716	1,134	1,007	1,212	1,265	12,469
1927 ..	1,952	3,602	1,019	1,350	1,345	644	919	804	628	718	850	1,217	15,048
1928 ..	515	2,134	1,951	1,196	1,482	413	1,533	940	824	2,701	1,287	610	14,695
1929 ..	769	*	862	811	675	587	707	1,603	1,302	1,102	632	525	*9,575
1930 ..	1,449	717	430	773	1,360	666	1,129	835	605	970	260	1,034	9,918
1931 ..	1,540	818	1,101	1,205	929	1,044	858	540	1,209	603	1,554	1,002	12,463
1932 ..	946	1,196	683	647	994	388	912	1,038	678	411	502	1,602	9,997
1933 ..	703	1,567	733	2,036	893	559	1,220	1,800	571	1,159	669	1,338	13,248
1934 ..	1,941	842	878	905	450	1,202	1,533	1,148	524	871	487	1,000	11,781
1935 ..	563	995	865	726	1,020	394	502	219	165	903	1,165	357	7,874
1936 ..	873	722	743	393	406	1,100	900	504	407	1,278	1,569	413	9,308
1937 ..	771	279	1,161	783	830	737	1,741	385	1,003	623	715	538	9,572
Average	10.80	10.55	10.83	11.31	9.01	8.76	10.75	9.93	8.93	9.94	9.35	9.03	119.19 inches

* 1924 and 1929 incomplete.

METEOROLOGICAL RECORDS.

HAKAU COFFEE ESTATE (40 MILES FROM KIETA).

Month.	1937.		Rainfalls.		Wet days.	
	Rainfall.	Wet days.	Period.	Average.	Period.	Average.
January ..	10.68	15	2 years	11.75	2 years	17
February ..	1.41	12	2 years	18.43	2 years	16
March ..	9.58	18	2 years	13.53	2 years	19
April ..	10.21	12	2 years	8.49	2 years	9.5
May ..	11.70	11	2 years	7.36	2 years	12.5
June ..	5.16	10	2 years	4.48	2 years	10
July ..	9.76	20	2 years	9.31	2 years	16.5
August ..	4.85	9	2 years	6.36	2 years	12.5
September ..	6.72	15	2 years	5.58	2 years	14.5
October ..	6.29	15	2 years	8.07	2 years	16
November ..	2.53	10	3 years	11.05	3 years	11.7
December ..	7.72	13	3 years	5.28	3 years	11

Average Annual Rainfall for 2 years, 1936 to 1937—111.18 inches.
Rainfall for 1937—89.61 inches.

TERRITORY OF NEW GUINEA.

ANNUAL RAINFALL.

District.	Number.	Locality.	Rainfall, 1937.	Years recorded.	Average.
SEPIK	1	Aitape ..	110.12	17	99.23
	2	Wewak ..	97.10	9	88.11
	3	Angoram ..	106.34	3	95.08
MADANG	1	Madang ..	119.16	20	140.11
	2	Kulili	130.71	3	143.60
	3	Urit-Kurum ..	134.41	13	115.07
	4	Ramu	75.47	4	77.56
MOROBE	1	Baiune ..	74.09	4	67.65
	2	Bulwa	63.88	3	60.20
	3	Bulolo	61.78	7	56.06
	4	Edie Creek ..	114.65	8	106.58
	5	Kaiyapit ..	93.87	10	85.15
	6	Otibanda ..	51.11	2	57.24
	7	Salamaua ..	187.55	..	..
	8	Sattleberg ..	188.76	13	176.55
NEW BRITAIN ..	1	Arawe	204.82	4	175.89
	2	Gasmata ..	267.73	20	244.53
	3	Keravat ..	103.29	8	104.74
	4	Kokopo ..	65.41	11	83.10
	5	Kolai	225.04	5	209.50
	6	Lindenhafen ..	308.60	18	225.75
	7	Notre-Mal ..	158.07	9	164.40
	8	Palmalmal ..	200.62	6	205.37
	9	Pondo	199.93	11	170.58
	10	Rabaul ..	98.90	24	88.75
	11	Rapopo ..	74.46	5	80.12
	12	Ring-Ring ..	337.72	3	297.76
	13	Sum-Sum ..	200.95	5	146.32
	14	Talasea ..	200.40	20	172.24
	15	Tobera ..	83.50	7	81.07
	16	Watnalbara ..	135.38	14	121.77
NEW IRELAND ..	1	Kalili	227.18	14	192.44
	2	Kavieng ..	116.04	21	120.34
	3	Katu	142.03	2	151.34
	4	Matandeduk ..	123.83	2	111.93
	5	Namatanai ..	143.43	20	136.90
KIETA	1	Hakau	89.61	2	111.18
	2	Kieta	95.72	21	119.19
	*3	Rugen	113.34	5	102.47
MANUS	1	Lorengau ..	143.19	20	150.60
	2	Pelleluhn ..	89.68	8	120.49

* — 1936. (Figures for 1937 incomplete.)

(*See* accompanying map.)

COCO-NUT IMPROVEMENT BY SEED SELECTION AND PLANT BREEDING.

By R. E. P. Dwyer, B.Sc. Agr., H.D.A., H.D.D.

Introduction.

This phase of coco-nut culture has received but scant attention in New Guinea, despite its being an important consideration, in increasing the yield of any crop. This is not remarkable, however, when it is considered how little has been done with coco-nut breeding and seed selection throughout the world, especially when the relative importance of this industry is taken into account and when older countries, which are much better financially equipped, have made rather disappointing progress with similar work.

The economic importance of coco-nuts to the welfare of New Guinea has been stressed and discussed at length in a previous article[15] where it was shown that copra is pre-eminently the most important agricultural product in this country. Thus any means of increasing their production or reducing cost of production, are worthy of the greatest attention. There are relatively few plantations in this Territory even amongst the newer areas which are derived from selected coco-nuts, though, where it has been done, even by rough methods of mass-selection, the improvement in the bearing areas can be clearly seen. It is not comprehensible why a fundamental and, usually, cheap and easy method of improving plantations, for all time, has been neglected. This is more notable when it is recognized that once a coco-nut area is planted, it may be in existence for more than 60 or 70 years. Once a planting of coco-nuts is carried out it is permanent and a very important fact is that poor seed cannot be replaced the following year, as is done with annual crops. The orchardist or farmer in temperate countries would rarely dream of utilizing inferior planting material. The same now may be said of the majority of rubber, cacao and coffee planters in tropical countries. The methods of selection used here would be ruinous with almost any other planting industry where the competition is greater. It may be pointed out that the coco-nut planter has fared better than would be expected considering the lack of attention given to original plantings. It is also doubtful whether the neglect of such a fundamental principle as seed selection would allow of success with most other crops, when the money and time invested are taken into account. There is the excuse that individuals developing in a new country, with small capital, require to commence their plantations as quickly as possible, so as to get early returns at small cost.

It is the intention of this article to emphasize the necessity for coco-nut seed selection, wherever new plantings are intended in this country. The advisability of long-term coco-nut breeding and investigations on pollination, nut-setting and other factors affecting yield are also indicated.

In all fairness it is pointed out that a proportion of the local planters have regularly practised seed selection and are quite cognizant of the need for care and attention in this direction, which is amply repaid by enhanced yields in the bearing plantation. A review of the work which has been carried out in other parts of the tropics in relation to selection and breeding of coco-nuts as well as its application to local conditions is presented. It is regrettable that so little local experience and

research on this very important subject is available, and it is considered that the subject as it affects New Guinea planters, as well as any plan of future investigations, should be reviewed.

The methods of practical seed selection, floral biology and so on are intimately associated with controlled methods of plant breeding, but the two subjects are discussed separately for convenience of exposition.

Factors Associated with Yield.

The factors associated with the yield of any crop may be briefly outlined with advantage.

Ecological and environmental conditions interact with the inherent characters in determining the growth and yield of any plant. The potentialities for yield are very largely determined by the genetical constitution of the plant, but it is often difficult to determine yield capabilities owing to the masking action of environmental factors. A tree of superior genetical constitution may be growing under very unfavorable circumstances and yield poorly whilst a comparatively weak type of tree may, under exceptionally favorable conditions, out-yield the former. It is known through the laws of chance and probability that, where numbers of individuals from a large population are considered and where selection is being made for high yield, the chances of this occurring are largely obviated with the bulk of the individuals under observation.

When the intending planter considers the commencement of a new plantation as a business venture, he should realize that the final yield, and thus the eventual income, will be controlled by the following main factors and all of the subsidiary conditions associated with them:—

1. Genetical and inherent characteristics of the trees or palms.
2. Environment.
    - 2a. Climatic environment, such as rainfall, temperature, altitude and prevailing winds.
    - 2b. Soil environment, e.g., chemical, physical and biological characteristics.
    - 2c. Cultural environment, e.g., manuring, cover cropping and cultivation.
3. Outside biological factors, such as pests and diseases, also changes and effects produced by other flora and fauna present.

It is hardly necessary to indicate that the incidence and effect of these factors are all closely inter-related with each other and with the ultimate growth of the plant.

The efficiency of the labour, management and harvesting methods may all have their effect and are probably best classified under the heading "cultural environment". The net returns from the crop are, however, determined by many factors which it is not intended to discuss here, but reference may be made to the previous article already mentioned (*loc. cit.*). The uses to which the products are put, supply and demand, competition with other products, freighting difficulties and other charges may, however, be mentioned as largely affecting market price.

The original climatic and soil conditions are usually difficult to change once a choice of site is made except by application of cultural methods, such as manuring control of natural erosion, &c.

The study of biological factors comprises several subjects such as entomology and plant pathology. Such factors are usually subject to artificial methods of control.

The genetical and inherent factors provide the subject of this article as being the most important determinant for yield capacity, especially when the environment is optimum. It may be stated, in other words, that the limits of the yield capabilities of any coco-nut plantation are determined by the hereditary constitution of the individuals which comprise the population on that plantation (regardless of however optimum the environment may be). As mentioned later in this article the largest proportion of such a population are hereditarily uneconomic, hence the aim should be to eliminate undesirable poor yielding palms and retain as great a proportion of high producers in a plantation as possible. This can only be achieved by methods of seed selection or by controlled methods of crop improvement. The advisability of investigating what methods of improvement are available can therefore be strongly advocated.

Effect of Environment on Growth Characteristics of Coco-nut Palms.

For more detail on this subject, the reader is referred to sections of an article on coco-nut disease by the present author[16] in volume 3, number 1 of the *New Guinea Agricultural Gazette* (pages 50-57) describing the relation of soil conditions to disease occurrence; also on "tapering stem" associated with soil erosion (page 52) and on "Deficiency Diseases," where a description of old palms growing on the soil-exhausted areas of New Guinea is given. It is pointed out that in the western islands the soils are usually rather shallow and light, being of coral derivation. Here the palms mature early and prosper for some years, but gradually go off as the soil conditions become exhausted. The stems taper and leaves gradually become smaller and fewer. On parts of these islands, it takes over 13,000 nuts to produce a ton of copra, while on parts of the Madang District, on the mainland, and on Dampier Island, in some areas just over 4,000 nuts are required to produce the same amount of copra.

There is a tendency for copra on soil-exhausted areas to become much thinner (also *see* article on diseases (*loc. cit.*)). It is known that the drain on manurial constituents by a heavily producing palm is very considerable, and when that has taken place over a series of years such effects are sure to influence adversely the growth characteristics of the palms and to mask the most favorable hereditary characters. The actual age at which palms naturally commence to decline is not accurately known as it appears to vary greatly according to soil and other conditions. In Samoa, Hamilton and Grange[25] have the opinion that palms there which are over 60-70 years old have declined more through old age than actual soil exhaustion. This does not appear to be the case with most areas in New Guinea, as chlorosis due to soil exhaustion may become apparent here in palms not half the age indicated. The older areas, however, are definitely the most affected, hence the inter-relation of both old-age and soil exhaustion to the decline of bearing areas must be considered.

Fernando in 1930[18] mentions a case where he planted over 100 acres in one area and over 500 acres in another area with nuts from two localities. One locality was characterised by palms with an open crown, the other carried trees with a full crown. Apparently these were environmental characteristics and no

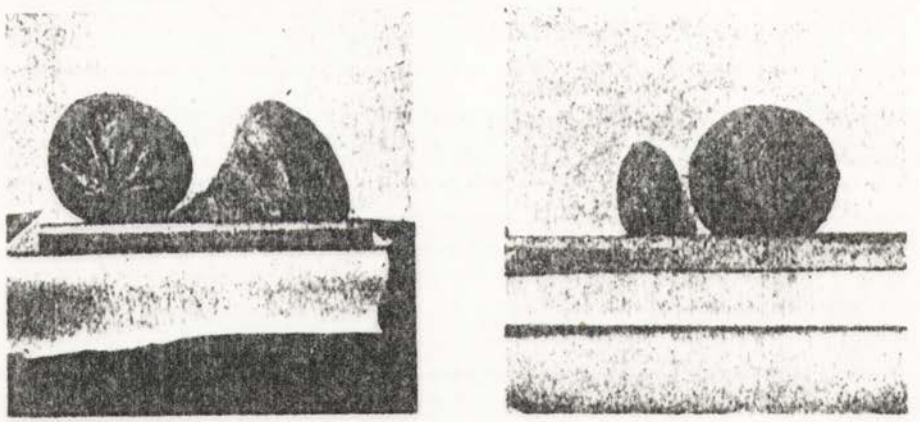
inheritance of such characters occurred. It appeared from this that there is no object in selecting a palm which was good just because it was growing on good ground.

Since the publication of the article[16] previously referred to it has been observed that palms growing in the Bainings District of New Britain appear quite different from those of similar type growing near Rabaul, in the same island. There the water table is close to the surface, a condition which would lead to rather shallow rooting, the fronds are decidedly more feathery and open than is the case with similar palms elsewhere. There is also a decided tendency for the spathes to hang on most of the palms until long after the whole spathe and the mature nuts are due to fall. Owing to this environment those hanging spathes are decidedly pendulous on the majority of palms and commence to hang down beneath the petioles or leaf stalks as soon as the nuts reach a certain age and weight. These nuts do not fall as would be expected in most other localities. The nuts also tend to run small but usually possess a good thick kernel. In many places in the locality, during the wet season, the water table reaches the surface, but moves fairly quickly towards the sea owing to the rather pronounced gradient on the foreshore areas.

It is not proposed to describe the environmental effects on palm growth in detail, but rather to indicate that they must be taken into account when coco-nut selection is being carried out. The effect of manuring with the well-known manures, nitrogen, phosphoric acid and potash, as well as supplying rare metal deficiencies, such as cobalt, zinc, magnesium and other elements on palm growth can only be considered as a separate subject, as is the provision of cultivation, cover-cropping and so on.

Nuts recently brought in from Agita Plantation, Matty Island, are said to take 15,000 to produce 1 ton of copra. The palms from which these nuts were produced are about 28 years old. There are said to be large numbers of native palms in this plantation which are considerably older. The native nuts in the village are also much smaller than elsewhere in the Territory.

PLATE I.—COCO-NUTS.



A—Unhusked. **B—Husked.**

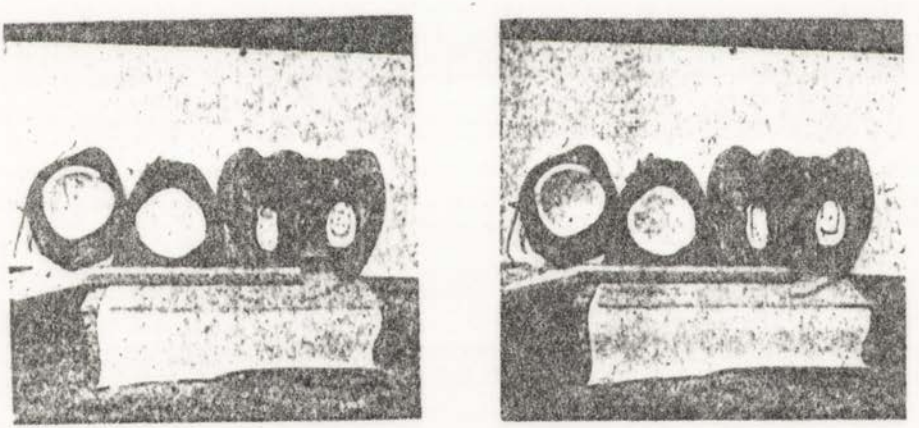
Comparison of western islands nut (small) with young nut from same situation originally from Kar Kar Island.

Palms derived from seed nuts grown on Kar Kar (Dampier) Island were planted out in these western islands in 1930 and are now bearing. The nuts on these palms are much larger and better developed than any previously seen on the island even by the natives. This can be partly accounted for by the difference in age of the palms and by the fact that less soil exhaustion has occurred where the palms are not so old.

Most of the native palms on Matty Island always produce nuts in which the true kernel forms a very small proportion of the whole, as there is such a large amount of husk present. Though there are small nuts present, the greater proportion of the original island nuts are large enough in appearance, but are extremely light. When the entire nut is pierced with a knife it is seen that a small elliptical or ovate nut is present at the dorsal extremity of the nut and is attached to the stalk end by a thick, strong, fibrous rope of connective tissue. When the entire nut was cut through with an axe it was seen that in one case the depression occupied by the nut with shell attached was only 2¼ inches across. The size of the complete oval-shaped nut was 10 inches x 7 inches at the shoulders, sloping to only a couple of inches in diameter at the base, while the ridges were very prominent. The size of the nut within the husk was only 2¼ inches x 4 inches in length while the husk thickness varied from 2½ inches in the centre to 3½ inches at the diagonal end.

The small husked nut when split appeared almost solid inside as the central hole was only 1⅛ inches across while the wet meat was at least ½ inch in thickness. Thus meat thickness as a single measurement is very deceiving in this case, as despite the relative thickness, the cubic capacity filled by kernel was very small compared with the total size of the nut. It is very difficult to cut the copra from such nuts. A new nut borne by the young palms originally grown from Kar Kar seed nuts, was roughly comparable in outside measurements with the above, except that it was 1 inch shorter and not so ridgy. In this case the size of he husked nut was 5½ inches by 6 inches which is almost a spheroid, and its cubic contents are nearly four times as much as the former small nut. The kernel was a little over ¾ inch thick, while the husk was only 1 inch thick in any part.

PLATE II.—COCO-NUTS.



Western islands (same as above) split to show differences in meat thickness.

The photographs give an interesting comparison of the two kinds of nuts. Undoubtedly the particular conditions on the islands have isolated, by a process of natural selection, a particular strain of nuts which resist the conditions. The soil is of residual coral derivation and in some places coral outcrops are seen. This soil is light in texture and contains scattered pieces of coral, shell and residual sand, while the humus layer is extremely shallow. There is a tidal swamp in the centre of the island. It is strange that this type of nut should produce so much husk, if soil exhaustion were the main cause of the reduction in size, as the husks are really the heaviest users of potash and some other manurial constituents. The introduction of new strains of nuts into this plantation was indicated as was the use of cover crops and methods of humus conservation.

There is, however, some evidence to show that even this apparently wide diversity in nut development may be mainly influenced by environment. P. Schmidt, the first planter to visit Kar Kar Island, stated to the author that "in the first plantings made there, 6,000 nuts were introduced from the western islands when they ran short of seed nuts." On the rich soil present there the western islands' nuts produced palms which were practically indistinguishable from the local types, which are noted all over New Guinea for their size and weight.

Variability.

The extreme variations and diversity of types present in any coco-nut plantation are well known to planters generally, as is the fact that individual palms show a wide range in fruiting ability. In this connexion, Jack and Sands in 1922[33] record from Malaya that the variation in the number of nuts produced per palm in Malaya was so great that 15.5 per cent. of the palms produce 24.5 per cent. of the crop and that 19 per cent. of the palms were uneconomic producers. Further, and what is of decided practical interest, they proved over a peroid of eight years (*see* Sharples[34]) that on the average, poor yielders and high yielders remain constant in this respect. In other words, on the average, good producing palms remain proportionately good yielders from year to year while poor yielders continue to produce poorly. Sharples[34] states that "no doubt the same constancy found in fruiting characteristics, also exists as regards the oil content of the copra within the range of seasonal variation; investigations are already in hand to prove this". Jack, 1930,[30] showed that on a good yielding plantation, yielding an average of 1510 lb. per acre, over eight years, an average of 59 nuts were produced per palm per annum, equal to 2,783 nuts per acre, per annum. The range, however, was from 5 to 115 nuts per palm per annum, over that period. He also stated that the average of 59 nuts per palm was some thirteen nuts better than the average for large estates in Malaya. The variable character, namely, number of nuts per palm per annum, showed a coefficient of variability of 34 per cent., compared with the mean under average estate conditions.

Smith, also of Malaya[50], in 1933 gave particulars of a very high yielding area as follows: "On a selected high yielding area of 80 acres carrying 3,875 palms only 17.8 per cent. bore 100 nuts or over. Thus the average of high grade palms in even a very high yielding area is very small and mass seed selection from such an area is unsound. Of the palms examined only 6 per cent gave 100 nuts of 500 grammes or more of wet meat and it is advised that 500 grammes is the lowest advisable standard for seed selection."

Sampson[92] stated the position in the following terms: "All coco-nuts are the products of cross-fertilization [this should be qualified.—*Author*], and, therefore, no palm has or can have a pedigree which would enable it to breed true to its female type. It is very largely on account of variation in the root habit and in the rate of new root production that there is such a difference in the bearing capacity of individual trees. Sixty nuts per annum is generally considered a fair average yield, yet every coco-nut grower knows that certain trees in his plantation will regularly produce more than double this number while other palms grown under identical conditions will not produce even half this average number".

In the case of tall palms cross-fertilization is believed to be general, thus not only are the palms under cultivation genetically impure and hence would not breed true to type, but knowledge of the seed nuts is limited to the mother or female palm. It is also an exaggeration to state that a very big proportion of palms in New Guinea plantations are hereditarily uneconomic producers. Variations in colour of nuts, such as green, yellow, reddish brown, are seen everywhere, as are variations in the size and shape of the palms, and of the fronds and nuts they produce.

Stockdale[93] in describing nineteen varieties of coco-nuts from a plantation in Ceylon mentions that the proportion of meat to kernel in one selection was 16 oz. meat to 16 oz. husk or a ratio of 1:1, while in another 12 oz. meat to 42 oz. husk, or a ratio of 1:3.5 was recorded. The above is only a brief introduction to the subject of variability present in coco-nuts, but many more variations are described under separate headings in this article.

Yield records over four years at Bandiruppuwa Estate, Lunuwila,[7] on a very uniform piece of land, confirm previous reports (from Ceylon and Malayan experiments) that high yield and low yield, both in number of bunches and number of nuts, are definite unalterable characteristics of the individual palm and fluctuate only slightly from year to year. More than twelve (12) bunches are usually produced in a year and there is a correlation between the number of nuts and number of bunches produced by a palm.

Selection of mother palms on the basis of high yield of bunches and nuts appears to be sound, without prejudice to the possible employment of controlled pollination later.

Professor Dash[12] in 1929 made statements concerning the position of coco-nut culture in British Guiana, which have some decided applications to the position in New Guinea. "Considerable expansion has taken place in the coco-nut industry of the Colony (British Guiana). Unfortunately after seeing a number of the coco-nut areas one is led to the general conclusion that the trees in most instances are not thriving. Many of these have been established on unsuitable soil with inadequate drainage and with scarcely any attention to cultivation. On light soils it is true that the trees are growing under conditions which enable them to resist cultural neglect remarkably well. For such trees to remain healthy and vigorous considerable expense is necessary for maintenance and cultivation, whereas normally on soils and under conditions suited to their growth, the palms fruit early and maintain productivity for a long period of years at a minimum expenditure for care and management.

A rough calculation obtained by equating copra and oil to nuts on the basis of (British Guiana), 1928 figures, indicates, after making necessary allowances, that the average yield per tree was hardly more than fifteen nuts. This is extremely low and supports the contention that all is not well with the industry agriculturally. Growers should not be satisfied until the average production per tree can be brought up to at least 50 nuts. ' This means that care will have to be exercised in the development of new areas and in the improvement of those already established. In the first place, I would urge greater attention to the question of selection of seed nuts, the main points concerning which are fairly well-known, but often not acted upon. Further selection is necessary in the nursery, young palms showing any signs of feebleness being rigidly rejected for transplanting. Then there is the question of giving young trees a good start. Apparently no one in this colony ever thinks that a coco-nut palm needs manure, and the proper time to commence to apply fertilizer is when the seedlings are transferred from the nursery to the field, which is a critical period in the life of the plant". Recommendations on manuring and tillage are then discussed.

Recent observations on five plantations in Zanzibar[2] for four years showed an average of 39.4 nuts per bearing palm, but in the fifth year a shrinkage to 31.7 nuts per palm was recorded. This shows considerable room for improvement by selection, if the yield is to approach the average for European plantations in Malaya, though the average is much better than that recorded by Dash (*loc. cit.*).

Methods of Seed Selection Commonly Employed in New Guinea.

In many instances no seed selection whatsoever is practised, and the seed nuts are bought as cheaply as possible. In some cases the precaution of purchasing seed nuts from an already good yielding plantation is taken, but this merely assures the perpetuation of average type coco-nuts. One has commonly observed the intending planter select germinated nuts ("Krus") which have been previously missed by the copra cutters. They are at such an advanced stage to be of little use for copra, and that accounts for their being utilized in planting, regardless of their shape, size, weight or yield of copra. Probably it is more common to select the seed nuts from heaps of fallen nuts gathered together 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 that good nuts would be obtained from good palms. The position is, however, comparable with barn selection in maize and other crops, as against seed selection in the field. The most progressive maize-grower, for instance, never selects his maize in the barn until he has first selected his plants and cobs in the field.

The great objection to selecting coco-nuts from a garnered heap is that one has no knowledge concerning the kinds and types of palms from which such nuts were derived. Palms may produce large nuts, because they are growing under particularly favorable conditions, and not because of any hereditary superiority. 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.

Typical examples of what occurs in new plantings were seen recently where the planters bought seed nuts from the neighbouring native groves and were prepared to buy any nuts the natives cared to sell them, because it was cheaper and handier in the first instance. Not the slightest attention was paid to what is one of the first precautions for successful coco-nut planting, namely, selection of good nuts. The excuses advanced for such neglect are centred around the time and cost involved, as well as the difficulty of obtaining sufficient selected nuts to plant up large areas. It is conceded that time and cost are involved—but it is a sound capital investment, which can only pay big returns in the future. A minority of planters here do observe the palms in the field, and then select heavy yielders of good type nuts from such individual palms.

In the planting of most native groves, very little conscious selection is practised, but their methods of close planting gives an enforced aid to natural selection, as it is usual for the stronger palms to survive. In certain districts of this Territory, the natives do select good seed nuts. They are well aware of a good type palm and only plant large, good shaped, heavy nuts.

A few of the most experienced planters here have marked individual palms on old plantations, and observed them singly for use as seed nuts, on new areas, which is a very commendable precaution. On one plantation in New Britain, where this was carried out, the coco-nuts are bearing very well. There are also better than average plantations where this has been done at Talasea, Gasmata, Bougainville, Kar Kar Island and Madang. A few instances of the methods used are given.

On one company plantation in Bougainville Island, the palms were derived from well selected old palms raised in proper nurseries. Later all weak and poorly growing palms were taken out and replaced, which procedure proved definitely beneficial.

Portion of a young plantation, which has just come into bearing, in the same island was planted with selected nuts, from old palms on another plantation which in turn were originally planted from selected nuts derived from the British Solomon Islands plantation. On appearance this area appeared to be better than the surrounding areas derived from ordinary unselected nuts.

One company recently planted up a large area in New Britain and selected a proportion of their seed nuts from old, heavily-bearing native coco-nut palms, which had been used for that purpose previously, and thus had been under observation for some time. In a new planting at Madang, a rather distinctive strain of palm with brick-red coloured nuts is being selected for seed nuts, as being a good type, as are palms carrying large nuts of the Markham type.

The owners of other plantations first allow the natives to select what they consider are good nuts. After being gathered into heaps these are then re-selected by the owner. Finally, after germination, all weak seedlings are thrown away. Some owners even go to the trouble of re-planting poorly-vigorous or chlorotic plants in the field. The weaknesses of this method all lie in the fact that nothing is known of the mother palms, as indicated previously. These, however, are all definite attempts to improve on present conditions.

Shape of Nuts.

Planters are mostly inclined to select round-shaped nuts, mainly because they are believed to be heavier in proportion to size. Elongated nuts are thought to have a bigger proportion of fibre at the ends, and, in some cases, this is undoubtedly true.

Work from Ceylon, the Philippine Islands and Malaya, seems to show that there is little practical difference in meat content between long or ovoid shaped nuts and round types, as either type may contain much or little meat. Some of the best copra-yielding nuts recorded have been long-shaped types. Further, red, yellow and green type nuts show more or less the same percentage of good and poor yielders, so that colour has little bearing on the yield.

As far as New Guinea is concerned it should be pointed out that the yellow type nuts are frequently associated with chlorophyll (green colouring matter) deficiency, though this is not necessarily the case. Genetically, chlorotic palms should be strictly avoided, though they may be useful for ornamentation. These yellow type nuts are common wherever coco-nuts are grown.

Maceda[40] compared the germination of 500 round nuts and 500 oblong nuts, and, twelve months after planting, it was found that round nuts germinated earlier than oblong nuts of equal volume, and also produced more roots, a greater number of leaves, and were heavier. Finally, both gave the same percentage germination. According to Copeland,[11] Walker made a very careful analytical study of brown nuts compared with green nuts, and this failed to show any constant difference whatever in yield of copra or in richness in oil, so there seems to be no practical object whatever in distinguishing between them.

In Guiana, it is said that a certain large orange-red variety is the best for planting, in view both of size and of yield of copra. A similar type of nut appears to flourish well on the mainland of New Guinea.

Methods of Seed Selection Advocated.

Jack,[29a] in 1929, stated that "there is ample opportunity for the improvement of the crop by the relatively simple process of elimination of uneconomic types, on developed estates, and by the selection of nuts from heavy bearers, for raising seed stock for new plantations." He further remarks that the term "section" as regards seed coco-nuts is mis-applied to a large extent, at present, because the methods of selecting them are far from scientific, and are rarely based on a thorough examination of the individual tree.

Thiele[61] and Staniforth-Smith[59] both stated that "seed nuts should be the product of healthy, heavily-bearing trees, not under twenty years old. Preference should be given to nearly round or oval shaped, medium sized with a thin husk, and they should be ripe, but not dry, while the three longitudinal ridges should not be too prominent."

Sampson[52] emphasizes the importance of selecting seed nuts from trees grown on land with similar soil conditions to those which are being planted up.

Copland[11] says, "select the seed of the palms which are conspicuously more productive than are their neighbours, which are growing under the same

conditions. Avoid those that have decided superiority of environment over their neighbours. Seed-nuts are chosen for their hereditary quality, and a good environment cannot be inherited."

The present author comments that this statement should not be carried too far, as it takes a favorable environment to give the best expression of the yield capabilities. It is well known, however, that palms growing on the edges of groves, around houses or manure heaps, should be best avoided as having undue advantage over their neighbours.

Smith[50] says "that the area chosen for the selection of seed nuts should contain a large number of palms yielding well above the average, when the chance of cross-fertilization with a high yielding parent will be probable; and a close examination should be made of individual palms which will at least ensure a good female stock. Only palms bearing 100 nuts or more should be selected as possible parents."

It is apparent that Sampson has stressed a very important point. Thus, where one is selecting coco-nuts for planting on the loose pumice soil, close to Rabaul, it is preferable to select them from palms which are doing well on a similar area. The same principle would apply when selecting for heavier soils, such as in the Bainings District, where it is feasible to believe that a different type of palm altogether might fare best. The standards as to a good producing palm could conceivably vary according to the conditions under which the selections are being made. It does not seem necessary to select from the best areas on the plantation only, because a palm which does well under relatively adverse conditions might be the most valuable seed parent.

It might be thought that this is a definite argument against introducing large nuts from islands, such as Kar Kar or Witu Island. This is not the case, because it is most probable that different strains of nuts are present here. If the palms growing on these islands are derived from different strains, and were also grown from selected nuts in the first instance, as is explained elsewhere, then it is a sound plan to use such sources as a basis for seed supply. If it is purely a matter of differences in environmental conditions, no good purpose can be served in introducing seed nuts to outside centres from such areas.

Planters here are generally of the opinion that they can only select from very old areas. This has a sound basis for recommendation, because in old areas the palms are necessarily long-lived and heavy yielders. In most cases the weaker and less vigorous palms have been weeded out, over the years. Nevertheless, although this precaution is desirable, it is not essential. In fact, selection from a relatively young estate known to be derived from previously selected nuts can be recommended where older areas are not available. It is widely believed that coco-nuts must reach a certain age before the young coco-nuts will germinate satisfactorily.

It appears from observations made in the *Kew Bulletin of Miscellaneous Information*[3] that the widely-held belief that the nuts from young trees should not be used and that plants should only be raised from fully-matured trees, was first based on a statement made by Simmons, 1877, in *Tropical Agriculture*.[88] The latter advocated selecting fully ripe nuts from fully-matured trees, and

amongst other statements said: "Those nuts which may be taken from trees of immature age will, if planted, rot away at the eye; and the plants, if any, be successfully reared on transplanting, will grow very rapidly, and acquire bulk, but the fruit will drop before the kernel acquires consistency, the root stalks break, and the trees entirely fail before mid age."

This idea seems to have been perpetuated by some periodicals and text-books, although Copeland[11] in his book lends no support to this contention, and there has been no experimental evidence to support it. Inquiries made from Kew could find neither direct confirmation, nor absolute refutation of the truth in this statement, but refer to it as follows: "On physiological grounds there would appear to be no justification for the statement as it stands, though no doubt it would be unwise, for more than one reason, to plant nuts from young trees in the first year or two of their coming into bearing. It is possible that it was based on a superstitious native belief or else the argument of a plantation owner who had trees of a particular age being offered for sale. In British Guiana it is advised by the Department to select nuts from good-bearing palms, which are neither very young nor very old.

In some islands in the Laccadives,[3] off the Malabar coast, it is stated that, where the soils are very poor, palms normally take fifteen to twenty years to come into full bearing. The natives there have regularly selected nuts from any good bearing palms present, which come into bearing at ten years, and they only select first-class early maturing material, with remarkable results.

Particulars are quoted in the *Kew Bulletin* (*loc. cit.*) of a coco-nut plantation in the Island of Nevis, West Indies, planted by a Mr. Crum-Ewing in 1907, where palms in their third year of bearing yielded perfectly sound and full-sized nuts (95–98 per cent. over 3½-in. gauge when husked) which, when used for seed, germinated freely and in a normal manner. It was stated that the original seed nuts used came from Jamaica, but in turn these came from San Blas, whence come the finest nuts in the Western Hemisphere. One thousand nuts, five years and three months old, when germinated for seed nuts, gave an 89 per cent. germination, seven months after placing in the nursery. It is recorded that one palm four years and four months old bore 40 nuts, which indicates the opportunities for selecting nuts for early maturity in an ordinary plantation. It was commented that the high percentage of good-sized nuts, borne on the young plantation at Nevis, afforded ample justification for the great trouble which was taken in selecting the original seed nuts in Jamaica and elsewhere. Crum-Ewing's statements are worth remarking, as he does not agree with Simmonds: "Nuts should be taken from trees whose good character is well marked. It appears that the pedigree of a coco-nut tree is of the utmost importance. It would be better to use parent palms showing similar characteristics to those for which the parents and grand-parents were selected, even if only one or two years' observations were available, than use old trees past middle age, of whose parentage there is no record."

It was mentioned that it would be better not to take seed nuts from palms until they were in their third or fourth year of bearing, mainly owing to the varying periods at which the nuts come into bearing. There is, however, probably

some truth in the statement that nuts from very young palms do not germinate properly as, for example, nuts which had fallen from young palms of the Markham Valley type at Koravat, did not germinate so freely at first, as they did later on. This was particularly the case with some individual young palms, and may be truer of certain strains.

It is not always possible for the planter to keep yield records of individual palms, but nearly every one who is familiar with his plantation knows of the existence of heavy yielding palms on the place. Many of these palms may be under casual observation for years. When such palms are found to be consistently high bearers, they should be distinctly marked either with tar or paint, or preferably numbered with a zinc or aluminium tag. These can then be observed more carefully as potential mother trees for future plantings. Planters are known here who have carried out the procedure outlined with good success. A few nuts from each selected palm should be examined closely for proportion of husk, thickness of kernel, &c. The thickness can often be determined without injuring the nuts at all, by just inserting a strong knife through it until the shell is touched.

The methods outlined are not ideal, as it would be necessary to maintain a cropping register for individual palms to obtain best results. Professional investigators would be obliged to keep detailed records on sheets or cards specially printed with suitable headings for that purpose. It would be a sound idea for some of the larger organizations here to keep similar records on selected areas of, say, about 50 acres in extent. Even a register of this nature would not be a sure index of the copra-producing ability of the palms, as there are many factors to consider. Still, it would afford a reliable indication for selecting good palms. Particulars of how to keep a cropping register are available from several sources, and it is not proposed to discuss them here. To indicate just how valuable accurate records and measurements are, Smith[50] says that an increase in meat thickness of 1 mm. between two nuts with kernels 12.5 and 13.5 mm. thickness respectively meant a difference of no less than 8 per cent. in the copra yield, and that it it almost impossible to detect this difference by eye alone.

Pieris, in Ceylon,[48] has listed several useful criteria which indicate a good palm on appearance. He and several other investigators have indicated, as far as possible, the correlation of external characteristics with that of yield of copra. Belgrave and Lambourne[5] (Malaya), in 1933, stated "that Cooke in 1932 had shown that there was a remarkable close correlation between the weight of husked nut and the meat content." Cooke,[9] in 1934, confirmed this finding, as did Pieris[47] working in Ceylon in 1934 and 1935.

For the purposes of the layman unity is taken as a complete correlation, and the latter showed in one large series of experiments that the correlation coefficient between weight of husked nuts and weight of copra was +0.971. This is almost exactly comparable with the findings in Malaya.

Cooke (1930-34), in Malaya,[9] used nuts in his determination which had been grown under a wide range of conditions to see whether there would be

a wide range of variability, and whether it was necessary to split the husked nuts to rule out possible variation due to the amount of water contained in each nut. The nuts were collected from estates 32 years old, 18 years old, and 17 years old, while nuts of mixed ripeness were collected from small holdings in the coastal areas of one district in Malaya. There was no very significant difference in the coefficient of correlation in nuts derived from various sources. He concluded that there is a high correlation between both unhusked nuts and meat, but especially between weight of husked nut and meat, and that the splitting of nuts is not essential in determining the yield of copra for all practical purposes.

Pieris,[47] of the Coco-nut Research Scheme, Ceylon, makes the following conclusion from his work: "Although there is a marked positive correlation between the number of nuts produced by a palm and the weight of copra manufactured from these nuts, the expression of yield by number of nuts is open to considerable error, although it is a very good rough estimate. The error introduced is due to the variability in the size of nuts from different palms, and more especially from different varieties of palms. Some varieties (or selections) produce small nuts, which although present in large numbers, may produce no more copra than a moderate number of larger nuts from other varieties. The correlation between weight of unhusked nuts and weight of copra is higher than that between weight of copra and the number of nuts. This ratio, however, tends to alter with progressive desiccation of the nut and the loss of water on storage in heaps. The third method of expressing yield is by making use of the weight of husked nut, and it is shown that this is the most satisfactory and least troublesome method of arriving at a reliable expression of yield. In this case, errors due to the variability in size of nut and to drying of the husk are avoided."

He also showed that with uniformly ripe nuts and average drying conditions the percentage ratio between weight of copra varied between 32 and 33 per cent., but that may be reduced as low as 30 per cent. where excessive drying was practised or the nuts were immature. It is not proposed to go into a scientific discussion on the subject, as Cook, Pieris and others have done this for the benefit of investigators in their particular countries, and there is practically no data to analyse as far as New Guinea is concerned. The practical utility of the findings quoted above is what counts from our point of view. It is most important to realize that it is not necessary actually to split the nuts and actually weigh the wet kernels or dry the copra to get a reliable expression of yield of individual palms. It is, therefore, a matter of great moment to find that the three characters, namely, number of nuts, weight of unhusked nuts, and weight of husked nuts, and especially the latter, are all positively correlated to a high degree with the weight of copra.

Pieris, in his article on seed selection,[48] has given the following criteria for the selection of mother palms, which are quoted verbatim:—

"A mother palm should be selected according to the following standards:-

1. The trunk should be straight and stout with leaf scars situated close to each other. Avoid very tall and curved trunks.

II. The fronds should be short and well-dispersed on the crown. The orientation of the fronds on the crown can be represented diagrammatically as follows; it will be noticed that there are three main types:—

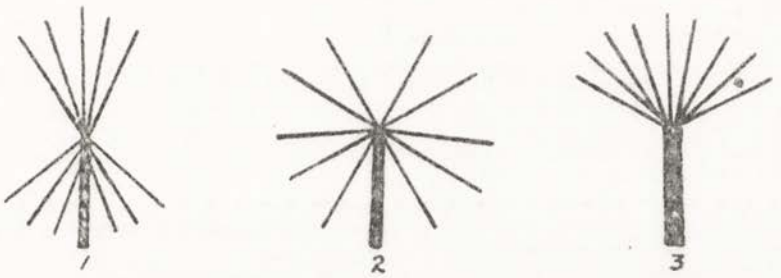


PLATE III.—COCO-NUT PALM.



Type I. "Undesirable." Fronds unevenly distributed; lower fronds drooping.

PLATE IV.—COCO-NUT PALM.



Type II. "Desirable," good type. Fronds evenly distributed.

PLATE V.—COCO-NUT PALM.



Type III. "Undesirable." Fronds distributed distally or in a semi-circular position.

Types 1 and 3 should be avoided, even if they show other desirable characters. Type 2 displays the best spread of fronds.

III. The bunch stalks should be short and should not show any tendency to droop.

IV. The inflorescences should carry a fair number of female flowers or button nuts —up to 100. Avoid palms with inflorescences (flowering spathes) that are over-stocked with female flowers. They are not thrifty.

V. The crown should carry a large number of fronds and consequently a large number of inflorescences. Avoid crowns that look empty on one side, even though the inflorescences on the other side appear to set many nuts.

VI. It need hardly be said that inflorescences should be well stocked with nuts. But it might be mentioned that inflorescences in all stages should be noticeable on the palm carrying their full complement of developing nuts. Very often one is deceived by heavy lower bunches.

VII. The size of the nuts is not important provided large numbers are present. [Very small nuts should be omitted.—*Author.*]

VIII. The weight of the husked nuts should be high since on this depends the copra producing power of the palm. The number of nuts and the weight of husked nuts provide the best standards of selection.

IX. Do not select palms growing in favorable situations, such as near cattle sheds and human dwellings, because they will be better than palms growing in the open field in competition with their neighbours, merely by reason of their favorable surroundings.

Palms that bear well in a normal or even unfavourable environment should be selected."

He also states "that at the end of three years all selections that have not produced on the average 100 nuts and 175 lb. of husked nuts, per annum, should be rejected. Wherever possible there should be at least one proved mother palm for every five acres on an estate."

Palms of hereditarily poor vigour are very liable to insect and fungous attack and are very susceptible to unfavorable soil conditions. There is no doubt that some palms show an hereditary tendency to chlorosis (chlorophyll deficiency). Such palms are readily apparent on even the best kept plantations, and should never be used for seed.

Sampson[52] and Hunter and Leake[28] have both indicated one potent cause of premature nut-fall. The weight of a well-developed bunch of nuts is considerable, and, if unsupported where the leaf stalks (petioles) are too long, the rachis (stalk) of the inflorescence will tend to buckle and twist. This causes constriction of the vessels which carry nutriment to the developing fruit, and leads to the fall of the immature nuts as the result of starvation. The natural support of the bunch is the leaf stalk, and a strong leaf stalk combined with a short inflorescence rachis forms the most important of the vegetative characters which are desirable.

Tangible Results to be Expected from Seed Selection.

The average palm in New Guinea plantations probably does not produce more than 40 nuts per palm per annum, and the average for all plantations may be less than that. One of the soil-exhausted areas in the Territory averages less than 30 nuts per palm per annum, an average plantation produces 40 to 50 nuts per palm per annum, while some of the best places in this country do not produce more than 60 to 70 nuts per bearing palm. In assessing the number of nuts per palm, it must be recognized that when numbers of nuts are the basis of comparison, the smaller size of the nuts on poor yielding plantations somewhat balances the smaller yield obtained under those conditions.

From certain islands of the Laccadives, Malabar Coast, particulars are given[2] of palms coming into bearing in ten years. These throw out a fruiting spike every month after that age is reached, bearing 15 to 20 nuts, and so yielding

180 to 250 nuts per year, and going on bearing at this rate until they are 60 years old. They often do go on bearing until they are 70 or 80 years old, and some are believed by the people to be more than a century old.

At Buitenzorg, Java, Mr. de Veer[13] has taken yield records on 46 selected palms derived from a number of different localities in that country. The lowest average yield per palm over that period, including the years when they were coming into bearing, was 84 nuts per palm, while that of the highest yielding palm was 178 nuts per palm over the same period. Thirty-three palms out of the 46 averaged over 100 nuts per palm over that period, while the average per palm for that period was 120 nuts. If palms capable of producing one-half to two-thirds of this total were used as planting material the increase in the bearing capabilities of plantations here would be very considerable, as simple calculations would show.

Jack,[30] Malaya, in the course of a lecture to producers gave the following figures and facts, which are very easy to follow. He said that "assuming the average palm to produce 60 nuts per annum (the actual average is lower) and that each nut produces 250 grammes of copra (a figure derived from actual weights, and 453.6 grammes = 1 lb.), then the average palm should yield approximately 33 lb. of copra annually, of course allowing for the limits of variation. [At this rate a palm producing 40 nuts should produce approximately 22 lb. copra per annum.—*Author.*]

"Owing to variability present it should be possible on new plantations to raise considerably the average yield per palm by the rigid selection of high yielding palms for the supply of seed nuts for future plantings. Seven of the 170 palms which were analysed for yield showed calculated yield values exceeding 50 lb. of copra per annum, while four of them even exceeded 65 lb. of copra per annum, so that the selection of palms as seed-bearers is not a difficult matter. A plantation planted entirely with palms capable of producing 50 lb. of copra per annum would be equivalent to an increased production per acre of approximately 50 per cent., and even this increase might conceivably be exceeded. While such an increase is possible under practical conditions, and considering the hybrid nature of many of the seed nuts, it is more likely that the first generation increase would be of the order 25–35 per cent., but even this increase would be highly desirable."

Smith[80] says "that with his standard scaled down to 100 nuts of 500 grammes of wet meat per palm only 6 per cent. of palms in a given area (high yielding) are for selection as mother palms." He also states that by selecting palms of this standard, yields of 20 piculs = 2,720 lb. per acre, should be attainable under favorable environmental conditions. It was indicated, however, that he had already recorded from a promiscuous seed supply the phenomenal high yield of 16 piculs, or over 1 ton 19 cwt., per acre (not hectare) for thirteen years over an area of 80 acres, the palms being 27 years old in 1933; this was equivalent to about 82 nuts per palm. This was, undoubtedly, due largely to environmental conditions, but said that it indicates that potentialities are greatly in excess of standards hitherto accepted as high, if close seed selection is carried out in an area of this yielding capacity."

This amount appears exceptionally high compared with what prevails under New Guinea conditions, but if an average acreage yield of the limits he indicates were harvested per hectare here, that would greatly increase the existing yields in this Territory. It would take controlled methods of plant breeding to get maximum increases in yield, yet a substantial increase may be expected from methods which are applicable on a commercial scale.

Hamilton and Grange[55] recently investigated conditions in Samoa on the New Zealand Reparation Estates. They advanced the following arguments in recommending seed selection there:. "Visual observations of trees in the plantation suggest that they vary considerably both in productivity and habit of growth. Different types of nuts were collected at the Vailele plantation and measurements made on a ton of them—

> The transverse diameter of the nut varied from 2.7 inches to 4.5 inches, while the longitudinal measurement varied from 3.6 inches to 5.1 inches.
> Thickness of meat varied from .35 inch to .50 inch.
> Dry weight of copra produced varied from—79 to 209 grammes.

Since the best of the nine nuts recorded returned three times the amount of dry copra per nut that the poorest did, it appeared that there is considerable room for improvement in the type of nut which should be selected for future plantings. The opinion was fairly freely expressed, however, that any selection for the larger size nuts would lead to decrease in the number of nuts produced per tree, but work conducted by Smith in Malaya seems to lend no support to this contention, provided selection for size is kept within reasonable limits. Smith, writing in the *Malayan Agricultural Journal* for June, 1933,[56] gives details of the results of selection in that colony. An area of 80 acres, which had an average bearing record of 82 nuts per palm, or 19½ cwt. of copra per acre per annum, was selected, and the individual trees graded according to production with the following results:—

Total number of palms examined	3,975
Total producing 100 nuts and over	690 = 17.8 per cent.
Total producing 50 nuts and over	1,109 = 28.6 per cent.
Average of "100" nut palms	117.23 nuts.

Nuts from these selected trees were then taken, and the yield of wet copra per nut determined—

Net weight of copra per nut in grammes.	Number of nuts in class.	Percentage of nuts in class.
Over 700 grammes	3	0.4
600-700 grammes	47	6.8
500-600 grammes	191	27.7
400-500 grammes	307	44.5
300-400 grammes	128	18.6
Under 300 grammes ..	14	2.0

For the purposes of comparison with the weights given for yield of dry copra from Samoan nuts, the weights given in the above table should be halved. From data given by Smith it would appear abundantly evident that it is possible to find trees

which combine both large size of nuts and heavy yielding capacity, and there appears considerable scope for selection if further areas are to be planted in Samoa.

In a crop of this nature planting is done once and for all, and expense incurred in securing selected seed may be repaid manifold during the normal life of the crop. Initial lack of selection cannot be rectified as in the case of annual crops.

Some selection has been practised in the past on the basis of nut shape and size, but while this is of undoubted importance, it should be carried a stage further and the yielding capacity of the trees producing such nuts determined or results are likely to be disappointing. Even with careful selection phenomenal results should not be expected; if production can be increased by 10 per cent., the cost of selection would be amply repaid while the elimination of low producing or "boarder trees' should materially assist to raise the average level of production".

Stockdale[69] from measurements made on a large number of nuts stated as follows: "It appears but reasonable to expect that larger nuts would possess proportionately more kernel than smaller ones; but the figures obtained do not appear to bear this out, for it was found that the three best nuts examined in this respect were comparatively small besides some of those examined which yielded less kernel. The range in weight of kernel for nineteen types varied from 12 to 18 ounces, whereas that of the husk showed a wide range of from 16 to 48 ounces". He mentioned that the husk takes up nine and a half times the amount of potash salts which is absorbed by the meat and over 100 times the amount of lime salts which the meat takes up. Thus it is obvious that the more fibrous type of nuts should be avoided as being uneconomic feeders.

According to de Veer[13] a very interesting practical demonstration of the value of selection was made in the East Indies. The Landbouw Instituut for purposes of comparison planted out 250 nuts from selected mother trees in various parts in both Java and Sumatra. The original nuts were collected and planted out in 1911, and the average yield of the palms from these selected palms over the last ten years (to 1934) was 120 nuts per palm compared with the average of 40 nuts per palm usually harvested on Java estates.

Govindu Kidavu[67] classified palms according to their bearing capacity on the basis of five years average yield records ending in 1927. He classified trees which yield up to 30 nuts per year as poor bearers, those which yield between 30 and 100 nuts as medium bearers and those which yield above 100 nuts per year, as heavy bearers. Over this period he recorded some palms as yielding an average of fourteen nuts per annum whilst others yielded an average of 121 nuts yearly.

It is as well to recognize when interpreting results that the nuts derived from even the same bunch show considerable variations. In an experiment to show this 1,200 nuts were examined at Buitenzorg, Java[18] from different positions on individual palms. It was found that there were fairly great differences in the percentage of copra and in the oil content of nuts where two were taken from the base, two from the centre and two from the top bunches in each palm examined.

According to Cooke[10] ripe Malaya coco-nuts average 0.5 lb. of dry copra per nut, while the highest yield of oil and copra is obtained approximately at the time of natural nut-fall.

E. C. D. Green, Superintendent of Keravat Demonstration Plantation, has made some detailed observations on coco-nuts at Raulawat Plantation, New Britain, but as the investigations are unfinished, details will be presented at a later date. Meanwhile a few interesting figures are quoted in support of the argument for seed selection.

The total weight of nuts where over 30 nuts were considered ranged from 26 oz. to 65¼ oz., with an average of 42 oz. approximately. The weight of husk present ranged from 8¼ to 22 oz., while the weight of shell varied from 4¾ oz. to 10¼ oz., and the transverse diameter of the nuts ranged from 9.9 to 12.4 cm. The amount of contained meat varied from 5¾ oz. to 17¾ oz. with a general average of 12.2 oz. approximately. The ratio of meat to total weight ranged from 1:2.7 to 1:7.0 which shows a wide divergence in percentage meat yield and the figures speak for themselves as to the advisability of selecting nuts yielding the heaviest proportion of copra.

Measurements were taken on 100 nuts at random from a representative collection, and the following figures were obtained for the nuts:—

Total weight	3.18	lb. per nut average
Weight of husk	1.395	lb. per nut average
Weight of shell	.45	lb. per nut average
Weight of wet meat	.75	lb. per nut average
Weight of Kruss present (slightly germinated nuts)	.57	lb. per nut average
Weight of dry copra	.42	lb. per nut average
The ratio of $\frac{\text{dry copra}}{\text{total weight}}$ was	13.2	per cent. approximately
While the ratio $\frac{\text{wet meat}}{\text{total weight}}$ was	26.3	per cent. approximately
$\frac{\text{The weight of dried copra}}{\text{husked nut}}$	23.25	per cent. approximately
$\frac{\text{Weight of wet meat}}{\text{husked nut}}$	41.8	per cent. approximately
$\frac{\text{Weight of dry copra}}{\text{weight of wet meat}}$	56	per cent yield.

Despite the fact that this is a good yielding plantation it is plainly apparent that the average size of nut and yield of meat could easily be improved upon if all the nuts present even approached the yield of the best nuts present in the random sample.

The following distribution table for 31 nuts depicts the range of variability present even where such a small number is considered:—

Total Weight.		Weight of Meat.	
Oz.	No. of Nuts.	Oz.	No. of Nuts.
25-35	5	5-8	1
35-45	15	8-11	8
45-50	9	11-14	14
50-55	2	14-17	7
		17-20	1

It will be seen that between one-quarter and one-third of the nuts are above average in weight and yield.

Coco-nut Introduction.

The extent to which coco-nut seed introduction into New Guinea has proceeded since historical times is not generally realized, nor has it been indicated. It is as well to point out that all islands of the South Pacific carry coco-nuts. The original habitat of coco-nut palms is doubtful, though some opinions seem to favour its South American origin, particularly as that country is decidedly rich in species of the genus *Cocos*. This subject is well discussed by Hill.[27]

Writers also disagree as to whether the coco-nuts pre-date the arrival of the native inhabitants of the Pacific islands.

The possibilities of coco-nut seed introduction were fully realized by German planters resident in this Territory before the war. Mrs. Forsythe, known as Queen Emma, is said to have introduced selected coco-nuts from Samoa to her plantations at Herbertshohe (now Kokopo). The German Government also imported two of the best kinds of coco-nuts from a representative of the Imperial Government in Samoa to the Rabaul Botanic Gardens, about 1911. The one producing large coco-nuts was introduced as Niu Vai, while a smaller variety was brought in under the name Niu iu.

In the earlier history of Samoan development, native labour was regularly recruited from Bougainville Island for work in their plantations. Seed coco-nuts were thus believed to be brought to New Guinea by the boats travelling backwards and forwards.

Mr. Winand, a planter resident here since 1902, has supplied the information which he gleaned from Mr. Mouton, also an ex-planter of many years standing, now resident in Australia, who was also a member of the "de Ray" expedition. He says that the ill-fated members of that expedition introduced selected nuts from New Hebrides and New Caledonia to the southern end of New Ireland. Palms derived from these nuts are still known to some old planters in the Namatanai district and are said to produce large nuts with thick husks.

One of the first actions of the old New Guinea Company was to introduce selected coco-nuts from some outside source to the mainland near Madang, and probably other places. It is also well-known that there has been continuous interchange of coco-nut planting materials between New Guinea and the British Solomon Islands Protectorate (Solomon Islands) probably since the earliest times.

During the German administration many exchanges of selected coco-nuts were made between districts here. It has been stated on good authority that the large New Guinea Company planted most of its plantations with nuts derived from Peterhafen, Witu Island. These nuts were said to be round, medium sized with thick copra. It is likely that this may be a distinct, regional strain, but there is the possibility of their characteristics being due to environmental effects which may not be reproduced in situations with poorer soils.

Their administration introduced palms bearing small attractive yellow nuts from "Stephansort" apparently at, or in the vicinity of, the plantation Bogadjim. These were stated, in the 1911-13 report on the Botanic Gardens, to have grown well and to be bearing plenty of fruit. Some of these palms are still in these gardens and appear to be breeding remarkably true for the yellow coloration.

Coco-nuts were also brought to Rabaul from Peterhafen and from "Jomba", Madang; these were badly attacked by the rhinoceros beetles and fared badly. Whether coco-nuts from these sources were distributed to outside plantations is not known.

Seed coco-nuts from the British Solomon Islands were introduced by at least three large planting groups to Bougainville Island. In one instance the manager stated that the Solomon Islands palms from which he introduced seed nuts were originally derived from selected seed nuts brought from Samoa.

At Numa Numa plantation palms from three separate districts were grown in comparison with each other, viz., from Rabaul, Bougainville, and the British Solomon Islands. These showed comparatively little strain difference, except that the manager noticed that the palms derived from British Solomon Islands Protectorate nuts came into bearing decidedly earlier than the other plots. Individual palms from all three sources showed great variation in fruit production as would be expected.

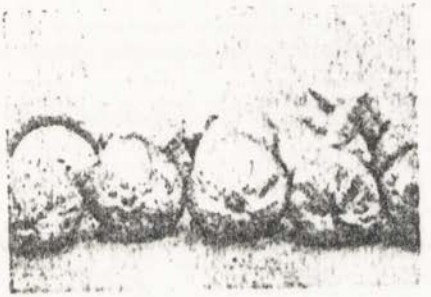
During a recent visit to Witu Islands, opportunity was taken of investigating possible reasons why the New Guinea Company so widely used seed nuts from this source. Another objective was to select good palms for the breeding programme at Keravat. The question is what special attributes prompted the company to use these seed nuts for extensive plantings. Geologically the Witu group is of very recent origin, and it is not many generations since the first seed nuts were brought there. The oldest palms there are not so high nor so old looking as palms seen in other parts of the Territory. Nevertheless, the palms are quite old, and have been forced upwards by the competition of the short surrounding bush. The islands previously supported a much larger population, but a great proportion was wiped out by an epidemic disease which occurred less than 40 years ago, and at present only a few hundred natives are left. Previously extensive plantings of coco-nut groves were made by these old inhabitants, and these still remain and appear exceptionally healthy. The soil, being new, is rather shallow but chemically rich and very friable.

The Germans of the old New Guinea Company made Meto, at Peterhafen, their head-quarters and afterwards for five years this was a copra concentration depot and store for the Expropriation Board, and it was later used for the same purpose by the Melanesia Company. The former company sent seed nuts from this centre to plant new plantations in all districts of New Guinea at such places as Madang and Aitape on the mainland, Bougainville and New Britain. It is said that some were taken to Kar Kar or Dampier Island, which place has also a good reputation as a source of seed nuts, but this is doubtful as probably most of the nuts planted there were derived from selected palms, either local or from the mainland near by. Paul Schmidt, the German planter who first opened up this island, informed the author that most of the nuts used to plant the original European places there were derived from Alexishafen and Potsdamhafen on the mainland.

Since the Australian occupation, plantations at Garua Island and Talasea were planted with coco-nuts from selected and marked palms at Witu. Inquiries from several old natives reveal that the coco-nuts first used to plant Meto plantation were selected from old native groves on the higher areas of the island. These coco-nuts are mainly growing at an altitude from 700–900 feet, and were planted by earlier inhabitants. The writer was conducted by an old native pensioner living on Ilia plantation, to see the palms from which these seed nuts were obtained. It is easy to imagine why these palms were selected as mother palms for seed nuts. Even at the present time (October, 1937) these original

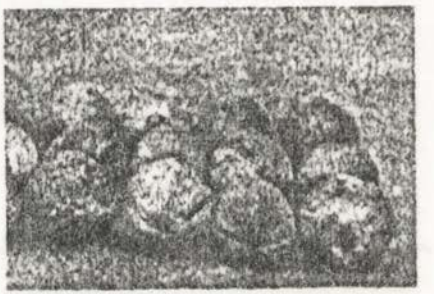
old palms are bearing heavily, and the nuts are usually round, of medium size, very meaty, and heavy in proportion to size, with a husk which is not unduly thick, while the frond canopy is a healthy green in colour. The number of nuts per ton at Meto has been ascertained as being approximately 5,000, hence they are not so big or so heavy as the Markham Valley or Kar Kar Island nuts. The first plantings at Meto were made in native fashion, not being properly lined or spaced, by a Malay in charge of several "Marys" (native women), but the later plantings were more carefully lined. Several old boss boys and old natives in villages were independently questioned, and they all agreed regarding the areas from which the seed nuts used were derived. Some of the boys questioned had been actually engaged in collecting the original seed nuts. There are numerous old palms left standing on the flat areas, but apparently these were not used to provide seed. The nuts used were selected by natives only from what they considered to be good, heavy bearing palms, and no other supervision was exercised.

PLATE VI.—SEED COCO-NUTS.



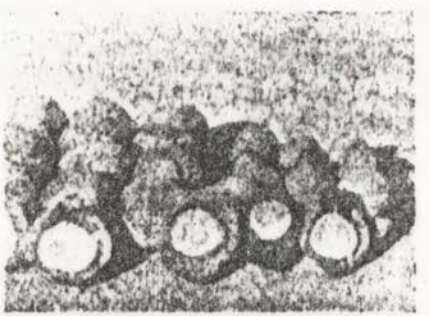
Good type, from Meto Plantation, Witu Island.

PLATE VII.—SEED COCO-NUTS.



Good type, from Meto Plantation, Witu Island.

PLATE VIII.—SEED COCO-NUTS.



"Split Open." Good type left of photo; bad type right of photo.

According to some of the natives these old native groves also provided many seed nuts which were concentrated at Meto for despatch to other parts of the Territory, and it was not until the palms were well in bearing that plantation nuts were used for this purpose. Thus it is practically certain that comparatively large areas of New Guinea plantation coco-nuts were derived from Witu coco-nuts, originally grown by natives.

Despite the age of the coco-nut palms at Meto, namely, 40 years approximately, and the haphazard plantings on this plantation, it is still yielding more than a ton of copra per hectare. The palms still have a healthy appearance and the individual palms are yielding much better than the yields given would indicate as there are many misses in the planted areas, and it is difficult to find really bad palms. It appears that there is a bigger proportion of reddish-yellow nuts, not brick-red nuts, than is usually seen.

If it is granted that the Witu coco-nuts have rather distinctive features, is the environment responsible? It would, undoubtedly, have a great influence on the resultant nuts. It does not appear, however, that the presence of the distinctive, rounded type of moderate sized nuts, often seen at Witu, is altogether due to environment or accidental causes, and it becomes necessary to consider the question of native selection.

It is feasible that a proportion of the coco-nuts brought to Witu came from the same centre as the original natives. Probably a big population did not develop until some time after their food plants had increased sufficiently, as the natives there do plant bread fruits, mangoes, eugenias, galip nuts (*Canarium spp.*) more extensively than in other parts of New Guinea. The original plantings were made in distinct groves as they can be seen to this day, close to old village sites which have now largely disappeared. The first introduction of seed nuts was most likely not extensive and it may be assumed that only better than average nuts were planted so that the foundations for a varying but regional strain were commenced. Numerous people here doubt the very possibility of natives having any idea of seed coco-nut selection. The author has tried out certain intelligent natives as to their knowledge of coco-nuts from this aspect. Allowance must be made for the possibility of their having seen some selection work done, but this would not be true of every case. Natives from certain parts of New Guinea do select nuts for planting in their own groves. Indentured boss boys on three plantations in Witu were asked to select palms in front of myself and their managers. These boys may have seen selection work carried out; nevertheless, without any guidance and in all three instances, the boys instinctively selected good palms after carefully looking over them and roughly tested the weight of nuts in their hands. The intelligent boys assured us that they actually use similar criteria for selecting good seed nuts in their villages. The aid of such boys would greatly simplify any programme of seed selection commenced by the planter.

From a genetical point of view and on theoretical argument, the planting of relatively few selected nuts at high situations would isolate the palms, even if it were done unintentionally. Then, owing to limited intercrossing, a distinct but, of course, variable strain could be evolved in this manner. In what degree this has led to the development of Witu nuts is only conjecture. According to Mr. Mills, the present manager of this plantation, the nuts derived from Meto have tended to give a low percentage of germination when shifted elsewhere and he gave a figure of as many as 40 per cent. being non-viable. If such is genetical, these seed nuts would not be so useful for new plantings as is claimed, but there may be other causes for this. Numerous introductions from Meto plantation to Keravat have already been made by this Department.

In German times seed coco-nuts were imported from Meto to Bali and from Bogadjim plantation on the mainland and were apparently selected for size and weight. Some plantation areas show a rather high proportion of heavy bearing brick-red nuts which may have come from the mainland. After the Australian

occupation about half the main bearing area at Bali was planted with seed nuts derived from the older palms which grew from originally imported seed. It is only very new areas at the rear of the plantation which were derived from local native palms.

Local native coco-nuts seen in the villages were usually smaller, more pointed and not nearly so heavy as those from plantation palms. It must be conceded that this diminution in size may have been caused by closer planting and competition with secondary bush. Though growing on similar soil the native nuts at Bali were quite a different type from those seen in the native villages at Witu, near Meto plantation, while the introduced nuts appeared superior to the local nuts on the plantation at Bali. It is thus believed that unconsidered selection was practised when the original selected nuts introduced by the Germans were used as a source of seed nuts for further plantings.

Members of one firm here which have introduced large selected nuts from Kar Kar Island to plantations in other parts of the Territory claim that they have fared better than local palms.

Lever's plantations in the Solomon Islands are said to have introduced nuts from several different countries such as Malaya and Fiji for comparison with local nuts. Managers have stated that palms derived from all these sources were far more liable to beetle damage and did not fare so well as the local nuts. This curiously coincides with the experiences where Markham nuts were introduced to Keravat and earlier when other types were introduced to Rabaul, but no good reasons can be advanced as to why this should happen.

The present Department of Agriculture has carried on a great deal of coco-nut seed introduction from outside countries and also from the various outlying districts in New Guinea. These are at present being grown under the supervision of the Superintendent at Keravat, but in most instances are too young for detailed observations on their behaviour.

The Director of Agriculture observed some palms growing in the Solomon Islands which were originally derived from seed of already selected tall palms growing in Malaya. These were 26 years old and bearing heavily. Re-selections derived from this area were introduced to Keravat Demonstration Plantation, in January, 1934. In January, 1935, seed coco-nuts derived from the best selected palms which had been subjected to yield recording for some years at the Landbouw Instituut, Buitenzorg, Java, by the Selectionist for perennial crops, Mr. de Veer, were introduced as part of a large consignment of plants brought in by the present author. More recently during this present year (1937), and through the courtesy of the Director, selected coco-nuts were introduced from palms which had been under observation for some years at the Coco-nut Research Station, Menado, Celebes, Netherlands East Indies.

A request has also been forwarded to the authorities in Manila, Malaya and Fiji for any selected coco-nuts of various kinds, which may be available at their research institutions.

In addition to the above programme of introduction, coco-nuts from selected palms on plantations growing in all parts of the Mandated Territory of New Guinea have been collected for inclusion in a breeding programme at Keravat. The following districts and sub-districts are represented in this collection: District, New Britain—Rabaul, Talasea and Gasmata, Sub-districts. New Ireland. Witu Island. Dampier Island, Bougainville Island, and the mainland of New Guinea.

The coco-nuts derived from the Markham Valley, particularly in the upper Atzera region, have been generally noted for their large size, perfect shape and good yield, and this has been commented on in several reports by Patrol Officers of the District Services, as well as by officers of this Department. In October, 1929, a large consignment of these coco-nuts was introduced to Keravat and planted out in an area isolated from coco-nut palms, at the Demonstration Plantation, derived from other sources. These palms have retained, to a marked degree, the original characteristics for which they were introduced under the widely different soil and environmental conditions which prevail there as compared with their original habitat. Mr. Moody, Inspector and Instructor, says that when these nuts were introduced to Lindenhafen, New Britain, they tended to break-up and become more pointed than is usual for the Markham nuts, but, although varying, still showed many of their original characters. It is possible that these coco-nuts did not come from the same area as the nuts growing at Keravat. At Keravat, these Markham coco-nuts, although still varying in colour and size of nuts, are very similar in general type and appear quite distinct from the ordinary native coco-nuts growing in New Britain, and could be classed as a regional strain. Their trunks are apparently shorter and require fewer nuts to produce a ton of copra than nuts from ordinary palms—less than 4,000 nuts as against between 6,000 and 7,000 nuts per ton for ordinary nuts in the vicinity. The nuts have a fairly thick husk, however, and it has not been determined whether their total copra yield per acre is superior to the ordinary types. At Keravat, for instance, the yields have not been compared with coco-nuts derived from local seed. The selections of the heaviest yielding palms were made for inclusion in the breeding programme, and are already planted out as will be described later. All the poor type palms have been eliminated. This plot of palms has been particularly liable to infestation by palm weevils. The Superintendent, Mr. Green, is inclined to believe that this may be due to a varietal tendency for the wood to grow soft. The isolation of a small group of palms would in itself lead to increased infestation, however, because of the greater limitation of the food supply of these various pests. The presence of such a regional strain seems to indicate a more encouraging future for coco-nut breeding than is usually anticipated. The question as to the origin and the presence of such a regional strain on particular areas of the Markham River country is very interesting and needs further study. It is reasonable to assume that the natives in this area may constantly practise seed selection with a definite objective in view. There is also the possibility of natural selection going on over many years having a similar effect. A more important consideration is whether this strain is more liable to self-pollination, than other types, owing to a different hereditary complex, and pollination studies are necessary to determine this point. Mr. O'Brien, planter from Madang, has provided some data which seems to have a more likely bearing on the point He has heard from old residents around Madang that Erima Beach plantation was one of the first places commenced on the mainland by the old New Guinea Company. The nuts introduced there by them were specially brought in as selected large nuts of a particular type. Some plantations planted with selections of this type are still known in that vicinity, and it is thought that the natives in the Markham may have obtained their seed from nuts originally derived from the original introductions. The diameter of husked nuts recently brought in from Madang by Mr. O'Brien ranged from about 6 inches to 8 inches while their diameter is greater than the depth, i.e., ovate. There was a tendency to ridging and the kernel was very thick. Whether such large nuts would produce

more per acre than ordinary nuts is not proved, but some planters near Madang are quite convinced that they do.

It might be said that there is no object in breeding or propagating regional types unless it is proved that a particular form is superior to any other. The San Ramon type of coco-nut later mentioned under varieties, appears to be an example of superior regional type. Copeland[11] says, "That there are no records from any other part of the world of plantation averages showing such size of nut as those of San Ramon. In 1905 for the entire plantation an average production was one metric ton of copra from every 2,800 nuts, while the average production from year to year shows that 3,270 nuts are needed to produce 1 ton or 2,240 lb. of copra." According to the annual report of the Coco-nut Research Scheme, Ceylon, 1935,[6] all other introduced types, with the exception of this variety, proved inferior to local varieties both in yield and susceptibility to beetle attack and quality of copra. It was mentioned that a similar type of this is found in several coco-nut countries of the East. It does appear roughly comparable with the Markham type found here. In the small island of Rotuma, Polynesia, there is another example of a superior strain. This island has been noted for the superiority of its nuts, which have been used for seed in Fiji, Tonga and other places. Coco-nuts from certain areas in the West Indies have been similarly noted for their use as seed nuts, e.g., at San Blas and parts of Jamaica.

The "San Blas" coco-nut of Central America has the layers of cells between the shell and the endosperm which are peculiar in breaking up so that the meat, kernel or endosperm is very easily removed from the shell. This race has been introduced to Malaya and deserves to be introduced here. It may be mentioned here as a noted fact concerning coco-nuts from some areas of the British Solomon Islands, that the half-kernels are easily removed from their shells. Whether this is due to soil or strain effect is not yet proved. In Bali there is a large coco-nut which has been widely distributed in the Netherlands East Indies, and this is known as the "Bali Klapper" in Java.

Smith[57] has indicated rather disappointing results with the "San Blas" coco-nut in Malaya. The palm differs in many characteristics from the tall. In general appearance is midway between that and the green dwarf. The stem is slighter; measurements of twenty palms of each variety at 6 feet gave an average girth of 30.3 inches San Blas, and 38.5 inches tall. The "San Blas" averages about 5 or 6 feet shorter to the lower leaf but the leaf is longer as is the spadix. The chief characteristic on casual observation is the very open crown and the large number of leaves hanging down more or less vertically. The fruits are much more elongated than the tall as is the nut proper inside. They have a very high husk percentage amounting to 43.7 per cent. of the whole fruit compared with 26.1 per cent. for tall.

	Husk.	Wet Meat.
	Per cent. whole fruit.	Per cent. whole fruit.
San Blas	43.72	25.26
Tall	26.15	28.85

Smith concluded that although the "San Blas" coco-nut has the reputation, in Central America, of being an extremely prolific yielder, it did not suit the heavy alluvial clays of the west coast of Malaya, when compared with the ordinary Malayan tall variety.

It may be pointed out that the regional strains, which have been described from Witu and the Markham Valley, could contain representatives of several of the "races" such as are described by Webster.[64] It is a wider term in the sense that it represents a collection of types constituting a strain which, owing to the long effects of natural selection, do show certain characteristics in common.

According to Crocker, Inspector and Instructor, one bag of San Ramon coco-nuts was introduced to Numai Plantation, Papua, by Mr. J. C. Hammett in 1919. When they first came into bearing the nuts were very big, but the yield was not very profuse; whether they did better later on is not known here. There is no record of the introduction of this type of nut to the Territory, but it should be introduced and tried out under varying environments in different districts, as some of these may give full expression of its yield capacity.

Genetical Abnormalities.

The following genetical abnormalities were recorded in a previous article on coco-nut diseases[16] as being present here. No palms showing genetical defects should be used as seed producers.

Yellowing of the Palms.

Genetical chlorosis is known here and even in the best plantations palms showing a genetical lack of chlorophyll are known.

Female Palms.

Male flowers suppressed; nuts often without embryos or with very little copra.

Soft Copra Produced by Particular Palms.

Such copra does not cure properly and remains soft and leathery.

Branching and Twin Palms.

The presence of true branched palms with up to eight branches was first recorded by Preuss[30] for New Guinea.

Bulbiliferous Coco-nuts.

At least eight investigators have recorded cases in which bulbiliferous coco-nuts with deciduous and sterile inflorescences develop small leaves instead of flowers.

Leaf Bases Remaining Attached to the Palms.

Either on the whole or portion of the trunk.

Head Droop.

This was recorded as a suspected virus disease in the article mentioned (*see* pages 71-76) and it was suggested that it would be definitely unwise to select seed coco-nuts from areas where "head droop" is prevalent and that seed nuts even from good palms growing close to a palm suffering from this condition should be avoided.

Gummy Leaf.

This is a condition common at Witu and other parts of the Territory where the pinnules (leaflets) of the palms remain held together and depressed to the midrib. Such palms produce hardly any nuts and should be avoided in the same way as "head droop" palms.

Frond Choke.

This is another common malady in coco-nut palms here. It is undoubtedly mainly present in weak-growing palms which lack vigour. Seed nuts from such palms should be rigorously avoided as they never become good, healthy palms.

Constricted Nuts.

The nuts become constricted in the centre, are very pointed and do not fill properly which is probably an hereditary defect.

PLATE IX.—COCO-NUT PALM.



Showing tendency to "Frond Choke".

Coco-nut Varieties.

Omar[43] says that in Singapore Island fourteen different races exist, twelve differing from each other in the nut, and two differing also in growth. The Malays have named four types from which most of the Singapore copra is made—"Kĕlapa bulat" (round coco-nut), "Kĕlapa besar" (big coco-nut) and "Kĕlapa jantong" and "Kĕlapa sapang" (both heart coco-nuts). Another common race "Kĕlapa laga" is too small for copra. He mentions two rare types, "Kĕlapa nipah" and "Kĕlapa hyau", which promise big yields of nuts suitable for copra making, and also the dwarf coco-nuts "Kĕlapa puyoh" (quail's coco-nut) which is green and the "Kelapa gading", the common yellow dwarf.

Other nuts with special uses are "Kĕlapa dadoh" (curd coco-nut) which, in about 5 per cent. of nuts, has detached granules of endosperm in the milk and is eaten with sugar as a delicacy.[62] "Kĕlapa kuning" (yellow coco-nut) has more sugar in the milk and is reserved for eating while the nuts of "Kĕlapa loji" are eaten young. (Races similar to these are present in New Guinea.) "Kĕlapa wangi" (fragrant coco-nut) with a scented meat and "Kĕlapa sekol" the shell of which is fancied for cups. Burkill[63] says there are twenty races recognizable at Kuala Kangsar, Malaya.

Stockdale[66] has described nineteen varieties from Ceylon which are said to be distinct from each other in respect of external features such as shape and size of nuts. Four were said to be special types, namely, the "tembili" or "king" coco-nut, the "yellow gon-tembili", a large imported nut resembling the large "San Ramon" which was also described, and another imported nut. The others were divided into nine main groups from detailed measurements and other particulars taken. Copeland[61] mentions the "San Ramon" nut of the Philippines as being the characteristic palm of the San Ramon district which has been distributed to all parts of the country by their Government. He regards the "Laguna" nut as the ordinary coco-nut of the Archipelago as a whole and it appears comparable with the typical ordinary coco-nut throughout the world.

Copeland and others have listed amongst other varieties "Coco nino" or "baby coco-nut" from the Philippines which produces fruit at the age of four years, when the trunk is so short that the nuts can be collected for several years by a person standing on the ground. The "Pugai", a very dwarf nut, is also mentioned, with a diameter of about 7 c.m. when husked. This fruits in three years and the very small nuts are used as curiosities.

He says, "that as clear cut and distinct as are the 'San Ramon' nut, the 'Laguna' nut and the two dwarf forms, when only these four forms are considered, it would probably not be difficult to collect in the Philippines an unbroken series without a break of 1 millimetre in diameter which would connect the largest and the smallest nuts and an equally perfect series could probably be found in other countries".

There is a variety in the Philippines which although not the same is not unlike the type found in the western islands. This variety, known as "Makapuno", has no cavity inside the hard endosperm, but instead there is moderately light but still firm tissue filling the entire interior of the nut. Such nuts do not germinate, however, and may be produced on the palms, part of which produce ordinary nuts. A similar nut is found in Java and in both countries it is valued as a delicacy. One hundred nuts of this type were recently brought into the Botanic Gardens. Many other varieties have been described, e.g., with extremely hard shells, usually thick husks, soft endosperm, blackish green husks and so on. It is not known for certain how the variations in types found in one country compare with those found in another, but there do seem to be varieties which are common to all parts of the world.

Hunter and Leake[28] writing on this subject say, "that the number of coco-nut varieties has not been accurately determined, partly because of the difficulties inherent in any such determination in the case of a plant of such wide distribution and with so long a life, and partly because of the lack of genetical purity, due to the fact that cross-fertilization takes place normally". Wester, 1920,[64]

enumerates over 80 names, many of which are no doubt synonymous, but he has by no means exhausted all the types available from all parts of the world. The most distinct variety is the dwarf coco-nut, but other very distinct types are known. There is a variety present in New Guinea whose appearance and behaviour would suggest an entirely different hereditary and chromosome complex. The type referred to is widely distributed and has been seen by the author in New Britain and Lavongai Islands. It has also been recorded from Bougainville Island and is undoubtedly present on the mainland. This coco-nut is well known to the natives who relish the edible husk. The whole husk as well as the interior of the nut is edible until a late stage of maturity and is sweet and said to be palatable although it turns red in the mouth. The variety with sweet or sugary husk is called "Tabau" or "Cuyamo" in the Philippines and "Kĕlapa Tebu" in Java. It should not be confused with a variety found in several parts of New Guinea which has a more sugary endosperm or kernel and is thus especially prized by the natives, such as in the Huon Gulf area and in parts of Bougainville.

It appears to the author that this is really a genetical abnormality, and that the whole edible portion consists mainly of a proliferation of soft terminal cells from the flower branch, such as is seen on the true growing point of the palm itself, which is also much liked by natives and has been named by Europeans the "Millionaire's Salad". Coco-nut palms which produce almost entire leaves, branching coco-nut palms (one growing on an island here, stated to have five trunks; palms with up to ten stems have been recorded elsewhere) and those palms, which produce female flowers only, are probably mutations (sports) which on crossing should behave as mendelian characters and be inherited in distinct ratios. There is also the possibility of an aberrent number of chromosomes being present in such cases which lead to abnormal developments.

There is a distinct field for a good cytologist who could study the cell structure and the chromosome number and behaviour of such off-type palms and thus learn much which would be of value to workers studying pollination and fertilization problems, or to those engaged in coco-nut breeding. One has only to turn to the value of such findings to workers on tobacco, maize and fruit studies to know how valuable cytological findings can be in elucidating difficult problems. As far as it is known the only investigation on the nuclear constitution of the coco-nut was conducted by Santos, 1928,[52] who finds that the haploid number of chromosomes present in the germ cell is sixteen.

Several true branched coco-nut palms have been described by Paul Preuss, 1911,[50] from the mainland of New Guinea and he includes a photograph of one palm from Matty Island with six stems. In his book he also describes six coco-nut varieties from Samoa and says that there are at least ten or twelve varieties in the Bismarck Archipelago and mentions a dwarf red variety as being present here. Branched coco-nuts are still known in some of the outlying islands of New Guinea.

Dwarf Coco-nuts.

It is pointed out, however, that the green and yellow varieties of the dwarf coco-nut from Malaya were introduced in 1930 and have been in bearing for some time at Keravat. They have also been tried out on a small scale in outside areas.

Handover[26] expressed the opinion that the Malayan dwarf race known as "Nyior gading" first originated as a sport or mutant in Java. Other apparently distinct dwarf races are known in the Philippines, Fiji, Madagascar, Ceylon, Maldini and Nicobar Islands. The above authorities[31] from observations show that the dwarf coco-nut from Ceylon is quite distinct from the "Nyior gading" and they give reliable descriptions of the two types together with the Philippine dwarf variety, "Coco nino", which is also a distinct type.

In Fiji dwarf coco-nuts are being grown and the Malayan dwarf has been crossed with the local dwarf coco-nut called "Niu luka"[1] an example of hydridization. Some of the resultant selections bear coco-nuts before the spathes rise above the ground. These should provide very interesting material as they have been artificially crossed and re-selected. Investigations on this cross show that it is liable to cross fertilization in Fiji.

With the idea of selecting superior dwarf palms from this cross, coco-nuts of individual palms were submitted to chemical examination in their first and second years of bearing. It was found that the weight of meat per nut varied from 361.4-531 grams on a wet basis, while the percentage of oil per nut (wet basis) varied from 23.76 per cent. to 39.92 per cent., hence considerable variation in these characteristics was apparent.

So far the cultivation of dwarf palms has not spread here although it has been the subject of many inquiries to this Department owing to its reputation for high yield in Malaya. Yields of around 30 cwt. to the acre are obtained under some conditions such as at Chersonese Estate.

Production of Dwarfs and Talls Compared.

The figures for dwarfs are average from six estates—after Jack and Sands.[32]

	Dwarfs.	Talls.
Number of palms planted per acre	90	48–55
Crops in pikuls per acre 4th year	2.29	..
Crops in pikuls per acre 5th year	6.19	.5
Crops in pikuls per acre 6th year	7.52	2.00
Crops in pikuls per acre 7th year	9.24	4.00
Crops in pikuls per acre 8th year	11.68	6.00
From 10th year (estimated)	13.00	8.73
Number of nuts per pikul of copra (mainly yellow)	560 (approx. 9430 per ton)	251 (4230 approx. per ton)
Number of nuts per pikul of copra—average of two estates (mixed dwarf palms)	482 (approx. 8118 per ton)	251
Number of nuts per pikul of copra—Green race only (estimated)	430	251
Weight in grammes of copra per nut to nearest 10 grammes	130 (.29 lb.) (4.68 oz.)	268 (9.36 oz.)
Number of nuts per palm per annum (conditions favorable)	90	50
Production of copra in pounds per palm per annum (favorable conditions)	25	32
Production of copra per acre per annum in pounds (favorable conditions)	2,250	1,600

Average oil content of copra = 64.78 per cent. and 7.74 per cent. (moisture).

PARTICULARS OF AREAS OF DWARF COCO-NUTS, CHERSONESE ESTATE.[63]

Area 41.05 acres. Date planted—1920.

Planting distance 22 feet x 22 feet square giving 90 palms to the acre, but owing to the fact that bunds and channels are included in the planted acreage the total number of palms is only 3,488 and the average number of palms per acre just under 85.

Varieties—

Dwarf "red"	3 palms.
Dwarf "greens"	90 palms.
Dwarf "yellows"	3,395 palms.

Year.	Number of nuts harvested.	Average number of nuts per palm.	Copra per acre in piculs.	Number of nuts per picul of copra.
1925	194,530	56	7.83	604
1926	235,360	67.5	9.54	600
1927	209,876	60	7.24	707
1928	386,876	111	14.33	646
1929	235,444	67.5	8.96	602
1930	369,050	106	14.88	592
1931	371,645	106.5	14.93	590.
1932	345,208	99	15.18	531
1933	514,091	148	26.99	457
1934	470,028	135	23.56	461
1935	531,219	152	27.60	458

NOTE.—1 picul = 133⅓ lbs.

Intensive irrigation was introduced in 1931 and fewer nuts were required per picul of copra in 1932. In 1933 and subsequent years, yields have been phenomenally high and the nuts have been very much larger than formerly.

In view of the results already recorded, the writers feel justified in anticipating potential yields of at least 30 piculs of copra per acre from the new area described above planted with "dwarfs" in 1935, and also the area it is intended to plant this year (1936) with the same variety making the total of 324 acres.

Lennox,[37] a visiting scientist from Hawaii, informed this Department that they have bearing dwarf coco-nuts in that country which fruit before the spathes are much higher than the ground level. The Maugipod variety in the Philippines is also said to produce fruit when the tree is so small that the cluster rests directly on the ground. Malayan dwarf coco-nuts have been tried in Papua and according to Moody, Inspector and Instructor of this Department, who was resident there for some time, they came into bearing and yielded well, but the copra was inclined to be leathery and not quite such good quality as the product from ordinary palms.

The utility of dwarf palms to New Guinea conditions is not yet apparent as this variety is far more particular in regard to soil conditions where it is grown, than is the case with ordinary coco-nuts. The growing of dwarf coco-nuts here is only in the experimental stages and it would take a long time to build up sufficient material for planting on a large scale. Copra from dwarf coco-nuts grown at Keravat has been cut and dried at Kabaira Plantation, but did not produce such

a good sample as ordinary copra, being softer and more pliable. Seed nuts from Keravat were planted out at intervals on higher ground at the back of that plantation. Seen as young palms they do not appear to be flourishing yet on this light rather pumiceous soil.

It may be of interest to record that one natural dwarf mutant palm was seen along the Kokopo road close to Rabaul, before the recent eruptions.

What would be more surprising to a great number of people here is to know that dwarf palms yielding reddish nuts are grown in many native villages along the Aitape coast on the mainland of New Guinea. Wood, Inspector and Instructor, stated that "the natives themselves indicated that the nuts first came through from the Dutch border in the course of their usual trading". He noticed that in nearly every village a small number of these nuts were grown alongside the tall nuts and were yielding profusely. For some reason they are usually "tambu" (forbidden) to the native "Marys" and only the boys eat them. It is probable that these are Malayan dwarf coco-nuts originally sent to Dutch New Guinea. These are now being grown in villages 150 miles from the Dutch border. It is easy to realize how similar planting material could have been spread by natives before the advent of white man here.

As these nuts appear to be flourishing under the local conditions they should form a good source for seed supply. Some intermediate types present at Aitape show the chances that some crossing with tall palms has occurred. It has been stated that though the yield per plant, despite the number of nuts borne, is less than that of the tall variety, the larger number of palms carried per acre more than counterbalances the deficiency. Dwarf coco-nuts are earlier maturing than tall coco-nuts and produce 700-900 nuts per acre from the more closely planted palms, but it takes approximately 8,000 nuts to the ton of copra. When the conditions are exceptionally favorable the yield of copra is far greater than from the tall palm, but the yields are unsatisfactory where the soils are unsuitable. While in Malaya the author was informed that the dwarf red nuts are very sensitive to unfavorable conditions, but that they give a very fine yield where the circumstances are ideal. The copra and oil are not so good as that derived from ordinary palms.

According to Jack and Sands[32] the average period which elapsed from planting to flowering of dwarf coco-nuts, in Malaya, was for yellows, 3 years, 86 days; reds, 3 years, 105 days; greens, 3 years, 263 days. The green types commenced flowering at uneven periods which was thought to be due to the greater genetical impurity of the strain.

The germination results of the second generation of nuts showed that, in respect of colour of the young shoots and subsequent growth, they were apparently true to the type of palm from which they were taken. This suggests that they are self-pollinated and breed true.

Mr. Murray, Director of Agriculture, says that during several visits to Malaya he found that opinions varied regarding them. The manager of one large estate had several hundred acres under dwarf palms, but he considered they were most unreliable and very variable as to production, even in the same field.

Referring to dwarf coco-nuts in their "Consols of the East", Smith and Pape[58] stated that two estates, "Sungei Nepap" and "Chuah", in Malaya have 500 acres of the "Nyior gading" dwarf coco-nuts in cultivation. These plantations

are in the Coast District of Negri Sembilan. The young trees which were planted 30 feet x 24 feet, giving 90 to the acre, are doing well. Preliminary expenses were rather heavy owing to difficulty in procuring seed. The palms should come into bearing in about four years, which means not only a shorter time and less expense on upkeep before revenue is obtained, but also a quicker return on money invested. It remains to be seen whether these advantages and the probable higher yield of nuts per acre will compensate for the greater expense in husking, &c., per lb. of copra obtained.

Chersonese Estate in Perak, Malaya, is exceptionally well suited for this variety and after the experiments carried out by the late manager, Mr. H. Wardlaw,[63] it was intended to plant another large area.

Soil for the dwarfs should be of heavy nature though pervious to water, and provided that the sub-surface water is moving a comparatively high water table is no disadvantage. The area in Chersonese Estate under "dwarfs" is on a peninsula, the sea on one side and salt water river on the other. The land is all bunded to prevent flooding with tidal waters (the tide averages a rise and fall of 3 feet) and provided with drainage and irrigation channels, water gates to be opened or closed as necessity arises. This system has resulted in a considerable increase in the size of the nuts.

Cooke and Jagoe[66] have shown by experiment that the copra from dwarf palm nuts is of inferior quality to copra prepared from ordinary tall palm nuts in a good kiln. It is difficult to prepare hard copra from dwarf coco-nuts and usually a large proportion of wrinkled, distorted, rubbery copra is produced.

SUMMARY OF RESULTS.

Copra ex—	Appearance (in order).	Percentage of rubbery pieces.	Nuts per picul of copra.
Tall nuts	Good ..	0–10	200–284
Green dwarfs	Fair	10–36	350–370
Yellow dwarfs	Poor ..	18–80	477–667
Red dwarfs	Very poor ..	50–92	370–513

They also concluded that the dwarf palms appear to favour a soil stiffer than that which is most suitable for tall palms and require greater attention to drainage and respond rapidly to improvement or deterioration in conditions. While very remarkable yields are obtainable at an early age if conditions are favorable, in most instances yields are only fair, or poor, because the conditions do not suit the exacting requirements of the dwarf palm. Early in 1933 they stated that "information had been received from estates with both tall and dwarf palm cultivation that, at least for the immediate future, only tall palms will be planted in new areas or as supplies, even though in two instances yields were good".

Dwarf Coco-nuts in Samoa.

Hamilton and Grange[25] referring to dwarf varieties for Samoan conditions state that "seven varieties which bear at an early age are now under trial at Vailele Plantation, having been obtained from the Agricultural Institute.

Buitenzorg, Java. A further type was observed under trial at the Central Agricultural Station, Navuso, Fiji. Here an attempt is being made by crossing to combine the best qualities of the Malayan dwarf coco-nut with those of the native dwarf "Nui leka". The F1 progeny shows considerable variation and the F2 generation may be expected to show further segregation. The "fixing" of a desirable type is likely to be a matter of some difficulty. Some of the F1 progeny have commenced bearing at three and a half years from the time of harvesting the parent nut. The experiments will be watched with interest, and as soon as the work progresses to a suitable stage, propagating material should be obtained for trial in Samoa. It is unlikely that under present plantation methods these dwarf varieties will fill any useful place in plantations, but owing to their rapid bearing they may fill some place in the native economy under special conditions".

In Malaya it is said that the profitable bearing life of the dwarf coco-nut is not so long as that of the tall coco-nut, which is an important consideration. The larger nuts from ordinary palms are decidedly more valuable than small nuts from dwarf palms, where two types of equal total productiveness are compared, because it costs as much to open a small nut as it does a large one. When a given number of small and large nuts are compared the copra can be manufactured more cheaply from the large nuts.

These detailed particulars of dwarf coco-nuts are given because of the recent interest displayed in them by planters here.

The area at Keravat where these coco-nuts are growing is rather heavy and somewhat inclined to waterlogging in wet weather. The palms have fared only moderately well under these conditions so the Superintendent is going to try them on somewhat lighter soils. It is suggested that it would be a good idea to establish trial areas on heavier soils such as at Lavongai (New Hanover) or on some areas at Manus. It is not yet possible to give a definite opinion regarding this strain of nuts, but it appears that they will not be suited to a particularly wide range of conditions in this Territory. The dwarf-red strain of coco-nut was tried out by Germans at Bogadjim Plantation, and even though a couple of entire rows of these palms are still left they are not utilized for their crop.

A few Malayan dwarf palms are growing in native villages at Witu, e.g., several at present at Balangori Village. At Lama Village, closes to Lama Plantation which is a few miles from the former village, there is one solitary dwarf red type of palm which is bearing most profusely. This palm is completely isolated from all except tall coco-nuts, and the nearest of these are about 60 yards away. Thus this palm is either completely self-fertile or else it is pollinated by pollen from tall palms. There is also one solitary dwarf palm similarly isolated amongst tall palms near Meto homestead about 2 miles from the palm described above which is the nearest to it. The yield of nuts on both of these palms is quite as good as would be expected if they were growing close to other dwarf palms. The interesting fact, however, is that these palms were said by the natives to have been brought in originally by a police boy from the mainland, the nearest port being over 200 miles away at Madang. As this boy came from Aitape, it is likely that the nuts were originally derived from Dutch New Guinea. This is a good example of the human agency in seed distribution.

Leaf Development.

Copeland[31] has stated "that in the Philippines the leaves take one and a half years from their first appearance until their full development and that another one and a half years are required for fruits to mature in their axils. This period could be expected to vary according to climatic and outside conditions".

In the case of dwarf coco-nut palms it is stated[32] that "the number of fully opened leaves of all ages, which form the crown, may vary from 24 to 28 in palms up to seven years old. As a rule there are from eight to ten expanded leaves above a spathe which is fully opened".

The rate of leaf development does not follow any set periodicity such as may be thought, as it is dependent on several variable causes. It is less rapid in the wet season than in the dry season and, further, there is usually also more leaf fall in the wet season. When the palms are carrying a heavy crop of nuts leaf development is slowed down. Even the number of leaves present on one tree varies from time to time and, of course, there is a wide variation in the number of leaves normally produced by individual palms. The recent volcanic eruption in May last greatly affected many thousands of palms, causing them to assume an umbrella shape, while in many cases only the central unopened fronds remained standing. Six months afterwards it is seen that in many cases, six and seven leaves have developed to between half and three-quarters of their eventual size. The indications are that many of these fronds will develop together almost within a few months of each other. If such were not the case these palms would take many years to recover instead of a couple of years as is expected. Of course, this may be the result of unusual circumstances, and the newly derived pumice soil has possibly forced the growth somewhat. Similar observations have been made, however, after a fire has passed through a plantation heavily infested with kunai, *Imperata arundinacea*. The fronds may be almost completely blackened off, but after a couple of years the palms may almost completely recover.

The rate of leaf development is directly related to the subject of this article because of the fact that it is so closely related to the development of the flowering branches. Since each leaf normally produces a flowering branch in its axis, their appearance roughly represents the rate of leaf development when those which are abortive are taken into account. As Sampson[32] has dealt very fully with this subject in his text book, it is not proposed to dilate on it. He says that, "if a tree is not thriving the rate of leaf growth and length of life is greatly lessened compared with a vigorous tree".

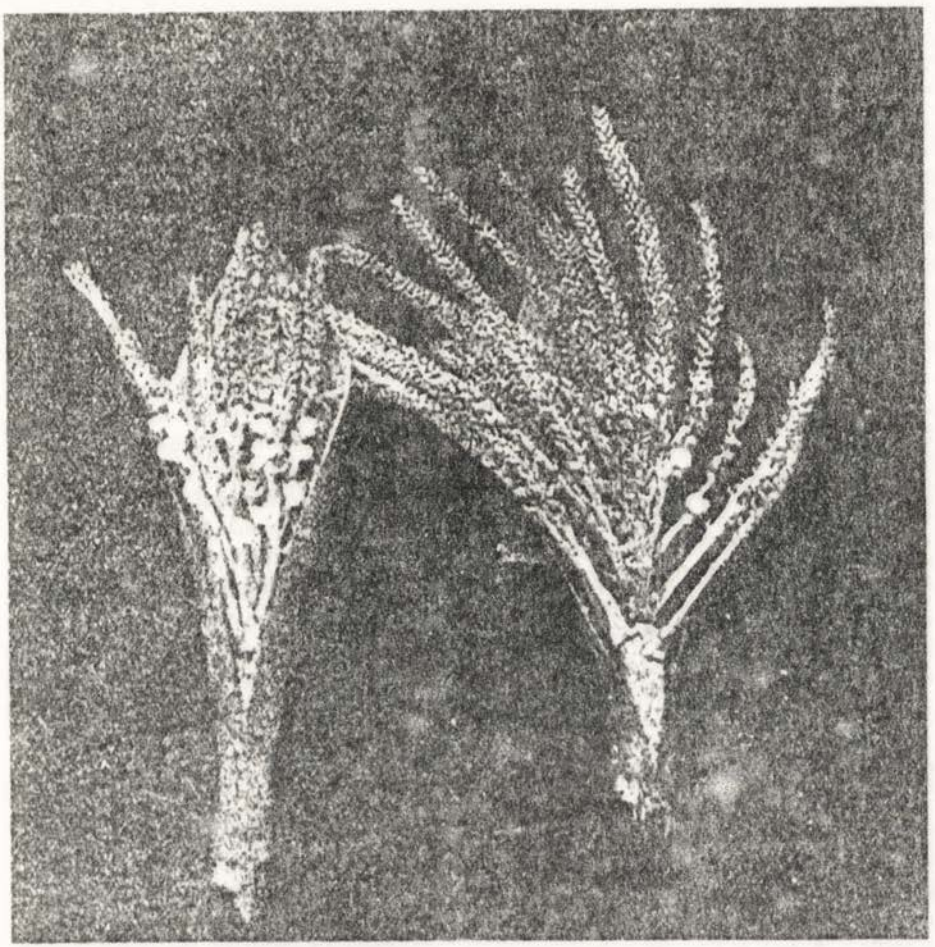
In regularly bearing trees the average number of leaves formed in a year is about fourteen and a variation has been noted of from twelve to nineteen in the same year on different trees. In brief, it might be said that all the factors which determine leaf development are related to fruit development, as the leaves are responsible for the elaboration of the plant foods brought to them in the cell sap from the roots. A tree with a compact crown and a large number of leaves will, almost invariably, be found to be a regular and heavy cropper.

Floral Morphology of Coco-nut Flowers.

The structure of the coco-nut flowers (floral morphology) is well known to botanists generally and has been described in many text books and periodicals (*see* [8-27 34-36-45]); thus it is not proposed to dwell on this subject except to present a general description in order to acquaint planters of the subject.

The biology and physiology of the coco-nut flowers, as well as the detailed life history of the flowers and fruit through all its stages, are much less known, but, nevertheless, a considerable amount of work has been done on this subject. Coco-nut spathes are formed in the axil of every leaf but are not always seen as mature inflorescences. All planters when cutting down palms have noticed the presence of abortive, i.e., permanently undeveloped, spathes which could not be

PLATE X.—COCO-NUT SPATHES.



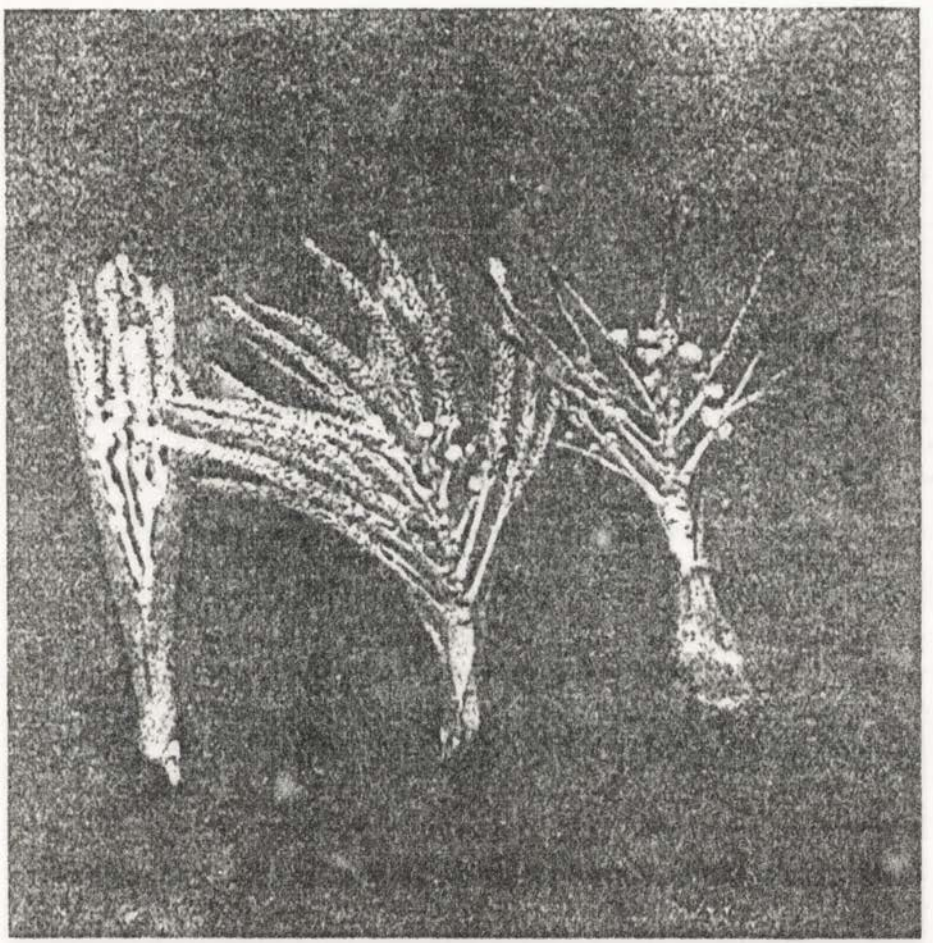
Early stages, showing male and female flowers.

A. Just opening (curiously, some anthers shedding pollen). B.—Spathe opened (male flowers intact).

seen externally, until the fronds were removed. This explains why the number of spathes produced does not often correspond with the number of mature fronds seen. Sampson and others have described the spiral arrangement of the fronds on the stem so that every sixth leaf opens nearly above the first one, and this spiral may be right-handed in some palms or left-handed in others.

Planters are also well aware of the fact that the much-branched inflorescence is at first contained within a thick, fibrous sheath called the spathe, which in its earlier life is in turn covered by an outer yellow, flat softly-fibrous sheath. This outer sheath does not last long, being pierced at an early stage by the hard point of the inner sheath usually on the ventral side facing the lower leaf. This latter emerges as a yellowish, flattened cone which later becomes more tubular in outline.

PLATE XL—COCO-NUT SPATHES.



First two stages (same as above). Additional spathe showing female flowers receptive, male flowers shed.

Until the spathe is fully grown the branched inflorescence is tightly compacted so that it is quite impossible for the flowers to open before the spathe splits. The whole inflorescence is known to botanists as a "spadix" because it consists of many flowering branches (spikes) which are arranged in spiral fashion, situated on a fleshy, central-flowering stalk (peduncle). The development of the inflorescence within causes so much pressure on the walls of the spathe that it

very slowly ruptures longitudinally, usually on the lower or ventral surface. It is said to take more than one day before the inflorescence finally makes its egress. There is usually a characteristic downward curve of the spathe so that it acts as a protection on the young florets, besides remaining attached as a collar which protects the base of the main flower stalk. It is common knowledge that the coco-nut bears male and female flowers on the same palm and, as a general rule, in the same inflorescence (known botanically as a "monoecious" plant). According to Furtado (*loc. cit.*), the size of the whole inflorescence may vary from 2½ to 6 feet in length from the tip to the base. Each branchlet is fringed with numerous male florets which are in some instances arranged in lines or groups of up to six or more florets in a row, but in most cases much fewer are present. The female flowers are situated lower down on the branches, and all flowers are non-stalked (sessile or sub-sessile), being attached closely to the branches.

Male Flowers.

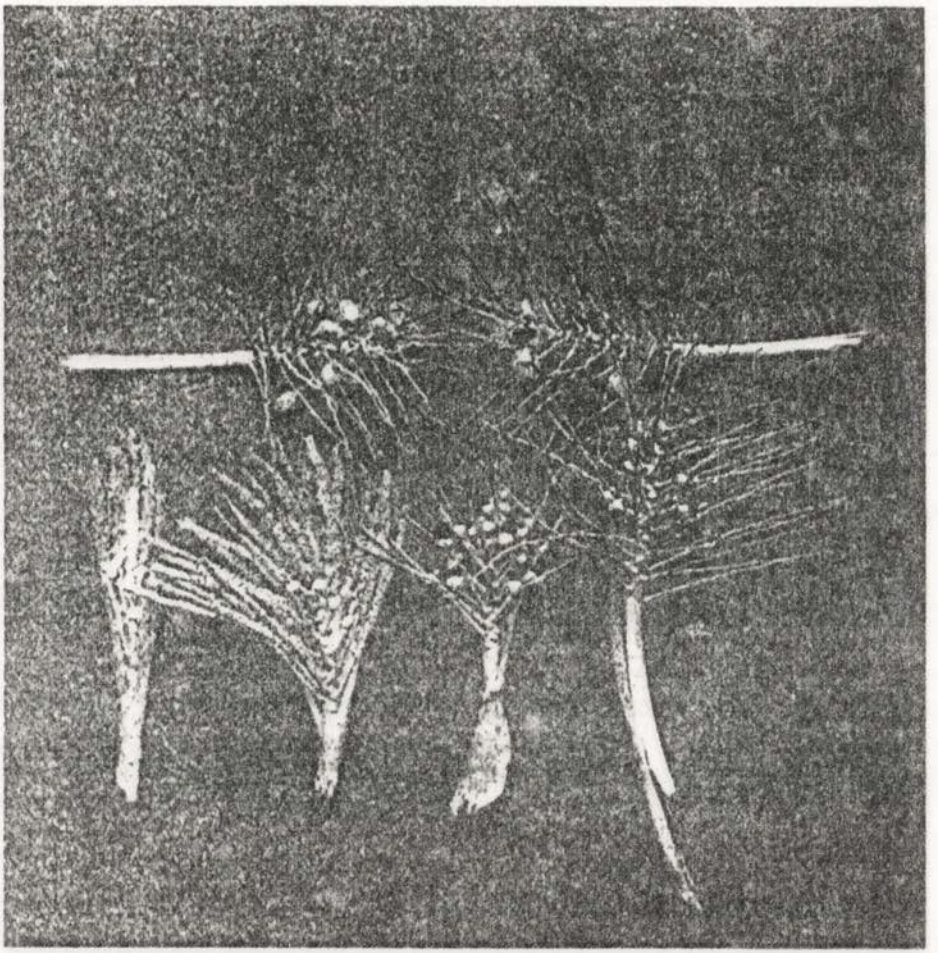
Each male floret has six yellowish floral leaves which are arranged alternatively in two whorls, the outer three being about one-third the size of the others. Within these are six hammer-shaped stamens which yield large quantities of powdery yellow pollen which represent the male elements necessary for the fertilization of the female flowers. In the centre of each male floret is a short column (rudimentary pistil) which at the apex is divided into three teeth; at the base of each of these is a nectary, the nectar of which attracts insects, birds, &c. The male flowers open from the tip downwards though at odd times a few flowers open out of order. The variable period during which male flowers on a particular spathe are opening and shedding pollen usually represents the duration of the male phase for a particular palm. Aldaba[4] observed in the Philippines that the majority of male flowers begin to open daily at about six o'clock and dehisce their pollen at about eight o'clock in the morning.

Female Flowers.

The female flower in its early stages, prior to its opening, is a small spherical, or slightly conical body, sometimes almost triangular in shape, which often grows to more than ¾ inch in diameter. It has a great resemblance to a young coco-nut and this may give planters the idea that it is a fertilized fruit, despite the fact that the pistil is still so young and so covered up as to be unreceptive to pollen. In the early days some investigators were inclined to believe that the flower had been fertilized, and the nut formed before the inflorescence opened which idea was, of course, quite wrong. As is the case with the male flowers, there are six floral leaves which are arranged alternately in a similar manner. They are developed so as to enclose the pistil completely, and entirely hide the inner parts of the flower until it has sufficiently developed as to become receptive to pollen. These floral leaves are much larger and thicker than in the case of the male flowers while, in addition, at the base of the whole floret there are two short and broad attachments known as "bracteoles". These are seen to remain attached to the branchlet if the young flowers happen to fall. It is because the floral leaves are wrapped so tightly around the female flower that it has often been taken for the fruit. Just prior to the flowers becoming ready to receive pollen a small bulge of tissue, surmounted by a white nipple, is seen emerging

from the tightly packed leaves. This is really the tip of the oval-shaped body contained within the leaves, which is composed chiefly of tissue which will develop into the husk of the mature fruit. Some time after the inflorescence opens it is seen that the white nipple is divided by three equi-distant grooves which meet at the apex. Alternate with the grooves are three bulges which extend right to the

PLATE XII.—COCO-NUT SPATHES.

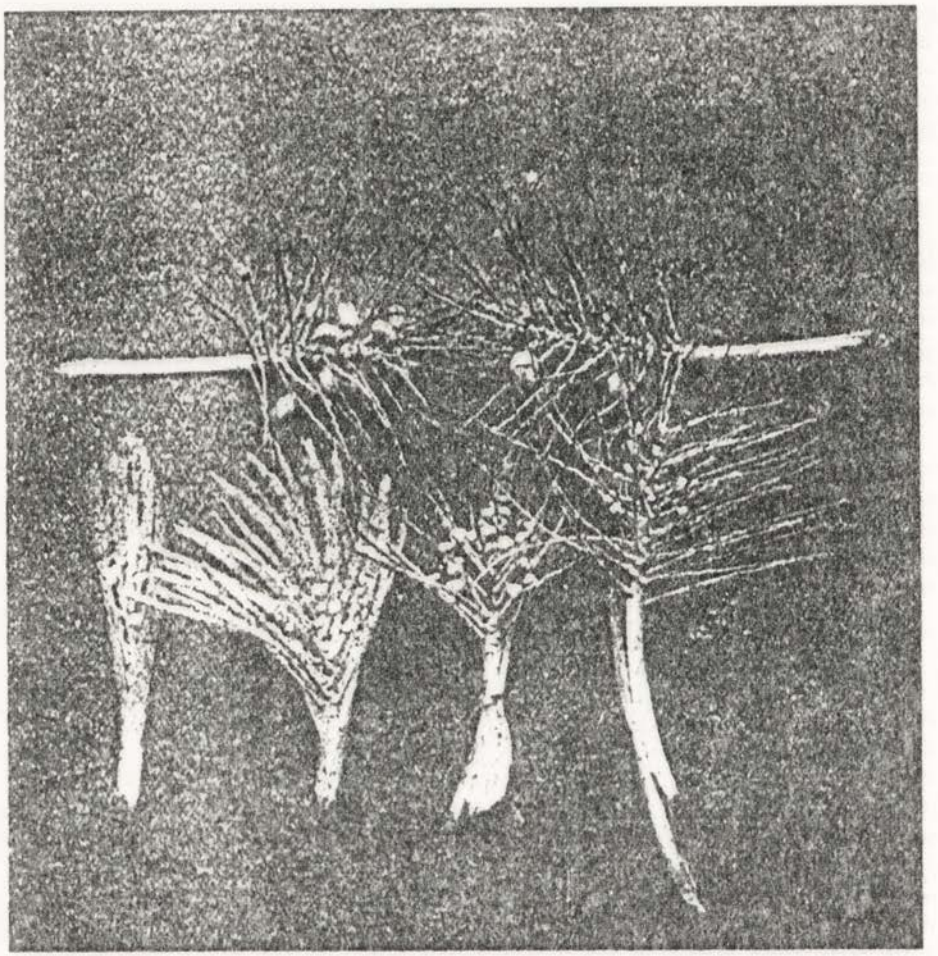


A.—Includes earlier stages (as above). B.—Also shows later stages, illustrating development of young fertilized nuts.
N.B.—Percentage shed compared with earlier stages.

base of the ovary making it appear globosely three-sided. When the female flower is ripe the pistil is recognizable as a small whitish body, the three short segments at the tip separate and stand erect as three prolongations or teeth, thus exposing the stigmatic surface on which the pollen must fall before the female flowers can be fertilized.

The stigma only becomes ripe or receptive to pollen when the ovules have reached a certain stage of development. The complex series of cell divisions which are associated with this development both in the pollen (male germ cells) and ovules (female germ cells) come within the realms of cytology and will not be

PLATE XII.—COCO-NUT SPATHES



A. Includes earlier stages as above.

B.—Also shows later stages, illustrating development of young fertilized nuts.

N.B.—Percentage shed compared with earlier stages.

discussed here. It is sufficient to state that a receptive pistil can usually be recognized by the fact that mature pollen is adhering to it, while there is a shiny, sticky exudate containing sugars and other growth substances present. The pollen

grains readily germinate in this medium and the pollen tube carries the male nucleus down towards the female nucleus where the two elements fuse and fertilization thus occurs. The stigma ultimately turns brown and later black, due to cell collapse, and can be easily recognized as a small, dark rounded area at the tip of the young fruit. The six floral leaves do not develop in size, but form the group of small basal leaves which remain until the mature fruit is ready to drop. The ovary (embryonic nut) has three carpels containing ovules; two of these become abortive and thus finally only one nut develops as is seen in an ordinary coco-nut. In the few cases where two or three of these ovules develop we get bilocular or trilocular nuts as the case may be. Thus the planter can recognize a main reason for twin germination or, in other cases, triple germination in the nursery. This type of nut may produce a palm with two or three stems, which case must not be confused with branched coco-nut palms where the branches come out from a single stem.

On nearly every rachilla (flower branchlet) one, two, three or five or, in rare cases, as many as nine female flowers develop.

Botanists who are interested in a detailed technical and scientific account of the development of the ovule and embryo sac (female elements) of *Cocos nucifera* are referred to investigations on that subject by Juliano and Quisumbung.[24] The following paragraphs of general interest are quoted: "In the development of the ovule and embryo sac of *Cocos nucifera* much time is involved. The internal growth of the axis of the flower must have begun long before the inflorescence has escaped from the outer spathe and ovules are developed after it has escaped from the spathe. The development of the female embryo sac continues and proceeds up to about the receptive stage of the stigma when it becomes ready for fertilization".

Fall of Young Female Flowers, Confused with Nut-fall.

Planters often notice very small female flowers which have fallen to the ground and these are mistaken for young nuts. The presence of such female flowers on the ground is then referred to as nut-fall. Some investigators also assume that it is mainly fertilized flowers which fall to the ground, which, of course, is a wrong premise, as when female flowers fall in the embryo stages this is really a form of "embryo abortion". This fall of unfertilized flowers may be due to causes other than those which are responsible for true nut-fall as, for example, hereditary tendencies, faulty nutrition and so on. It is believed that as far as coco-nut flowers are concerned absolutely no work has been carried out on this important subject. In fact, prior to about 1913, when Fredholm[19] corrected the view, it was customary for coco-nut planters and even some investigators to consider all female flowers even when they were not ripe to receive pollen as fertilized or at least pollinated flowers. Some believed that pollination occurred before the actual opening of the sheath. In other words, the female flower bud was mistaken for the young nut (fertilized ovum).

The young female flower, prior to the pistil being exposed, as mentioned under the description of the female flower, has a superficial resemblance to a young nut. The portion which is seen covering the female flower actually forms the basal leaf rosette at the base of the young nut, so it should not be difficult to correct this view.

Development of Inflorescence or Spathes.

The inflorescence initially begins as a minute protruberance at the axil of the petiole. The practical questions which are associated with the development of the inflorescence and flower structure (floral morphology) and which affect related problems of pollination and fruit setting, may be briefly outlined as follows:

(*a*) The period from spathe differentiation to flowering and other questions regarding bud differentiation (i.e., first appearance of the primordia), such as chemical changes, have not been satisfactorily worked out for coco-nuts, and this presents a field for research. The conditions essential to spathe differentiation would influence the whole yield of nuts.

(*b*) The period from spathe opening to receptivity of the first female flowers to pollen has been worked out by Pieris[39] in Trinidad, but on a small number of palms only (eight palms about nine years old) and, under their particular conditions, he names the period as varying between 19 and 24 days. Marechal[41] found that this period varied from 9 to 32 days in "Niu Leka", the Fijian dwarf coco-nut, and from 9 to 23 days in Malayan dwarfs.

(*c*) The age or period of growth at which spathes first appear. This apparently varies greatly as, for example, palms come into bearing much later on the heavier soils of Bougainville than on the light soils of the western islands and this period may range from four years in the latter to eight years in the former environment.

It is also fairly conclusively proved that manuring young palms with either complete or nitrogenous manures brings them into bearing earlier. Another question which requires elucidation is whether it is possible to bring coco-nuts into bearing earlier by using substances such as ethylene gas as is done with pineapples in Hawaii. Very close planting is known to delay greatly spathe differentiation which is, undoubtedly, a question of competition for light and nutrients. It is certain that usually the first spathes and the flowers which they bear are abortive. Thus the period of bearing does not commence until some time after the first spathe appearance in young palms. It is a familiar sight to see almost fully developed green nuts fall from young palms and in many cases whole spathes of such nuts are shed. The tendency for this to happen is apparently more pronounced in some young palms than in older ones. The chemical changes which occur at this stage also need working out as they should have a decided bearing on manurial and pollination questions.

(*d*) The interval between the opening of one spathe and the opening of another was worked out by Pieris,[38] on the same palms referred to above, as varying between 25-37 days. This period of roughly one month agrees closely with opinions expressed by various planters here, but more detailed observations are, however, necessary under local conditions as this interval is very variable. According to Furtado[22] a very prolific palm will produce twelve or more inflorescences per annum, or approximately one per month, but quotes records of palms having produced sixteen inflorescences per year. The shortest average interval between successive inflorescences was recorded as twenty days for dwarf coco-nuts in Malaya.[32] Aldaba[4] in the Philippines, from observations on two small palms, shows that the average interval is 25 days. The effect of environment on the appearance of spathes is extremely great even on a single palm and in the

course of a few months. Petch,[45] for example, observing one palm at Peradeniya found intervals ranging from 24 to 58 days. He showed from observations on many palms that the longest interval corresponded with the driest months while the shortest interval occurred in the hot moist months of their wet season. The intervals are governed by many other factors and it is easy to conclude why such differences in behaviour have been recorded even between palms of the same variety. In dwarf palms just coming into bearing in Fiji[1] 1933, the number of spathes produced per palm per annum ranged from 4-15. These palms were very young as it was the second year nuts which were produced. Jack and Sands[32] found that the number of days between the opening of successive spathes varied for

(*a*) Yellows—18.5 days to 21.1 days.

(*b*) Reds—19.3 days to 24.2 days.

(*c*) Greens—18.7 days to 23.1 days.

The average for a normal dwarf race, therefore, is twenty days.

(*e*) Period of overlap between the male and female phases on the same palm. This refers to whether the male flowers open or not while any of the female flowers on a particular palm are receptive or ready for pollination. This apparently varies with the locality, climate and variety of palms and is a main determinant as to whether palms are liable to self or cross pollination.

Jack and Sands[31-32] claim that the Malayan dwarf palm is normally self-pollinated in Malaya and that the male and female phases definitely overlap. Maréchal[41] on the basis of his experiments shows that this is not the rule with Fijian dwarf coco-nuts, although in this variety he never observed the male phase to end before the female phase began. Working on tall palms, it was found by Petch in Peradeniya[45] that a period varying from three and a half to five weeks was required for the opening of all the male flowers of an inflorescence; that an interval of two to five days then elapsed before the female flowers of the same inflorescence began to open. The female flowers all opened in a period of from one to seven days according to the number present. He naturally concluded that self-pollination was impossible except for the rare occurrence of overlapping of inflorescences in the same palms. Information gleaned in Java indicates that there the female flowers are usually receptive about one week after all the male flowers have disappeared. According to Jack and Sands[31] coco-nuts behave differently in the warm humid atmosphere on the lowlands of Malaya. There the length of duration of the male phase is curtailed, while the duration of the female phase would appear to be longer in both tall and dwarf palms. The most striking fact is that the female phase, not only begins, but most frequently ends before or at the same time as the male phase thus rendering self-pollination the rule, instead of being an occasional chance occurrence. The average duration of the male phase in dwarf palms eight years old was 21 days with a variation of from 15-24 days, and that of the female phase was eight days. On Witu the author found in tall palms several male flowers open on spathes containing young female flowers which were practically ready for receiving pollen, although on other spathes with receptive female flowers the male flowers had entirely disappeared. This is probably a variable characteristic which may be hereditarily transmitted. This question requires much more detailed investigation as far as New Guinea is concerned.

(*f*) The question of overlapping appearance of male flowers on one spadix and female flowers on another spadix of the same palm. It appears that this rarely occurs, although it would be a valuable genetical characteristic if present.

(*g*) Profuseness of male and female flower production. It is a well-known fact that the first spathes which appear on most palms have a tendency to produce male flowers only. It is known also that there is a decided tendency for some palms to produce female flowers only, and for others to produce male flowers mainly at all stages of growth. These are probably hereditary characteristics which may be temporarily influenced by changes in environment such as excessive drought. The male flowers always exceed the number of female flowers present in any spathe and may range from a small number to thousands, depending largely on the branching of the spadix and the length of the branches which carry them. The dying off of the spadix branches from the tip is a common phenomenon where soil conditions are unfavorable and in this way, the numbers of male flowers present are greatly reduced. The female flowers are produced in much fewer numbers, and are always produced towards the basal portions of the floral branchlets. One has only to look at any plantation to observe individual tall palms carrying some hundreds of small nuts and naturally such palms carried large numbers of female flowers in the first instance. The profuse fruiting of the Malayan dwarf coco-nuts is another example of heavy female flower production. Frond choked or poorly vigorous palms carrying no female flowers at all are often seen and these represent the other extreme of shy production. All investigators have indicated the wide variability of female flower production. Furtado[22] states that the number in a spadix may vary from zero to over 300, depending on the strain, treatment, &c.; whilst Sampson[52] records having counted up to 235 flowers on one spathe and that frequently there may be from 100-200 flowers present. In Fiji,[1] on crossed dwarf palms just coming into bearing, it was found that the number of female flowers per spathe ranged from three to 62. Pieris[46] made counts on 215 inflorescences in Ceylon and obtained a range of variation of from one to 92 female flowers. He presents a table which shows that the frequency distribution is very symmetrical, and that more than 94 per cent. of the observations lie between the limits of none to 44 flowers. Very little correlation was found between the number of branchlets in the inflorescence and the number of female flowers. In Malaya[22] the number of female flowers per spathe carried by various dwarf palms was found to be as follows:—

Greens, 21.4; yellows, 13.6; reds, 10.6 in three years' observations.

(*h*) Periodicity of flowering and consequent bearing as related to season. As stated before, there is evidence of the spathe production being related to season in Ceylon; Sampson gives detailed records and a graph showing that there are very definite seasonal fluctuations on the coast of India, and suggests a correlation with climatic conditions, but very prolonged and detailed records are still necessary to determine this point precisely. Maréchal[41] records a tendency for Malayan dwarf coco-nuts in Fiji to produce more female flowers in the inflorescences which open from November to March than in those opening during the rest of the year. The question of periodicity of bearing and alternate bearing as related to hereditary and environmental conditions needs much more work.

The Nut.

Planters are all familiar with the structure of the coco-nut, which has also been described many times in books on the subject (*vide* Sampson and others). Botanists in general regard the fruit of the coco-nut palm as a "drupe" and not a nut, as the term so widely used applies. It consists of a smooth, tough, brownish to greyish epicarp (the smooth surface); a fibrous, mottled, brown mesocarp (husk), and a hard, thick, brown endocarp (shell) within which is the endosperm (kernel) enclosed in a closely adhering testa (skin).

Juliana[35] has written a careful technical account of the origin, development and nature of the stony layer of the coco-nut as well as an account of the development of the spadix, the female flower and the fruit. It is not proposed to deal further with the morphology of the fruit here, as detailed accounts are readily available. It might be pointed out, however, that long before the time of fertilization the endocarp (developing stony layers) is already differentiated as a soft, creamy white structure surrounding the loculi.

Age of Bearing.

The age at which palms come into bearing is definitely variable, and is largely correlated with soil and climatic conditions. Strain also does have a decided influence in determining at what period young palms reach the bearing age.

In any young plantation it is seen that certain palms come into bearing much earlier than others. As for example, it is seen at Keravat that certain young tall palms, not more than three years old, have thrown out spathes and are bearing young nuts while the surrounding palms in the same area show no evidence of fruiting whatsoever. It is this variation in maturity which should allow of the isolation of early maturing strains such as is mentioned in the section dealing with coco-nut breeding. Dwarf palms usually begin to fruit in their third or fourth year and reach their best at about the fifteenth year. A tall palm usually commences to fruit somewhere about the fifth year, and probably reaches the stage of maximum production in about the 20th to 30th year. The stage at which palms come into bearing here and reach their maximum production is very variable, as palms grown in the light coral soil of the western islands commence fruiting earlier, and go off earlier, than palms in the heavier soils of Bougainville Island. On heavy soils palms often do not commence fruiting until about their eighth year, which means that the period when they come into profitable production is around the twelfth year. Many palms growing on soil-exhausted areas here are definitely over their stage of maximum production before their 40th year. Palms 60 years old under favorable circumstances show no sign of falling off. How long they remain fruitful is not known, but it more than exceeds the century mark.

Palms which are closely planted, such as in native groves, are often ten or twelve years old before they commence bearing properly. All other things being equal, the sooner the palms come into bearing the less cost is involved in bringing a plantation to the bearing stage, which is a most important consideration.

Palms coming into the stage of maximum maturity have been noticed to suffer a physiological setback, and this has been seen in scattered parts of New

Guinea on several occasions. This often affects the production for two years. This condition has also been reported from Malaya, and is most prevalent on certain types of soil under particular climatic conditions. This occurrence has been mistaken by certain planters for a new disease. It must be remembered that palms reaching the bearing stage are at a physiologically critical period. The fruiting places an extra strain on the plant, which becomes apparent when the conditions are not entirely favorable. The character of the soil and the care bestowed causes very pronounced differences in the development of the young plants, which, in turn, influence the time at which the palms come into bearing. At six to eight years is quite a reasonable time to expect the palms to produce their first crop of nuts for copra production, and at about ten years they should reach the stage of profitable production.

The following report on Orangerie Bay Government Plantation, by Staniforth-Smith, in the Papua Annual Report,[44] supplies very good figures on a plantation coming into bearing. "The area of 591 acres planted between 1912 and 1914 yielded this year (1923-24) 238 tons of copra, or slightly over 8 cwt. per acre. The area of 529 acres planted between 1914 and 1918 was then coming into profitable bearing, and yielded 35 tons of copra. The estimated yield for 1924-25 is 300 tons."

—	1917-18.	1918-19.	1919-20.	1920-21.	1921-22.	1922-23.	1923-24.
Acreage collected from ..	74	350	500	600	600	600	680
Nuts per tree	1.6	9	13.5	16	28.1	42.3	37
Copra per acre in cwt. ..	..	2.92	2.96	3.6	6.07	7.66	8
Nuts per ton	..	5,002	5,132	5,034	5,181	5,484	5,160
Tons of copra	.3	17.35	74.17	109	182	230	273
Total number of nuts, 1,000's	6.6	167	379.8	548.6	943	1,261.3	1,408.7

Natural Nut Setting.

The percentage of flowers forming mature nuts is governed by all the cultural and environmental factors which affect the growth of the palms, such as climate, cultivation, &c. The question of hereditary variations in the number of mature nuts produced by coco-nut palms has been dealt with in discussing seed selection.

In addition to the general condition of the palms the factors governing cross-pollination and cross-fertilization greatly influence the proportion of mature nuts set compared with the original numbers of flowers produced, and require elucidation.

As late as 1929 Cheeseman[8] indicated that the information available as to whether palms producing numbers of female flowers necessarily set a large proportion was limited to a statement by Sampson to the effect that some trees never produce a large number of female flowers, but at the same time set a high proportion of them. The result is that the cropping is relatively steady, whilst other palms are very irregular in bearing. Since that time, however,

Pieris[45] having noticed that the number of female flowers on the inflorescence varied within wide limits, calculated and showed that the number of ripe nuts produced showed a definite positive correlation with the number of female flowers produced. This was not so high, however, as would be expected (+0.64). He showed that for fairly small numbers of female flowers, say, below 50, the correlation is fairly close, but for larger numbers of female flowers the numbers of nuts produced are not always correspondingly high. He concluded, however, that it would be safest to select palms whose upper immature inflorescences display the largest number of buttons. Sampson says that fruit is properly set about 50 days after the flower has faded.

It has been mentioned elsewhere that the number of nuts borne to maturity depends on several factors. A number of young nuts fall due to competition for nutrients, or because of lack of fertilization altogether. Lever and Phillips[38] showed during their work in the Solomon Islands on the relation of the "Amblypelta" bug to nut-fall that 70 per cent. of the nuts fell in cases where the insect was included, which means that approximately 30 per cent. of the nuts matured. They also found that the natural nut-fall in the field was estimated at two-thirds of the number of female flowers present, which closely agreed with the ratio obtained inside cages which were designed to exclude insects only. It can be calculated from figures given by Pieris in Ceylon[46–48] that he obtained an average of a 34 per cent. natural set, which agrees closely with the results obtained in the Solomon Islands. In his experiments the mean number of female flowers present in 236 cases was 20.92 per spathe, which set an average of 6.8 nuts (34 per cent). One of the highest percentage sets recorded was where one spathe with 28 female flowers set 25 nuts (nearly 90 per cent.), while on the other extreme 84 female flowers set three nuts, or 3.5 per cent. approximately. The highest number of female flowers to be recorded on any one spathe was 116.

Sampson says that "normally the number of female flowers which set will be about 25 per cent. of those present in the first instance, while it may rise to 50 cent. in the case of trees which form a large proportion of fruits. On 25 trees figures showed that the percentage of nuts set to female flowers present varied from 9–34 per cent. according to season, with a general average of nearer 20 per cent." In crossed dwarf palms in their second year of bearing in Fiji,[1] it was found that the percentage set of female flowers ranged from 10 per cent. to 100 per cent., while the final percentage of mature nuts which resulted was from 7 per cent. to 9 per cent. These results are hardly comparable with what would occur on mature palms; further, it was found that the coco-nut spike moth *Tirathaba trichogramma* was present and destroyed from 0 per cent. to 17 per cent. of the female flowers on individual palms.

Jack and Sands[32] made the following observations on the natural setting of dwarf palms: "The percentage of fruits to flowers remaining at two (2) months was for 'yellows' 38.90 per cent., 'reds' 53.2 per cent., and 'greens' 26.4 per cent. Subsequent losses of fruit amounted to 5.7 per cent., 5.4 per cent. and 4.2 per cent. only, respectively. The high percentage of infertile flowers was not due to insect injury, but rather, it is thought, to imperfect pollination or absence of viable pollen in unfavorable weather. It is possible that the failure of the development of a certain number of young fruits may be physiological."

The setting of a standard for a good percentage of nut setting compared with the number of female flowers present on any series of coco-nut palms is difficult to establish owing to variations caused by season, environment, &c. Owing to the relatively few female flowers present on most spathes a satisfactory percentage natural set of coco-nuts should apparently be high so as to provide a satisfactory yield, e.g., between 20 per cent. and 35 per cent. This indicates that optimum pollination conditions are very important; and also where palms are suffering from chlorosis, soil exhaustion or bad drainage, this percentage would be greatly lowered. If it is assumed that the comparatively large number of 200 female flowers is present, and that such a satisfactory percentage of, say, 30 per cent., flowers set was obtained, this would mean that 60 nuts should be carried to maturity. This calculation gives some idea as to why heavy bearing palms are in the minority and selection is necessary.

Agents of Pollination.

Petch stated[45] "that coco-nuts depended on cross-pollination by insects, and probably also by the wind." He considered that bees and hornets, which feed greedily on the honey produced by both the male and female flowers, were the chief visitors to the coco-nut flowers. He said that "the ubiquitous ant, though it revelled in the nectar of flowers, was unlikely to assist in cross-pollination, or even to have access to the pistil of the female flower at all, thanks to the natural protection afforded by its ring of nectar at the receptive period." It must be commented here that ants do not always visit flower spathes to collect nectar even during the receptive period, but also to collect the honey dew secreted by species of mealy bug and aphids; at least that is the case in New Guinea. (*See* also Furtado's[22] remarks.)

The late W. W. Froggatt in 1911[20] makes the following reference to insect visitors to coco-nut flowers: "The coco-nut appears to be comparatively free from destructive insects when flowering and fruiting, though when the male flowers burst into bloom they attract a number of flies, bees and wasps; but these are more beneficial than otherwise, as they help to distribute the fine, dust-like pollen from the male spathes to the female spathes, and aid in their fertilization."

On the question of natural pollination Maréchal[41] agrees with other workers that both wind and insects play a part, but regards bees as by far the most important pollinating agents as to be essential for high production of nuts. The role of bees is still highly questionable under New Guinea conditions, hence it is seen that more local experimentation is desirable. According to Furtado,[22] Jepson, who paid special attention to insect visitors to coco-nut flowers in Fiji, had earlier expressed the same opinion and attributed the dropping of female flowers in many districts to insufficient insect visitors. He noticed that the yield was heavy on estates where bees were present in large numbers, either owing to artificial rearing or otherwise, and recommended planters to introduce bees to their coco-nut estates.

Sampson[52] says that fertilization is largely done through the agency of bees, but there are many other insects which visit the female flowers for the sake of their nectar but which do not bring pollen at the same time. He believes that ants are harmful to pollination, as they drive off the bees, many of which

are small and stingless. Among the ants was specially mentioned the red ant *Oecophylla smaragdina* (common Kurukum here) as being harmful in preventing the female flowers from being fertilized, where they live on mealy bugs and build nests preventing the entrance of other insects.

Several investigators[4, 8, 22] admit that there is decided possibility of ants acting as pollinators. Furtado says that "in Singapore unlike Peradeniya the nectar secretion is not in sufficient quantities as to exclude the ant from the work of pollination and they may self-pollinate where the male and female phases overlap." Owing to the fact that ants move so slowly from palm to palm they are not liable to have much effect in cross-pollination, but are likely to upset studies on self and cross-pollination on the same palm, as they are not easy to exclude.

Pieris, according to Cheeseman,[8] tried to assess the relative importance of the natural pollinating agents and to separate the effects of wind, crawling insects (red and black ants) and flying insects. The flying insects he observed in the inflorescences were *Apis mellifica, Musca domestica* [both relatively scarce here.—*Author*], *Polistes annulatus,* and a small black beetle. These were easily excluded by bagging emasculated inflorescences with coarse muslin, which would not interfere seriously with wind-borne pollen. The separation of wind and small crawling insects was found much less easy as, even with fine-grained muslin tied around the base, wind-borne pollen was not entirely excluded. In the fine-meshed bags a 6 per cent. set was obtained, which was said to be probably due to the imperfect exclusion of wind-borne pollen. Pieris concluded that wind pollination can only be as effective, as in this experiment, at fairly close quarters, as did Aldaba in the Philippines.[4]

He repeated Aldaba's experiment of exposing vaselined plates in different positions to catch wind-borne pollen, and where the source of pollen was only three trees away only three or four grains of pollen were collected.

Cheeseman (*loc. cit.*) sums the position as follows: There is a general agreement that both wind and insects play a part, and that wind is only effective at fairly short range. Further, there is a striking similarity between the lists of insects observed visiting flowers in different parts of the world. All observers place bees at the head of the list in importance and add *Hymenoptera.* Also the common house-fly, or closely allied species, and at least one species of beetle, are reported, but little importance assigned to them. Jack and Sands[31] believe that wind is the main factor in coco-nut pollination in the Malay Peninsula, and that insects appear to play an unimportant part. Although numerous insects,[1] more particularly bees, visit the male flowers to collect pollen and nectar, few appeared to be attracted by the female flowers situated near the bases of the branchlets of the inflorescence. Their statement concerning wind pollination follows: "When coco-nut flowers are in full bloom at about 10 a.m. when the dew has dried up, and when the gentle breezes frequently begin, clouds of pollen can be seen floating away in the sunlight. In a very slight breeze these pollen clouds do not travel far owing to the weight of the pollen, but it is highly probable that with the strengthening of the breeze as the day advances the pollen clouds are carried to considerable distances, and thus cross-pollination is effected."

The question of wind velocity as effecting distribution of pollen is a very important one, because plants which have fully entomophilous flowers, such as apples or pears, may have their pollen carried over 100 yards in heavy winds. Other investigators state that, although the structure of the inflorescence apparently favours wind pollination, the presence of nectar glands in both male and female flowers, as well as the suture in the pollen grains, suggest insect carriers. Male flowers possess three nectaries at the base of the teeth which crown the central column, and the stigma, or receptive surface, of the female flowers also furnishes nectar, so that the visits of insects to both types are assured.

If the flowers are adapted to efficient insect pollination only, it is hardly likely that such large quantities of male pollen would be produced over such a long period. Various grasses and crop plants, such as maize, which are mainly adapted to wind pollination, also secrete sugary solutions. Thus arguing on analogy is not altogether sound.

It is, as Cheeseman says, that the coco-nut flowers are adapted to pollination by both wind and insects, and possibly birds. The appearances are that some agencies are more active in some countries than in others. Except for the Dammar bees, *Melipona praeterita* Wlk., there is not a large bee population which visits coco-nut flowers here. As far as New Guinea is concerned, the question needs detailed investigation.

Insect Visitors to Coco-nut Flowers in New Guinea.

So far no detailed work has been carried out on this problem here, and investigations on this subject are required. As the identification of insect visitors to coco-nut flowers is more in the entomologist's field, Mr. J. L. Froggatt, Entomologist,[21] was able to name some insects likely to visit coco-nut flowers in New Guinea. It needs caging trials and microscopic examination before the relative ability of these insects can be accurately determined. Insects which visit flowers may be beneficial where they act as pollenizers, or they may be casual visitors only, while in the case of others, such as *Axiagastus cambelli*, they can be injurious to them. It appears fairly certain, however, that the small native bees *Melipona praeterita* Wlk. are amongst the most frequent insect visitors to coco-nut flowers here. These small bees commonly fly on to one's skin or hair, and may be recognized as a tenacious little insect, although they do not sting, and are known as the "dammar bees" in Malaya. Although several genera of the family *Apidae* are present, bees of the genus *Apis* (or types closely related to and including the hive bees) are apparently not common in this Territory. Such genera of this family as *Crocisa spp.* and *Megachile spp.* are more common, but their relation to coco-nut flowers, if any, is not known. Amongst the various flies of the order *Diptera* present are the following: *Syrphidae* or hover-flies (several species), *Sarcophaga spp.* (these are large, striped flies, mentioned by Aldaba as being useful pollinating agents in the Philippines), and *Muscidae spp.* (especially *Lyperosia exigua* de Mey). These families and genera are the most likely to contain any efficient pollenizing insects here.

Some wasps of the order *Hymenoptera* may be found to be pollenizing coco-nut flowers here. *Polistes annulatus* has been mentioned by Pieris[8] as being an effective pollenizer on coco-nuts in Trinidad. There are several species

of these Vespid wasps in New Guinea, such as *Polistes lepidus* Sauss and *Polistes bernardi* le Guill, but their efficiency as pollenizing agents here is not known. Wasps of the genus *Vespa* are said to visit coco-nut flowers in the Philippines. A large reddish-brown wasp of this genus is also commonly seen on coco-nut flowers here, but usually they are not plentiful, though they appear to work quickly and efficiently.

Two small unidentified species of wasps (apparently Thinnids) appear to be the busiest pollenizers at Keravat plantation. Mr. Froggatt has recorded several beetles of the family *Cetonidae* as visiting coco-nut flowers here, but, as they are pollen feeders, there is also the possibility of their being pollenizing agents. The green beetle, *Lomaptera batchiana* Thoms, is a very common visitor to coco-nut spathes in New Guinea. *Poecaliphyra emilia* White, a small green beetle, has also been recorded several times on coco-nut flowers here. Many other beetles have been caught on coco-nut spathes, but are doubtless casual visitors.

Aviagostus cambelli Dist., the stink or flower bug, family *Pentatomidae*. This insect may, in addition to destroying blossoms by sucking sap, act as a casual agent in pollination. It must be conceded that they move slowly from one palm to another, and are more liable to do harm than good. One company here, in the belief that ordinary hive bees may assist nut-setting, made extensive introductions of ordinary hive bees, *Apis mellifica*, and Italian bees to the majority of their plantations. These did not survive, and this was said to be due to the depredations of wasps and other insects present. Despite the absence of hive bees here, coco-nut flowers do pollinate and set entirely satisfactorily, and it is decidedly doubtful whether bees would increase the set. However, this could only be satisfactorily determined by caging experiments.

Other Agencies of Pollination.

Knuth[30] has stated "that the coco-nut is pollinated through the agency of wind"; but quotes Father Dahl, who noticed the birds *Charmosyna subplacens* Sel. [a small lorrokeet.—*Author*], *Cinnyris frenata* S. Mull, and *Cinnyris corinna* Salvad as the frequent visitors to flowers in the Bismarck Archipelago. Reference to Father Meyers' book[32] indicates that these two latter species belong to the Blumensauger (lit. blossom sucker) known in English as sun-birds, belonging to the family *Nectariniidae*.

Furtado[33] says "that *Anthreptes malaccensis* is the sun-bird, which is almost invariably associated with coco-nuts in the Malay Peninsula, and various other birds were seen in the vicinity of coco-nut inflorescences, but it must be borne in mind that even these birds, which possess especial adaptations in their beak for extracting nectar from various kinds of flowers, often visit them for the purpose of capturing insects for their prey. He concludes that, where there are insects such as bees to pollinate the flowers, their ability is, like the wasps, doubtful." There is no experimental evidence to disprove Father Dahl's original assertion as far as New Guinea is concerned, and it is the author's opinion that in certain parts of New Guinea birds do play some part in coco-nut pollination, though this may be as an adjunct to wind and insect agencies. The very size and shape of the female flower suggests the possibility, as does the fact that nectaries are present in both male and female flowers, which they are adapted to suck.

Bird Pollination at Meto, With Island.

On Saturday morning, 16th October, 1937, and again on the following Monday and Tuesday, it was noticed at Meto that a small sun-bird, with the local native name Pitchu or Peetshu, was present in large numbers in the flowers of the coco nuts, both in the mornings and in the afternoons. Slightly larger lorrokeets were also seen to visit the flowers, but not so frequently. Natives present on the plantation from other parts of New Guinea all recognized these birds as belonging to the flowers, and said that they were common almost everywhere, such as in the Bismarck Archipelago. It was noted that the birds move quickly from palm to palm, and, being small and flying at a height, the large numbers present were not noted until a special look-out was made. Once notice was taken of their movements, it was found that practically every spathe observed was visited every few minutes, and often more than once in that time. Thus, assuming that these birds are capable of acting as pollen-carriers, the frequency of their visits was sufficient to enable them to act efficiently as pollenizers, especially as they could visit a great number of flowers in one day. It was also observed by the acting manager, Mr. Whitehead, in company with the writer, that these birds were active from early morning until 5.30 p.m., which is similar to what happens with bees in temperate zones. They usually fly only short distances at a time, and appeared to move about in a series of short flights and thus visit many palms in a relatively short time. They usually crawl all over the spathes, either male or female, before flying to other palms close by. In many cases they fly to the spathe and hang underneath the floral branchlets by means of slender, prehensile claws, and sup the nectar with their forked tongue and finely-hooked beak. Thus pollen should easily be shaken on to their ventral surface, while their back feathers are also in contact with the lower branches. The birds also crawl over the flowers and come in close contact with them in this manner. Their beaks are very finely pointed, and the tongue is a marvellous adaptation, being extensile, long, flattened and forked at the tip with a terminal brush.

A large, new spathe, which had just been visited by some birds, with the male flowers just opening and the female flowers not nearly receptive, was cut down and examined. It was seen that, apparently, they had not damaged the male florets in any way, and that some pollen present was mature. It was thus thought likely that these sun-birds may be important pollenizing agents at Meto, more especially as they confine a good deal of their attentions to young spathes. A native boy was deputed to shoot some of these small birds while actively at work on the palms. At about 8.30 a.m. a male bird was shot on a female branchlet. The bird actually did not fall from the spathe, and it was found that one of the main feathers was closely pinned to the flower stem within 1 inch of the receptive pistil (covered with moisture of syrupy consistency). On this spathe the male flowers had disappeared. A preserved specimen of this branchlet was taken with the feather still adhering. About half an hour later another bird (female) was shot, and this one was attached to a spathe with a few male flowers, while the female flowers present were not yet receptive. In this case, also, distinct confirmation of the activities of this female bird was obtained, because when the bird was shot the blood was actually scattered over the anthers still shedding pollen in male florets, showing where the bird had been attached.

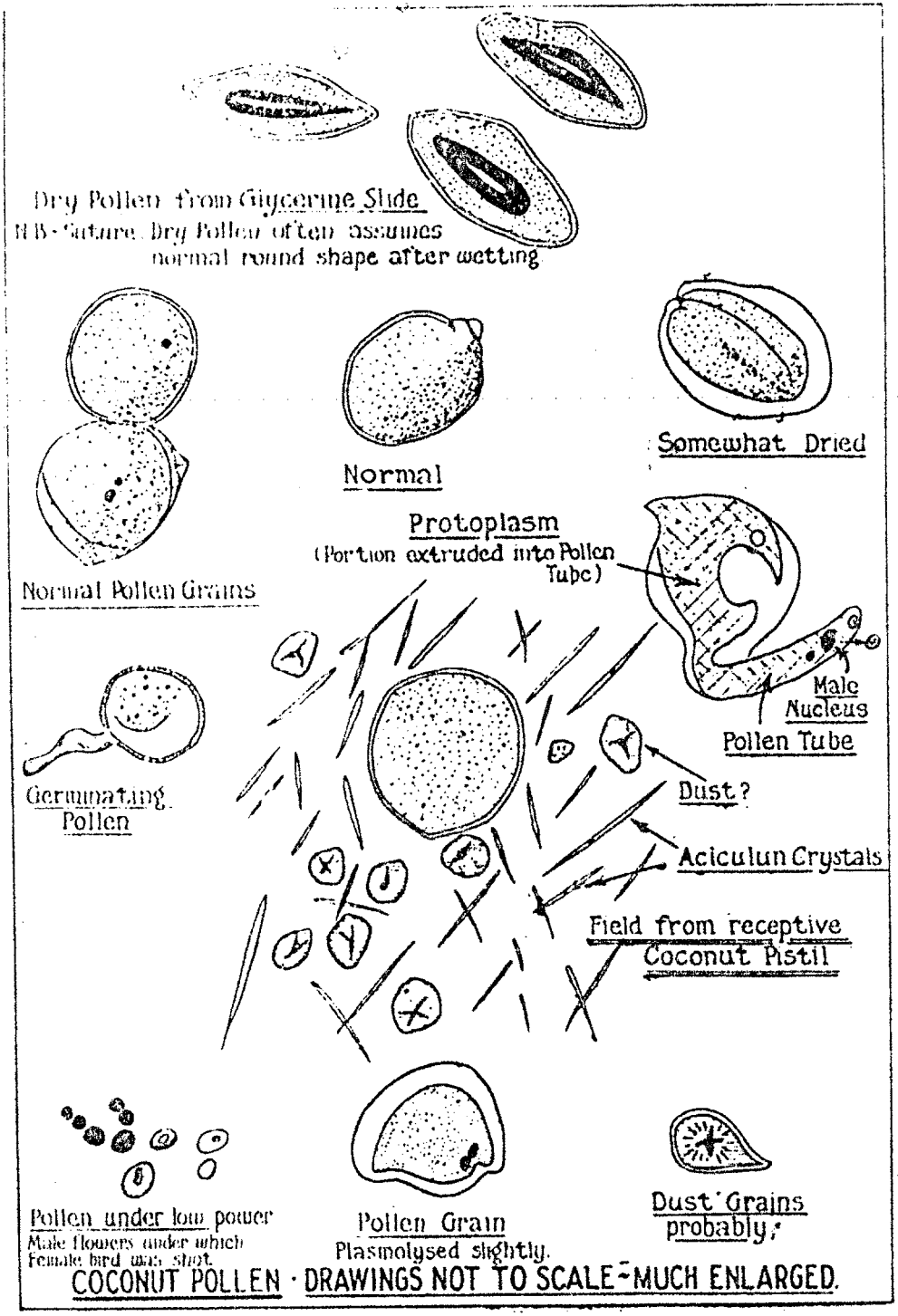
It should be noted that on the spathes examined only *Oecophylla* (Kurukum ants) and mealy bugs were present. Other active insects were noticeably absent. Unless ants are more useful than is admitted elsewhere, insects must have been responsible for very little of the pollination occurring at this period in the particular plantation. These birds, although present in New Britain, have not been seen in large numbers such as was the case at Meto.

Microscopic Examination.

To prove whether any transference of pollen had occurred it was necessary to examine the feathers for pollen, and it was apparent to the eye that some was present on the male bird. A small microscope was available at the plantation, and this enabled some interesting observations to be made despite the limited facilities. Feathers from the male bird were taken and a slide made from the dust on the wing. Odd pollen grains were observed in this dust, and also on the feathers when a separate examination was made. It was not so plentiful as would be expected, as the feathers of both the male and female birds are apparently ideal for holding pollen. The small pinnae of the feathers which form the blade have distinct epidermal serrations, due to the peculiar compressed structure of the cells of which they are built up. The interlocking edge of these serrations appear well suited for pollen-carrying, especially where they are so finely divided, as in this particular bird. Both the back (dorsal) and front (ventral) feathers are short and as soft as down. Such a structure would act almost like a powder puff. New pollen was actually obtained from receptive pistil on the female flower where the male bird was shot, together with some acicular crystals and some dust in the same field (*see* rough drawing of fluid). Some of the grains seen may have been dried-out pollen. Much pollen was also seen on the outside surface of the button, showing that a good deal of pollen had been transferred to this particular pistil. The pollen seen on the birds was compared with pollen taken direct from fresh male flowers, and they appeared very similar. The possibility of this bird acting as a pollen-carrier was thus definitely established, and the chances are that the birds described are responsible for a considerable amount of cross-pollination on Witu Island, and may act similarly in other parts of the Territory. It was noted that the wind was only strong at odd times during the time of the observations at Meto. There was however, some rain at intervals which on one afternoon was accompanied by strong winds. A rather lengthy description of these birds as pollen-carriers was given only to show how much more it is required to know about the subject. Most investigators agree that wind pollination is the main factor in cross-pollination of coco-nuts, and without necessary experimental data this concurs with the writer's opinion, also. Insects, birds and other agencies may have decided utility for pollinating coco-nut flowers in periods of calm weather.

Identification of Birds at Meto.

The following is a short description of the birds under observation. Specimens were taken for identification. Both the male and female birds are really light and small, being about the same size as a diamond sparrow. Birds are less than $3\frac{1}{2}$ inches long, and are provided with a long slender pointed beak, slightly hooked and shiny black at the tip.


Dry Pollen from Glycerine Slide
N.B - Nature Dry Pollen often assumes normal round shape after wetting
Normal
Somewhat Dried
Normal Pollen Grains
Protoplasm
(Portion extruded into Pollen Tube)
Male Nucleus
Pollen Tube
Germinating Pollen
Dust?
Aciculun Crystals
Field from receptive Coconut Pistil
Pollen under low power
Male flowers under which Female bird was shot.
Pollen Grain
Plasmolysed slightly.
Dust Grains probably.
COCONUT POLLEN · DRAWINGS NOT TO SCALE - MUCH ENLARGED.

Beak and tongue are specially adapted for sucking nectar. Legs are grey and yellow, with slender prehensile claws. Male bird is darker in colour than the female, and has a large red splotch on the throttle (ventral surface), while the crown of the head is black. It has a general greenish-yellow sheen, especially on the back overlying the darker colour. The body appears more slender and is not so fluffy as that of the female. Nevertheless, in both, the feathers on the back and ventral surface are short and soft. The female bird is plumper in outline, and almost wholly coloured grey. It has a lighter greenish-yellow sheen, especially bordering the tail attachment. Tail feathers are shorter, and there is no reddish splotch on the throttle, except for a reddish tinge which develops on old female birds. Specimens have been identified by the ornithologists of the Australian Museum as follows:—

"The specimens are male and female of *Myzomela sclateri* (Sclater's Honey-eater). The genus (family *Meliphagidae*) has many New Guinea species, and is also found in Australia. The species of *Myzomela* superficially resemble Sun-birds (family *Nectariniidae*), which range from Africa and Southern Asia to New Guinea and Australia. In the *Meliphagidae* the tongue is extensile, forked at the tip, and has a terminal brush, but in the *Nectariniidae* it is tubular and has no brush."

Problems of Pollination and Fertilization.

The importance of pollination studies to plant-breeding of coco-nuts is discussed in conexion with that subject. Investigators on pollination problems necessarily differentiate between pollination, fertilization and fruitfulness (or production of mature nuts).

Pollination refers to the actual transference of pollen either to flower pistils on the same palm (self-pollination) or to flowers on other individual palms (cross-pollination) by any agency whatsoever; which, simply stated, means transference of viable pollen grains to the stigma. Fertilization refers to the actual union of the male and female nuclei, or elements, carrying the hereditary determiners, after the pollen tubes have grown down the pistil and reached the ovule. This does not necessarily mean that fertilized young nuts will develop to mature fruits, but it does pre-suppose pollination of the pistils. Fruitfulness refers to the capacity of the palms to produce fruits, or in this case coco-nuts. It is obvious that not all fertilized flowers develop to mature nuts, as is recognized by the extensive study given to the problems of nut-fall by various investigators. The reader is referred to a detailed discussion on this subject by the present author.[16] There is also an hereditary tendency for some palms to produce nuts without any fertilization at all. Such palms are known in all countries where coco-nuts are grown and are familiar to some of our local planters as the so-called male or seedless coco-nut palms. These usually develop a long spindly nut with no embryo and little kernel, though they might hang on until quite dry and shrivelled. This undoubtedly represents a form of "parthenocarpy" or vegetable development of the nuts. Much work remains to be done to determine accurately what outside factors such as temperature, moisture, humidity, and hours of sunlight are really optimum for pollen germination, pollen tube growth and fertilization. This means that accurate recording with continuous recording instruments, such as thermographs and hydrographs, should be carried out while any pollination investigations are being made. The fact that coco-nuts bear so well close to the seashore or at low levels suggests

that moving, warm air of high humidity may provide the optimum conditions. Prolonged dry weather or too much rain at the time of pollination may be unfavorable for pollen germination.

After drying out longitudinal sutures appear on the pollen grains and they assume an elipsoidal shape instead of the normal round shape of turgid pollen (*see* rough sketch). Such dried-out pollen grains when moistened assume a normal round shape, and such alternate drying out and moistening may happen more than once. This suggests an adaptation which would keep the pollen viable until sufficient moisture was available (e.g,. on the pistil) for proper germination or during the time it is being disemminated through relatively dry air.

Maréchal[11] and Pieris[8] have shown that pollen may be stored for about a week without special precautions, but it can be stored for many days under dry conditions, such as in a desiccator, over sulphuric acid, or in gelatine capsules. The former found that 35 per cent. to 60 per cent. retained their vitality for sixteen days over 30-40 per cent. sulphuric acid, while the latter found that after eight days loss of viability occurred, but was able to get a 4 per cent. germination on the 31st day in pollen from gelatine capsules. In each case 25 per cent. sucrose (cane sugar) solutions were used for the germination studies. It is certain that a high humidity favours pollen germination, but a low humidity favours retention of viability by the pollen.

Both Pieris[8] and Aldaba[4] have found that all coco-nut pollen samples examined show the presence of varying proportions of shrivelled and small abortive pollen grains, and the writer has also observed these. The presence of such sterile pollen grains has also been seen by the author in temperate crop plants such as lucerne. The amount varies with the individual plant, and can be explained on the basis of East and Manglesdorf's conception of inhibiting, hereditary factors.[17] Such pollen sterility lessens the chances of nut-setting by self-pollination, and emphasizes the importance of cross-pollination to the natural economy of such plants as coco-nuts.

The period during which the female flower remains receptive apparently varies in different places. According to Furtado,[22] in India, and Petch,[18] at Peradeniya, this period is about 24 hours, while it was shown by Aldaba,[4] in the Philippines, and Furtado,[22] working at Singapore, that it lasts two or three days. No work has been done on this aspect in New Guinea. As far as one can judge, no one has yet determined whether coco-nuts have an optimum time of the day for pollination, except for general statements that it is about 10 a.m. or from 8.10 a.m. Most crops display an optimum period, as for example pumpkins only pollinate early in the morning, while in Australia oats pollinate best in the early afternoon. In New Guinea, coffee pollinates best in the morning between certain hours. It is probable that there may be some such defined period with coco-nut flowers, and, if it is in the morning, as is indicated, then rain in the afternoon would have little effect on pollination. Sampson says that "when the flower is about to open the stigmas swell, turn white in colour, and when the flower actually opens they expose a sticky, viscous surface in the tri-radial opening. They are then receptive, but apparently do not remain so for long, as they have a strong scent in the early morning which soon passes off in the heat of the day. The scent is distinct and apparently designed to attract insects."

In the flowers of most plants, liable to cross-pollination, there is a differential rate of pollen tube growth where a pistil is fertilized with pollen from the same flowers compared with the rate of growth of foreign pollen placed on the same stigma at the same time. Thus while a stigma may receive pollen from the anthers of male flowers on the same inflorescence or flowers, it grows more slowly than the foreign pollen and self-pollination is not so likely where foreign pollen is present.

It is not generally realized by laymen that different grains of pollen from the same flowers, on any individual trees, display differential hereditary capabilities as to length of pollen tube growth in the same way as tall and dwarf palms may appear. The pollen tubes must grow a certain length down the stigma to carry the male nucleus to the female nucleus in the ovule, or egg, and often only a proportion of the pollen grains which reach the pistil are capable of doing this. This is further complicated by the fact that inhibitory factors are commonly present which may partly or completely retard pollen tube growth. This is a brief attempt to explain a technical subject which needs more attention from professional investigators in carrying out coco-nut pollination work.

Selection in the Nursery.

This side of coco-nut planting receives insufficient attention although it is practically as important as the original selection of the seed nuts and should not be neglected. It is very poor economy to place insufficient seed nuts in the nursery so as not to provide for the rigid selection of only good type and vigorously germinated seedlings which are strong, sturdy and healthy. To allow of the rejection of inferior types and non-germinated nuts and to replant misses in the field, more than 60 to 80 per cent. in excess of the nuts actually required to plant a certain area should be set out in the nursery. This may seem costly and unnecessary on first appearances, but, when the non-germinating or weakly viable nuts are rejected and also the unhealthy or off type seedlings are put on one side, the precautions and cost of laying down the extra quantity of nuts are fully justified.

The planter must remember that these nuts are the products of cross-fertilized flowers and, regardless of the outside appearance of the nuts, the seedlings derived from any one palm will display considerable variation and some palms will tend to produce much stronger seedlings than others. Long rangy plants or those having any tendency to yellowing or chlorosis should be avoided. Plants with long, slender leaf-stalks and long, narrow leaf-blades, i.e., "leggy" seedlings, should be discarded as unlikely to produce profitable trees. Similarly, those seedlings which have any tendency to twisting or any hereditary abnormalities should not be used, while any sickly or weak young plants should be rigorously discarded. Bad seedlings can never produce strong, healthy palms.

Where selection of seed nuts is being made from marked trees, or for inclusion as a population in a breeding programme, it is as well to know that there is a tendency for the nuts from some palms and even from some localities to germinate badly. This is a variable characteristic which is probably more often transmitted than not. Of course the presence of nuts which had grown to maturity without proper fertilization would give the same effect but this may also be an hereditary trait peculiar to the particular palms.

It is also found that the nuts which germinate first usually give the best seedlings. Pieris[9] says that "plants which germinate tardily produce equally tardily in the fields". Smith[36] in Malaya carried out germination trials with 500 heavy nuts, all over 575 grammes in weight, derived from 66 palms; the tabulated differences in behaviour between populations from individual palms were so striking that he laid down a second series from the same individual mother trees. In almost every case the general characteristics of seed from the same mother palm were identical in both batches. On the whole, large nuts showed a smaller percentage germination and less strong healthy plants than did those of more nearly average size. In both lots the germination percentage was around 60 per cent. after about five months. Perusal of his data shows that some populations produce no good plants whatsoever though the germination was 100 per cent.; others produced a large proportion with malformed shoots while others gave 100 per cent. germination all of which progeny were strong and evenly grown. The fact that some populations were comparatively uniform suggests either cross-pollination between very good type palms forming a compara-uniform G1 population which is not infrequently observed or else some self-pollination occurred in the generations preceding selfing. The significance of this will be explained in the section on plant breeding.

If, as it was shown in the Philippines,[40] round nuts give sturdier seedlings than oval-shaped nuts, despite the fact that there is little difference in copra content, this indicates that it would be preferable to use round nuts for seed purposes. The arguments advanced offer very good reasons why planting at stake should not be carried out under any circumstances, especially as there is a distinct possibility that a large proportion of the nuts set out will not germinate.

Selective Re-planting in the Field.

This is most necessary to assure that only sturdy, young plants of good type are perpetuated in the developed plantation. It is not possible to separate out all of the plants which are not likely to thrive from nursery selection. The wide variations in depth and type of rooting which develop after the plants are set out will give one very potent reason for this. The reader is referred to Sampson's text-book for a full description of variations in coco-nut root systems. Any injuries to the plant during transplanting or to the growing point by insects, rats or animals during the young stages provide a serious set-back to the plant for all time and injured plants should be replaced. It is an extremely wise plan to go over young plantings at regular intervals until the plants are well established. All plants which are not thriving and all misses should be replaced with strong and sturdy replants. The best time for replanting is while the surrounding palms in the plantation are still young so that the replants receive little root competition from older plants and are not deprived of necessary light and air while original humus from the forest soil is still present.

Necessarily, nursery management, nursery selection and replanting in the field deserve much fuller description than is given here, and would warrant treatment as a separate subject.

COCO-NUT BREEDING.

Objects of Coco-nut Breeding.

The main aims in coco-nut breeding depend upon which products are to be derived from the coco-nuts in the greatest quantities after the processes of manufacture. Since copra is the main product and the basis of all market transactions, the outstanding object should be to increase the yield of copra per unit area by all means available, and thus increase the yield of oil contained therein, as this ultimately determines the value of the product.

The use of improved planting material is one of the readiest and cheapest methods of attaining that end, as the yield of copra depends on the hereditary capacity of the palms to yield coco-nuts, although improved cultural methods, &c., would all have their effect. Reduction of cost of production is mostly readily attained by such increased yield per acre, or hectare, and must be given due consideration. For further information on the utilization of the coco-nut products reference may be made to a previous article in the *New Guinea Agricultural Gazette*.[24] There it is pointed out that oil content of the copra is most important, for it is the coco-nut oil which is mainly employed in the industries of margarine manufacture and soap-making.

So long as weight and appearance, and not the actual oil content, is the basis of selling the copra, the production of improved strains with nuts of higher oil content has been a secondary aim. This question of oil content cannot be disregarded as there is now a tendency instead of selling copra, to increase oil extraction, in the country of origin, such as has occurred in Ceylon, Netherlands East Indies and particularly the Philippines.

The definite question is whether it is possible to breed coco-nuts with an inherent capacity for high oil content and the answer appears to be in the affirmative. Work on this aspect of coco-nut breeding is being conducted in Malaya and Sharples, 1930,[54] points out that the oil content in coco-nuts, as ordinarily picked in estate practice, varies from 45-75 per cent.; but, since considerable differences exist in different pieces of meat from the same nut, and also in the meat from nuts of varying degrees of ripeness, the methods of sampling require standardization before selection for oil content can be usefully undertaken. The difference between oil content of ripe nuts and germinated nuts has been found to vary to as much as 7 per cent. It is possible, however, that this increased content is balanced by loss in yield.

Pieris, Ceylon, in 1934[49] states the problem very lucidly: "The main coco-nut products that are of commercial importance are copra, oil, desiccated coco-nut, and coir fibre. In the three former substances the important constituent is oil, and so improvement in their quality will be concerned mainly with increasing the percentage of oil in the kernel. It is not yet known whether this increase could be brought about by the use of particular manures on established plantations. Even if it could, such improvement will only be confined to that particular generation which has been treated and will not be handed down to the offspring. There is little doubt, however, that, from a genetical point of view, it is possible to breed coco-nuts for increased production of oil. This can be done in one or two ways—

1. By keeping the quantity of the kernel constant and breeding for high oil content of the kernels.
2. By keeping the oil content of the kernels constant and breeding for high weight of kernels".

The combination of the two methods is also a possibility. It will be seen, however, that of the two aims that concerned with the actual increase of weight of kernel is now the main objective due to present marketing practice. It is apparent that the important consideration is to increase the production, or high yielding capacity, of the individual coco-nut palms. It is certain, however, that there are other important objectives which must be considered, such as—

1. Yield of a high quality product with a high oil content, as previously mentioned, should be combined with the gradual elimination of poor yielding palms.
2. Inherent vigour and longevity.
3. Uniformity as far as possible, which is linked with 1 and 4.
4. Regular bearing of heavy crops and elimination of alternate bearing.
5. Development of early maturing, heavy-yielding strains. The comparatively long time which it takes coco-nuts to come into bearing greatly influences the cost of establishment in plantations. It is well known that some palms come into bearing much earlier than others, in any plantation.
6. Elimination of genetical weaknesses such as liability to chlorosis, frond choke and so on. This is also related to No. 2.
7. The production of improved strains suited to a wide range of environment. Improved material suited to only a limited range of climate and soils would exert little influence on improving the present position. Experiences with other crops indicate that there are great possibilities of producing improved strains, which would do well under a wide range of conditions.
8. Ease of harvesting where picking is practised. Short, high-yielding palms would be preferable providing all other factors were equal.
9. Development of disease and pest resistant strains. This should be one of the most important aims in coco-nut breeding. Casual observations, and actual experience with other crops, indicate that there would be definite chances of isolating populations with resistance to such diseases as "Thread Blight", *Corticium penicillatum*; and "Leaf Blight", *Pestalozzia palmarum*. With the method of close breeding described later, this should be a most definite aim of improvement.

COCO-NUT BREEDING TECHNIQUE.

(Mainly Semi-Technical.)

Coco-nuts belong to the great division of Monocotyledonous plants as opposed to the other main group of Dicotyledonous plants such as rubber or cacao. The plants belonging to the former group usually have only a single growing point and have not the power of annual increase in growth, such as occurs by cambial activity in plants of the latter group.

It appears, from analogy, that the behaviour of coco-nuts, on self or cross pollination, would be somewhat comparable with what is experienced in maize breeding; the latter being an annual Monocotyledonous plant. The reasons underlying this statement are linked with the fact that the problems of maize breeding have received much more attention than is the case with coco-nut breeding. This can be largely attributed to the greatly increased chances of getting quick results with maize breeding and of raising improved strains of the crop within a comparatively few years. The relative economic importance of maize as a food-crop, in all parts of the world, also assures that this plant receives much attention from plant breeders and geneticists. Some methods of breeding which are employed in breeding maize appear, undoubtedly, worthy of application to coco-nut improvement.

The long term of years which is involved in anticipating results from coco-nut breeding has provided one of the greatest deterrents in the improvement of this crop by artificial self and cross pollination methods, although various kinds of mass selection have been employed in some countries. It is of great interest, however, to note that coco-nut research schemes have been evolved in various parts of the Colonial Empire, such as Ceylon and Malaya and in such outside countries as the Dutch East Indies, particularly in the Celebes. It is the policy of this Department to introduce any improved planting material from such sources wherever possible. In this connexion, as mentioned before, some improved strains have already been introduced from Menado, Celebes and from the Landbouw Institute at Buitenzorg, Java, through the courtesy of the Dutch authorities.

Hunter and Leake[28] state "that the improvement of coco-nuts and building up of super-types is a problem, which owing to the absence of the genetical purity of the available material, together with the time interval between generations will appal the stoutest-hearted breeders. The scope for improvement of the crop is considerable, but owing to the age to which the plant grows the methods for securing that improvement must necessarily be tedious".

Jack, 1922,[31] remarks that "the production of pure strains of coco-nuts which is the only certain method of producing uniform and high-yielding strains, lies beyond the power of the planter, because it necessitates initial work stretching over at least three generations of trees during which period much attention has to be paid to detail and great patience must be exercised."

This rather stretches the position in regard to uniformity as modern plant-breeders dealing with the improvement of crops liable to cross-pollination are not slaves to uniformity so long as a measurable increase in yield and uniformity is obtained. "Strain building" to develop a high proportion of hereditarily high yielding types in the population is a more progressive aim for plant breeders with such crops and this must be carried on continuously. Experiences with such crops as maize indicate that it would not be possible to get genotypical uniformity such as is possible in self-fertilized crops. Planters can greatly assist the building up of superior strains when they use intelligent methods of seed selection on their plantations. Then by utilizing plant breeding methods it is possible to capitalize on such ground work done on the plantation to a larger extent.

It is a most apparent fact that the very height of well-developed mature, tall coco-nut palms is one of the greatest reasons why artificial pollination methods have not been developed on a large scale. This fact also explains largely why

very little artificial pollination work has been done even in an investigational way on tall palms while there is far more data available for dwarf palms. The usual height of a well-grown palm ranges from 40 feet to 100 feet from the ground. Palms have been measured here which are over 110 feet. Some have been recorded from Malaya which are nearly 200 feet, while Burkill[68] measured palms there which reached 120 feet.

It is no easy matter to carry on pollination investigations at even half the height mentioned as some kind of staging is essential for each palm if the investigator intends to supervise the work closely. Failing this reliance would have to be placed in a native or Malay to do the work under direction, which would be only partially satisfactory. It is clearly a very big job to cage or bag individual spathes on large numbers of palms under such conditions, and this provides a distinct limitation to the scope of controlled pollination. This consideration alone increases the value of methods of close-breeding in such work.

Self and Cross Pollination in Relation to Vigour and Fertility.

The effects of self and cross pollination in relation to vigour and fertility of coco-nut palms are not clearly understood due to the small amount of work on this aspect of coco-nut breeding. Tall coco-nuts are said to be liable to natural cross-pollination. It can be assumed that individual palms are also liable to natural self-pollination, even if it is to a lesser extent, and it is more prevalent in particular varieties under particular conditions. Owing to floral structure, maize is known to be extremely liable to cross-pollination, but even in that crop, natural self-pollination is known to occur. The results of the investigations already carried out on coco-nuts are conflicting, apparently. It has been shown, for example, that cross-pollination is more prevalent in some palms at some elevations than at others. This is not such an important consideration to the plant-breeder as is the physiological effect of self as opposed to cross fertilization, in either decreasing vigour in the first instance (in-breeding) or of increasing vigour in the second instance (out-breeding) causing hybrid vigour (heterosis).

Investigators generally concede that cross-pollination, by different individual palms is most effective in favouring maximum nut setting. To what extent cross-pollination would increase the nut setting, over artificial self-pollination, has not been sufficiently proved, and much more work is necessary in that direction.

The earliest work in the direction of in-breeding is of too recent a date to give even an indication of the effect of such in-breeding on the loss of vigour. As stated previously the work on other crops of the Monocotyledonous group, which are liable to self-pollination, such as maize, would, by analogy, suggest the probability of the loss of vigour where tall coco-nut palms are subjected to in-breeding.

Such very fundamental knowledge concerning the extent to which this loss of vigour occurs is essential before a successful scheme of plant-breeding can be evolved and it is essential that the work be carried out.

The examination of seedling progenies from even once-selfed flowers should give a very good measure as to whether some palms are more liable to cross-pollination than others. Such work would also give some indication as to whether some progenies breed truer than others and as to the amount of self-pollination

in the generation preceding selfing. Although Smith[30] did not draw any such conclusions, from his work in Malaya, the presence of comparatively uniform progenies, as well as varying populations in the coco-nut seedlings from open pollinated palms, which he had under observation, suggests very interesting possibilities. It appears likely that either he was dealing with first generation (G1) crosses between good palms leading to comparative uniformity or else self-pollination does occur in some generations. This is comparable with what has been found in lucerne and coffee breeding for example.

Some palms which have been isolated at some considerable distance from other coco-nuts have been noticed to bear fairly well here; this has also been recorded elsewhere[29a]. This fact suggests the possibility that some coco-nut palms would be more liable to self-pollination than others. This contention is borne out by the behaviour of almost all cross-pollinated plants, where "heterosis" or hybrid vigour is a well-known phenomenon. Indirect support of this statement seems to be borne out by the fact that the dwarf coco-nut in Malaya is believed to have originally originated as a sport or mutant from the tall coco-nut. The Malayan dwarf is known to vary somewhat though not nearly so much as the latter. Jack and Sands[32] are inclined to the opinion that the dwarf group shows greater definiteness, because of the fact that it is commonly self-fertilized. Maréchal[11] on the other hand has concluded that cross-pollination is more the rule with the dwarf types normally growing in Fiji. It was shown conclusively in Malaya, that the dwarf forms will cross up with the tall forms, so that semi-talls or intermediate forms may be found. This could be expected to give rise to a wide range of behaviour as to the ability to self-fertilize. It seems that owing to cross-fertilization it will not be possible to originate strains or varieties of coco-nuts which have the faculty for breeding true and thus have the definiteness, which is applied to varieties derived from plants which are normally self-fertilized. The question of the effect of cross-fertilization as opposed to selfing on the size of the resultant nuts should be an extremely valuable study.

Methods of Breeding.

In an article on lucerne breeding technique by the present author[14] the methods of breeding that crop plant are described in detail. They are not all applicable to coco-nut breeding, but a system of close-breeding was described, which, in the author's opinion, would have considerable use in the improvement of coco-nuts.

The following methods of plant breeding may be outlined as available for the improvement of crops. The question is which methods have utility for the particular work of coco-nut breeding:—

1. Introduction of strains, varieties, or nationalities.
2. Artificial self-pollination, selection in self-fertilized lines and their recombination (self-pollination methods).
3. Hybridization—Naturally or artificially.
4. Mass selection and strain building.
5. Plant to row methods.
6. Close and line breeding.

It is not intended to describe each of the above methods, but rather to indicate the application of such methods to coco-nuts improvement.

1. Introduction of Strains, Varieties or Nationalities.

This obvious method of increasing the range of suitable material available for selection and breeding has been already dealt with in the first section of this article. There is a danger of introducing new diseases from outside countries, attendant on this method, which needs to be closely watched.

2. Self-pollination and Recombination Methods.

The importance of self-fertility studies in coco-nut breeding has been mentioned in the section dealing with the relationship of self-pollination to vigour and fertility. Methods of in-breeding and recombination to increase vigour and yield such as is done with annual crops does not appear to offer much scope in practical coco-nut breeding. The long generations involved in this work means that this work would have little application except as a means of determining loss in vigour. It could also be done to determine which palms would be most suitable for recombination and crossing by other methods.

Artificial Self-pollination.

Pieris[8] concludes from his experiments with fresh and stored pollen that the possibility of artificial selfing of coco-nuts, in Trinidad, was definitely established. The experiment was on a very small scale as he obtained only three nuts from fourteen flowers pollinated, where he used pollen from the same inflorescence as the female flowers, collected before the male flowers shed and stored the pollen for seven days.

Jack and Sands[31] working with "dwarf palms" on which three unopened inflorescences were bagged in muslin bags, stated that self-pollination was effected naturally and fruits were formed.

In three other inflorescences which were emasculated (male elements removed) immediately on opening, no pollination took place, and no fruits were formed, though the female flowers behaved normally and although male flowers on adjacent trees were in full bloom. The question of whether these flowers were self-pollinated requires more proof; firstly, because the numbers were small; secondly, because any injury due to emasculation was not taken into account; and, thirdly, it is not certain that wind-borne pollen is excluded by muslin.

To control the parentage of seed nuts the flowers of the palms must be protected against foreign pollen. Emasculation of the male flowers on the individual spathes is also essential, and any injuries caused thereby should be checked by control tests.

Bagging must also be carried out with material which precludes any possibility of the entrance of wind-borne pollen or of pollen carried by crawling insects. This is especially the case where artificial self-pollination is being carried out. The meshes of most muslins are too far apart to exclude fine wind-borne pollen as has been found in special experiments designed to test this in such temperate crops as lucerne. Bagging with muslin bags, undoubtedly, provides some impediments to the free entrance of pollen, but does not necessarily exclude all pollen, especially where heavy winds occur. Against this, there is the fact that bagging with air-tight bags, or with bags which exclude light, usually produces conditions which are unfavorable for fertilization.

Van der Wold[62] has shown that the ripening of female flowers is hastened by covering them with black paper, so as to reduce light and warmth. If the female flowers can be covered so as to become receptive at the same time as the male flowers on the same spathe, then the problems of artificial self-pollination are greatly lessened. It is most likely that the differential environments in close proximity to the flowers may have their effects in rendering flowers liable to self-pollination in some places and not in others. Temperature and humidity can be just as easily increased by using other coverings, such as plate mica or glass, hence a big field for research is opened out.

Furtado[22] obtained results by emasculation experiments on dwarf varieties which differed from those obtained by Jack and Sands (*loc. cit.*). He was able to obtain nuts even though the nearest tree from which pollen could be brought was about 50 yards away from the palm he was working on. This happened despite the fact that the inflorescences looked sickly, and nectar secretion was reduced because of the injury resulting from emasculation.

There is still very much room for investigations in artificial self and cross pollination studies, even before a proper technique is evolved or perfected. Such work is said to be now proceeding in Malaya. Owing to the very height of mature tall coco-nuts and to the comparatively few female flowers found on each palm, the carrying out of extensive pollination studies is no easy matter on such palms. Studies of this nature are not properly significant, unless carried out on a comparatively large scale over long periods of time.

Artificial Cross-pollination.

Maréchal[41] crossing dwarf palms in Fiji obtained a set averaging about 30 per cent. of the flowers artificially cross-pollinated. This compares with the percentages of natural set recorded by other investigators elsewhere.

Pieris,[48] when artificially crossing ordinary Trinidad coco-nut palms, obtained a set of six nuts from 38 flowers (approximately 16 per cent.) when fresh pollen was used, and two nuts from eleven flowers from fresh pollen stored seven days in a gelatine capsule.

It is apparent that the amount of artificial cross-pollination, so far attempted, is very limited and that it would be very unsafe to draw many definite conclusions from such work. Cheeseman[8] comments on the bagging of emasculated inflorescences by Pieris as follows:—

> In waxed paper bags all flowers shed in a few days, but the dark humid conditions inside the bags may have been as much responsible as the complete exclusion of the pollen.

In fine meshed muslin bags ten flowers set nuts out of 156 enclosed, equal to 6 per cent.—from general observations it was concluded that these were probably due to wind-borne pollen and not to ants. In coarse meshed bags out of 70 flowers enclosed, 22 set nuts or 31 per cent. When emasculated flowers were left freely exposed, 42 flowers out of 108 set nuts or 39 per cent.

Hybridization—Cross-breeding.

The value of artificial cross-breeding as a practical method of breeding coco-nuts has not been elucidated, though, as mentioned before, it has been tried in Fiji. It is an accepted method of conducting inheritance and pollination studies. The isolation of desirable types for natural cross-pollination and the establishment

of isolated seed gardens, which comprise only progenies of selected palms, sown in separate rows so as to facilitate both observation and natural crossing, must be considered as to feasibility.

The provision of isolated seed gardens has been used by rubber companies with success in increasing yield.

Another method which suggests itself is that artificial self and cross pollination be carried out with certain selected mother trees to test their behaviour. Then seed nuts from the best proved palms could be isolated together for natural crossing by systematic interplanting as for example two rows derived from each palm sown diagonally in apposition. The practical difficulties associated with established coco-nut seed gardens would be the location of suitable areas at sufficient distances from other coco-nuts, and, secondly, the difficulty in raising sufficient seed for distribution on a commercial scale; while the time and cost involved in getting results must be considered. It is not known, for certain, whether improved strains raised under the environmental conditions obtaining in one district would suit other areas. The probability is very great that strains can be evolved which would do so.

Recently to hand is an account of some carefully planned coco-nut cross-breeding work conducted by Dr. Patel[88] at the Agricultural Research Station, Kasaragod, Madras Presidency, India. "It was found that on an average of twelve years, 13 per cent. of the trees yielded 21 per cent. of the total crop and 7 per cent. of the trees produced only 2 per cent. The characteristics of these 13 per cent. eco-types of the palms are: (1) presence of relatively a larger number of leaves in the crown, which is not so much due to the higher production of leaves as the greater longevity of the leaf, (2) reduction in response to cultural, manurial and seasonal conditions. Apart from the variations in the yield of nuts, these eco-types vary in the production of female flowers, the setting, the size of the nut and the thickness of the meat. In order to determine whether this variation is inherited and to what extent it is possible to combine these characters, crosses have been made between the eco-types exhibiting these characters. Suitable selfed and naturally pollinated material forms the control. About 30 per cent. of the population is not regular in the production of nuts. Crosses have also been made between regular and irregular bearers. It is well known that the dwarf type of the palm commences to yield earlier than the ordinary tall type. The dwarf type and the tall eco-types have been crossed. It was found that a larger proportion of crossed nuts germinated earlier than the selfed and naturally pollinated nuts, and among the crosses those with the dwarf male as one of the parents germinated most rapidly. On the whole it is found that variability with regard to the characters like the period for emergence of successive leaves, and the height and the girth of the seedling, are more in the F1s than in the selfed first generation. Of the progeny of the twenty tall type of parents, tree No. 1/121 and 11/107 are superior in respect of the above-mentioned three characters and also in respect of early separation of leaflets. It appears that the progenies of parents producing a very large number of female flowers are better than the progenies of trees yielding exceptionally well. The development of the F1s of dwarf x tall crosses is outstanding".

[Eco-types represent strains of similar appearance and behaviour, in one generation, but whose progeny do not necessarily behave in the same way in subsequent generations, i.e., phenotypically similar types.—*Author.*]

It is proposed to cross the Markham Valley type of palm with the Malayan dwarf coco-nut at Keravat, also to cross the tall palm in a similar manner and at the same time carry out the reciprocal crosses, using only selected palms in this work. A big handicap, as far as carrying out such technique in New Guinea, is that the local native has not the same intelligence and adaptability as, say, Javanese, Malays or Indians. This means that the investigator here has to work in a small way, although larger scale operations would be decidedly preferable.

Colour Variations in Cross-breeding.

Govindu Kidavu[67] describes a very interesting colour variation in a coco-nut palm growing on Kalpeni Island, in the Laccadives. In this instance three bunches contained green nuts, one bunch with yellow nuts and another, a fifth bunch, with both yellow and green nuts. [He does not describe it as such, but this is a most interesting chimæra or somatic colour mutation, commonly known as a sport.—*Author.*]

The obvious inference is that there is only a (one) factor difference between the green and yellow nuts. Further the chances are that yellow is recessive to green and would breed relatively true to type for that particular character. It is also a significant fact that the colour of the nut is generally correlated with that of the leaf and flower stalk. Counts seem to indicate that red colouration is also recessive and is governed by two or more factors, but further information is required on that point. This question of inheritance of colour differences should be of great import to coco-nut breeders.

Natural Cross-breeding: Assisted by Selection of Male Palms.

As the aim is to evolve practical methods and not academic methods of coco-nut improvement it is as well to mention a method of isolation of mother palms combined with selection of male palms which has been advocated.

The first procedure is to select an area of good yielding palms on an isolated island of rather small size, or else an area of palms completely separated from other palms by wide stretches of bush country. Then the worst mother palms are meant to be cut out or prevented from flowering. Selected male spadices from selected marked palms are then brought in from any outside areas where good parent palms are known to exist. These spadices are tied on to the selected palms on the island which are thought suitable for crossing. It should prove practicable to emasculate the spathes of selected palms. This is not a controlled method as outside crossing could not be altogether prevented, nevertheless, it is a definite practical attempt to control the parentage. An improvement on this method would be to use means of keeping the male spathes alive and actively shedding pollen for some time. That this may be done by using an acid solution as is done with sugar-cane crossing is quite possible. This was demonstrated to the author by Lennox[37] who used a solution of 5 per cent. sulphurous acid H_2SO_3 + 31 per cent. aqueous solution of H_3PO_4, ortho-phosphoric acid in his crossing work with sugar-cane. This solution keeps the sugar-cane fuzz alive for a long time when the base of the stalk is immersed in rubber containers containing this solution. It remains to be proved whether some such means of keeping the coco-nut spathes alive for a long time would be successful.

Mass Selection.

It is seen from the description of the methods of coco-nut seed selection employed in New Guinea that rough principles of mass selection are often employed here, though, in the vast majority of cases, not in an organized manner. As a short-term outlook, the greatest advances from the practical point of view may be expected from this mode of approach to the problem; hence practical seed selection as outlined should be encouraged in every way. Controlled mass selection combined with individual plant selection should also be a necessary prelude to any programme of coco-nut breeding. It has been stated that mass selection, properly employed, offers a ready means of capitalizing on the work which nature has already accomplished, through natural selection, over long periods of time. The term indicates that coco-nuts from selected palms, or selected areas of palms, are used for bulk plantings. The procedure could allow for the cutting out of inferior and diseased palms and only allowing the best palms to cross in an area designed for seed production, and also prevention of inter-crossing by other means such as the removal of spathes on such inferior palms.

Plant to Row Methods.

This appears to be comparable with the methods employed at Klang, Coco-nut Experimental Station, Malaya, and at Buitenzorg, Java. This would be a very useful method to employ either in the preliminary stages or as an adjunct to the close breeding methods described later, and would also be very useful for establishing isolated seed gardens. The seed nuts or progeny derived from palms which appear to be superior on appearance, or as indicated by the various criteria used for selecting good palms, or preferably by previous yield records, are sown out in rows for comparison and further recording of yields. It is possible to cut out any rows which are inferior in type or in yield capacity and thus allow only the best types to cross. A necessary preliminary to either plant to row methods, or to the provision of isolated gardens or to commencing close breeding, is proper nursery selection. Only progenies which give a high percentage germination and produce strong healthy seedlings of even growth should be planted out regardless of the individual yield records of the mother tree. Hence, even in the nurseries, it would be a sound plan to arrange the coco-nuts derived from each individual palm (plant progenies) in rows, side by side, under optimum conditions. Then the hereditary behaviour (plant to row) of individual palms can be judged to some extent even in the very early stages. The production of even, sturdy plants means that both parents were strong and that few variable, inhibitory or undesirable characters are present.

It is common knowledge that plant to row methods has led to great yield increases in other crops, liable to cross-pollination, and is also indicated as a means of coco-nut improvement, though it is of necessity slow, from the practical point of view, unless extensive areas are planted out. It should be recognized that improvement of yield might accrue, but the yield of improved nuts might not be on a sufficient scale to influence large commercial plantings.

When using controlled plant to row methods it would be necessary to obtain results which would yield sufficient seed coco-nuts to be of practical value to the planting community. It is an important consideration that the difficulties of

utilizing improved coco-nut material are great, because it would be necessary to have sufficient seed nuts developed finally to be available for public use, so as to warrant any expenditure and work carried out.

Close and Line Breeding.

The most important desiderata centre around the question as to whether breeding of coco-nuts is practicable and whether results can be expected to eventuate within a reasonable period of time at comparatively reasonable expenditure.

In rubber breeding vegetative propagation furnishes a ready means of capitalizing on any progress made in breeding and provides methods of increasing any high yielding tree to any sized population required. This development of large population from one individual plant by vegetative propagation is called "clonal propagation" and the population so developed is termed a "clone". Rubber clones have been developed and increased so that many thousands of acres have been planted with individual buddings originally derived from one tree.

There is no such short cut to coco-nut breeding, hence it is necessary that some scheme be evolved, which as far as possible can be fitted in with the commercial running of a plantation while still furnishing some measurable improvement in yield and type.

It appears to the author that the only probable means of attaining the desired end is by a system of "close-breeding". Investigators who are interested in a discussion of this breeding technique are referred to an article published in *Herbage Reviews*, March to June, 1936.[11] The reasoning applied by Macauley[39] for close-breeding with maize suggests the basis which can be used for close-breeding of coco-nuts, although important modifications will be found necessary. The limited programme which has already been commenced at Keravat Demonstration Plantation is now outlined. It is also pointed out that the programme of close-breeding is combined with the scheme for the introduction of superior selected coco-nuts, both from within and outside the Territory. Seed coco-nuts derived from open pollinated flowers of selected individual palms are collected and numbered. The seed nuts from each individual palm are kept in separate plots in the nursery. The seedlings are selected in the nursery before planting out is done as is described under line breeding. At Keravat these are later planted into distinct and separate plots in the field. It has been the practice here to plant out the seed nut population derived from each individual palm into small square blocks in the field. Owing to space consideration only one dozen seed nuts from each mother palm could be used in each individual plot.

It is seen that the behaviour of the mother trees can be determined, and that the pollen or male parent is the unknown factor, owing to the ease with which cross-pollination apparently occurs with coco-nuts. It seems very difficult to obviate this, except by controlled cross-pollination in the first place, or by the more crude method of hanging spathes from selected palms to act as male or pollen parents for the selected mother palms.

The elimination of inferior types in the first series can be done by observation and perhaps by weighing the husked coco-nuts when the palms come into bearing. Any obviously bad populations such as those with a tendency to chlorosis or any growth malformations will be eliminated before the palms come into bearing at all.

The term "close breeding" is derived from the fact that, as far as possible, the pollen produced by the individual palms in one population is meant to fertilize flowers of other palms belonging to same population, all of which were derived from nuts harvested from the same individual mother tree.

In practice it will be difficult to prevent the intermixing of the pollen of the various populations, but some precautions are indicated to eliminate this possibility, as far as possible.

When selecting nuts for further plantings all that can be advocated, is to select nuts from the centre of the best plots. It should prove possible to remove spathes from the palms on the borders of each individual plot, and thus prevent their fruiting. This would be more practicable with short or young palms. It must be conceded that even by observational methods, many inferior populations will be recognized. These can be cut out and eliminated from any possibility of crossing so that any outside crossing which does occur should be with individuals of superior populations. At such time as it is possible to recognize any superior populations, the next step is to plant seed nuts from these together, as separate plots, in a new area. If possible this second stage should be arranged for yield testing as well as to give maximum facilities for close pollination. Close-bred plants are sufficiently variable (heterozygous) so as not to lose vigour after continued selection in the close-breeding plots.

It is considered that a continuous system of close-breeding would permit of the continuous elimination of inferior strains after each generation until finally only the best strains, as determined by performance on yield, or under observation, are perpetuated. Such a process of elimination really amounts to "strain-building" and does not preclude the building up of other improved seed plots from the best strains, at any time, without interfering with the programme of improvement and without loss of vigour in the resultant progeny.

It seems possible that it will be necessary to wait for some years to obtain an improved strain of seed coco-nuts for multiplication and distribution, but in any case the method described offers the quickest means available. Another advantage is that this improvement should be increased with each generation of further selection.

Practicability of Coco-nut Breeding.

The objectives and practicability of coco-nut breeding are stressed right throughout this article, but there are other difficulties which present themselves. It must be decided whether the introduction of comprehensive programmes of coco-nut breeding such as described is warranted. The possibiliites of controlled coco-nut breeding are surveyed in this article, but it is seen that the problems involved are not simple, and that there is no set road to success with such work. One certainty is that it would be advisable to carry out coco-nut breeding by all practical methods available, which is no limited task.

Such controlled plant breeding cannot be carried out by private individuals, and is a matter for institutions which must devote most of their time to such work. The question as to whether the economies of the present situation merit such work on a large scale devolves upon the fact that a large proportion of the available areas have been and are becoming planted up with ordinary type coco-nuts. Against this argument it must be pointed out that it is not known what proportion of the bearing areas in the South Seas are economic producers or in

other words to what degree the good producing areas are carrying the low-yielding areas, on the individual plantations. It is certain that an economic survey would show that a great proportion of the bearing areas in this Territory become uneconomic producers when the price of copra falls below a certain level. This applies more particularly to the low copra producing plantations situated on infertile soils. If improved planting material were available this marginal yield per unit area would be increased in the same ratio as any yield increase obtained by using improved seed nuts.

The heaviest bearing plantations and thus the most economic producers stand the most chance of competing with other countries and other competing oils when the margin of profit is reduced owing to a fall in prices. By using improved seed nuts areas which are at present uneconomic might be brought into cultivation. There is no doubt, whatsoever, that the use of improved seed material, if available, would greatly lessen cost of production.

Facilities Necessary.

It is obvious that the provision of facilities is really the determining factor as to whether such work should be commenced or not. A great consideration is whether it would pay an individual Government in a partially developed country to inaugurate such work where questions of fairly heavy finances are involved.

It would, undoubtedly, require that a whole plantation be devoted to such work. It seems, however, that if such breeding and selection work were carried out on a large scale, the plantation used could be made to pay for most of the expenditure involved, once it is brought into bearing. The precedent for this is where the areas devoted to coffee and rubber breeding have been made to pay where such experiment stations were established elsewhere.

It appears that the ideal plantation for such work would have about 100 hectares already in bearing to help carry the expenditure. This would serve as a source for solution, and would provide areas for manuring and other experimentation. This bearing area would need to be associated with at least as large an area of virgin country to carry on breeding programmes, such as described. There is little doubt that it would be possible to plant up a whole plantation of, say, 100 acres with coco-nuts arranged for close-breeding in the manner described. It would be preferable to plant 25 or 50 nuts from each palm in the individual plots. Then it would not be unnecessary to remove any spathes to insure that there was sufficient close-pollination within the centre of the plots, while cross-pollination would take place with the adjacent plots on the borders. Where these adjacent plots appeared to be both superior types, crossed nuts, derived from the edges of the plots, may provide very useful material. Where larger plots were used it would be possible to supply much more material from selected plots. It would be necessary to select the original mother trees by using the various criteria and known correlations between desirable characteristics, earlier described. In this manner, it should be possible to select only high producing, good type palms for inclusion in such a programme.

Such a large area could be run commercially and would be used for experiments and still act as a main centre for seed distribution. If planters were interested in first-class seed nuts, a small extra charge could be made for improved material. The initial cost of establishing such a coco-nut research centre is, as with most new ventures of this nature, the important consideration.

Should the provision of such a plantation be beyond the resources of any one individual Government, it is possible that a scheme could be made to apply to the whole Southern Pacific, if some well-organized central institution were available to carry out such work, but so many Governments are involved as to render such an establishment unlikely. The time factor is a most important consideration, and it is this more than anything else which has held up coco-nut breeding for so long. It is only a Government or an institution with a long-term viewpoint which could satisfactorily carry on such work.

There is no doubt that the development of improved seed nuts would have a wide application, as the results would apply to most coco-nut-producing countries, but particularly in those Pacific Islands where European plantations form the bulk of the planted area. There is not only the desideration as to whether coco-nut breeding is a feasible aim, but there is the question as to whether sufficient seed nuts could be increased from any improved strains to affect a great number of plantations. It is this consideration which determines that any controlled system of coco-nut breeding would necessarily have to be carried out on a large scale.

If it were considered by central authorities and plantation interests that the work of developing improved seed nuts would be of great value, the institution of such a programme should not be delayed.

It is as well to realize the difficulties involved, but an important function of this article is to show that the feasibility of controlled coco-nut breeding has been given much consideration by this Department. It is granted that the question of the establishment of such a scheme of coco-nut research could not be decided by any particular individual, or even by this Department, without the full co-operation of all interests affected.

Besides the major objective of developing improved strains of coco-nuts, a coco-nut-breeding station could carry on fundamental studies with all the problems mentioned in other sections of this article.

A study of self and cross pollination as related to fertilization and nut-setting could be carried out in connexion with the breeding programme, as could investigations on other factors affecting nut-setting.

Experiments on manuring, cover cropping and cultural methods could be carried out at the same time. Such work would indicate the quickest methods of increasing yields for any money expended. The longer term results from controlled plant breeding should, however, be more permanent and progressive.

SUMMARY.

This article deals with two main problems, and hence is divided into two main sections: A.—Coco-nut Seed Selection; B.—Coco-nut Plant Breeding.

A.—Coco-nut Seed Selection.

In problems of seed selection the effect of environment on the growth characteristics of the coco-nut cannot be underestimated. Unfavorable environment may mask favorable hereditary characteristics of the individual palms and render selection difficult.

The hereditary characteristics of a palm which determine its inherent capacity for yield are constant, but the factors associated with the expression of yield—such as climatic, soil, and cultural environment—are constantly changing, and these are briefly outlined.

Individual palms in any plantation show a wide range in growth characteristics and in fruiting ability, so that in any unselected area a very large proportion of the palms present are shown to be uneconomic producers, thus coco-nut seed selection is strongly advocated.

The methods of seed selection employed in New Guinea plantations are outlined. These are usually crude, where not entirely neglected, though a few experienced planters do practice proper seed selection. Excuses advanced for such neglect mainly centre around the time and cost involved, though it cannot be denied that seed selection is a sound capital investment.

Improvements on the existing methods are described and recommended. Heavy-bearing palms of good type should be selected according to various criteria which are elucidated. The selected palms should be permanently marked and observed, individually, for some time before finally selecting them as a source of seed supply.

Certain external characteristics, such as type of crown, number of spathes and female flowers present, have been correlated with yield tendencies. In other countries a very high correlation between weight of husked nut and copra yield has been indicated; thus by simply weighing the husked nuts a very close measurement of the yield of copra from individual palms can be made without the trouble of drying the kernel.

The tangible results which can be expected from seed selection are indicated as being well worth any cost or trouble involved. Yield increases of the order of 20 per cent. would easily be anticipated, if rigid selection of high-yielding palms for producing seed nuts were carried out as, on the average, high-yielding palms produce high-yielding progeny, and vice versa for low-yielders. If production can be increased by 10 per cent. the cost of selection would be amply repaid.

The extent to which coco-nut seed introduction into New Guinea has proceeded since historical times is not generally realized. The introduction of seed coco-nuts from outside countries such as Malaya, the Philippines, Java and Samoa, and seed interchange between various parts of New Guinea, has been carried on extensively both during and since German times.

The present Department of Agriculture has also carried on a great deal of coco-nut seed introduction, and representative collections are being grown at Keravat Demonstration Plantation near Rabaul in connexion with a breeding programme.

The presence of "regional strains" (not varieties which breed true) in this country and elsewhere are indicated. It is apparently this fact which has led to the interchange of seed nuts from different districts here. The Markham River, Witu and probably the western islands types of coco-nuts appear to be varying regional strains which, however, possess some distinguishing characteristics. The influence of selection of seed coco-nuts by natives, together with natural selection, has had a decided influence on the types of nuts propagated in different districts.

A short discussion on coco-nut varieties is presented and several genetical abnormalities, which should be avoided when selecting seed nuts, are listed. The utility of the dwarf varieties to New Guinea conditions is not yet apparent, but they have been the subject of many inquiries, and hence are described in some detail. Some types were introduced years ago by German planters.

The floral structure (morphology) of the coco-nut spathes and flowers, also the development of the inflorescence, male flowers, female flowers and nuts are dealt with, and many practical applications of such work are given.

The natural nut-setting or the percentage of flowers forming matured fruits (usually in the vicinity of 30 per cent.) is influenced by the original profuseness of female flowers present, as well as by the general condition of the palms, together with all of the factors governing growth, fertilization, and so on; closely related to this are the problems of nut-fall. The falling of unfertilized flowers (embryo abortion) is often confused with nut-fall.

The problems of pollination and fertilization of coco-nuts are presented, while the agencies of pollination, such as insects, wind and birds, are discussed with particular reference to New Guinea. Knowledge of such problems is a necessary preliminary to any controlled methods of coco-nut breeding.

A brief discussion on seedling selection in the nursery and selective re-planting in the field is given, although these may be treated as separate subjects. Insufficient attention is given here to these most important precautions for successful coco-nut planting. The seedlings being derived from originally cross-fertilized flowers show extreme variations, and only the sturdiest plants should be selected for planting out. Neglect any palms showing an hereditary tendency to low germinability of seed nuts.

B.—Coco-nut Breeding.

It is only recently that scientific plant-breeders have taken an interest in the improvement of coco-nuts by systematic plant-breeding.

The long term of years which is involved before any results could be obtained from coco-nut breeding, the height of the palms, and the long intervals between generations, have so far provided the greatest deterrents to the initiation of plant-breeding with this crop.

The possibilities of controlled coco-nut breeding as far as New Guinea is concerned are surveyed in this article, and it is shown that the problems involved are not simple; nevertheless, they are not insurmountable.

So far few results have been obtained anywhere from methods of controlled breeding of coco-nuts, and hence the literature and information available on the technique likely to be employed in such work are very meagre.

Controlled plant-breeding cannot be carried on by private individuals, as it is a matter for institutions, which must devote a great deal of their time to such work. The objects of coco-nut breeding, such as breeding for yield of copra, oil production, elimination of disease, actual increase of copra production, constitute the main aims in such work.

A most important consideration is not whether controlled breeding of coco-nuts is practicable, but whether results can be expected to eventuate within a reasonable period of time at comparatively little expenditure.

The difficulties of utilizing improved coco-nut material are stressed, as sufficient improved seed nuts would need to be produced to affect a large planting area, in order to warrant the trouble and expenditure involved.

The question of the provision of facilities, and a suitable plantation for such work, is discussed, and this is really a determining factor governing the initiation of such work in this country.

The effect of self and cross pollination on the vigour of the resultant palms is outlined. Self-pollination leads to in-breeding, which leads to reduction of vigour in crops liable to cross-pollination, such as coco-nuts.

The possible methods of coco-nut breeding are described and it is explained that controlled mass selection, combined with individual plant selection, should be a necessary prelude to any programme of coco-nut improvement.

Six methods of crop improvement are outlined, and these include the possibility of artificial pollination methods being employed.

It is believed that "close-breeding" methods, and the provision of various kinds of seed isolation gardens, offer the readiest means available for coco-nut seed improvement.

Such methods are being utilized on a limited scale at Keravat Demonstration Plantation, near Rabaul.

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LITERATURE CITED.

1. Annual Bulletin of Divisional Reports. Dept. of Agric., Suva, p. 3 and p. 23, 1933.
2. Annual Report of the Department of Agriculture, Zanzibar Protectorate. Government Printer, Zanzibar, 1937.
3. Anon. "The Selection of Coco-nuts for Germination." *Kew Bull. Misc. Information*, No. 2, 72-76, 1915.
4. Aldaba, V. C., "The Pollination of Coco-nut." *Philip. Agriculturist*, X., pp. 195-207, 1921.
5. Belgrave, W. N. C., Lambourne, J., "Manurial Experiments on Coco-nut and Oil Palm." *The Malayan Agric. Journ.*, Vol. XXI., 200, 1933.
6. Burkill, I. H., "Some Notes of the Pollination of Flowers in the Botanic Gardens Singapore and Other Parts of the Malaya Peninsula." *The Gardens Bull.*, Straits Settlements, Vol. 2, No. 5.
7. Ceylon, Coco-nut Research Scheme, Annual Report for 1935 (Stencilled) Bandirippuwa Estate, Lunuwila, p. 53. *See* also Imp. Hort., Abs. 6, No. 4, Abs. 987, December, 1936.
8. Cheeseman, E. E., "Coco-nut Notes: The Floral Biology of the Palm" (An Account of Experiments by H. A. Pieris in 1927-28). *Tropical Agriculture*, Vol. V+, No. 10, 289-92, Oct., 1929.
9. Cooke, F. C., "The Relationships between Weights of Coco-nuts, Husked Nuts and 'Meat'." *The Malayan Agric. Journ.*, Vol. XXII., 539, November, 1934.
10. ——— "The Harvesting of Coco-nut for Copra Production in Malaya." *Malayan Agric. Journ.*, Vol 19, No. 10, pp. 477-83, 1931.
11. Copeland, E. B. *The Coco-nut* (3rd edit.). MacMillan & Co., Lond., 1931.
12. Dash, J. S., "Coco-nut Cultivation" *Agric. Journ. British Guiana*, Vol. ii., No. 1, March, 1929.
13. de Veer. Unpublished information. Landbouw Instituut, Buitenzorg, Java, 1934.
14. Dwyer, R. E. P., "Lucerne Breeding Technique: A New System of Close Breeding." *Herb. Rev.*, Nos. 1-2, March-June, pp. 1-8, 1936.
15. ——— "A Survey of the Coco-nut Industry of the Mandated Territory of New Guinea." *Agric. Gaz.*, Vol. 2, No. 2, Oct., 1936.
16. ——— "The Diseases of Coco-nuts (*Cocos nucifera*) in New Guinea." *New Guinea Agric. Gaz.*, Vol. 3, No. 1, pp. 28-93, April, 1937.

17. East, E. M., and Mangelsdorf, A. J., "A New Interpretation of the Hereditary Behaviour of Self Sterile Plants." *Proc. Nat. Acad. Sci.*, Wash., II., 166-171, 1925.
18. Fernando, H. M., "Some Problems of Coco-nut Research." *Trop. Agric.*, Ceylon, 75, 310-20, 1930.
19. Fredholm, A. Quoted by Smith and Pape, pp. 591-593.
20. Froggatt, W. W., 1911, "Pests and Diseases of the Coco-nut Palm." *New South Wales Dept. of Agric. Sci. Bull.*, May, 1911.
21. Froggatt, J. L., 1937. Communicated Information.
22. Furtado, C. X., "A Study of the Coco-nut Flower and its Relation to Fruit Production." *The Gardens Bull.*, Straits Settlements, Vol. III., 7-8, pp. 261-274, Nov., 1924.
23. ——— "Branched Coco-nuts and Their Fertility." *Ibid* Vol. 3, 7-8, pp. 274-9, Nov., 1924.
24. Green, E. C. D., "The Agricultural Aspect of the Coco-nut Industry in the Mandated Territory of New Guinea." Section I., The Products and Uses of the Coco-nut Palm. *New Guinea Agric. Gaz.*, Vol. 2, No. 3, pp. 3-9, Dec., 1936.
25. Hamilton, W. M.; Grange, L. I., "Report on the Soils and Agriculture of Western Samoa." Dept. Sci. and Ind. Research. Report made for Samoan Administration on New Zealand Reparation Estates, September, 1937.
26. Handover, W. P., "The Dwarf Coco-nut," *Agric. Bull.*, F.M.S., VII., p. 195, 1919.
27. Hill, A. W., "Nature." 27th July, 1929.
28. Hunter, H., Leake, H. M., *Recent Advances in Agricultural Plant Breeding.* Pub. J. and A. Churchill, London, 1933.
29. Jack, H. W., "Variation in Coco-nuts with Particular Reference to Fruit Production." *Malayan Agric. Journ.*, XIII., No. 2, Feb., 1925.
29a. ——— "Variation in Coco-nuts." *Malayan Agric. Journ.*, XVII., 2, p. 37, 1929.
30. ——— "Improvement of the Coco-nut Crop by Selection." *Malayan Agric. Journ.*, XVIII., No. 1, pp. 30-31, Jan., 1930.
31. Jack, H. W., Sands, W. N., "The Dwarf Coco-nut in Malaya." *Malayan Agric. Journ.*, X., pp. 4-12, Jan.-Dec., 1922.
32. ——— "Observations on the Dwarf Coco-nut Palm in Malaya." *Malayan Agric. Journ.*, Vol. XVII., 6, pp. 140-165, 1929.
33. ——— "Variation in Coco-nuts." *Malayan Agric. Journ.*, XV., No. II., pp. 387-399, Nov., 1927.
34. Juliano, J. B., Quisumbing, E., "Morphology of the Male Flower of *Cocos nucifera* Linn." *Philip. Journ. Sci.*, Vol. 45, No. 3, 449-55, July, 1931.
35. Juliano, J. B., "Origin, Development, and Nature of the Stony Layer of the Coco-nut" (*Cocos nucifera* Linn.). *Philip. Journ. Sci.*, Vol. 50, No. 2, p. 187, June, 1926.
36. Knuth, R. *Handbuch der Blutenbiologie.* Bd. III., pp. 54-78, Leipzig, 1904.
37. Lennox C. E., Communicated Information.
38. Lever, R. J. A. W., Phillips, J. S., "Further Experiments with *Amblypelta* and Immature Nut-fall." *B.S.I.P. Agric. Gaz.*, Vol. 3, No. 4, Supplement, Feb., 1936.
39. Macaulay, T. B., "The Improvement of Corn by Selection and Plot In-breeding." *J. Hered.*, 19, 57-72, 1928.
40. Mareda, F. S., "A Study of Coco-nut Seedlings in Relation to Shape of the Nuts." *Philip. Agriculturist*, 22, pp. 430-41, 1933.
41. Maréchal, H., "Observations and Preliminary Experiments on the Coco-nut Palm with a View to Developing Improved Seed Nuts for Fiji." *Agric. Journ. of Fiji*, Vol. 1, No. 2. pp. 16-45, 1928.
42. Meyer, P. O., *Die Vogel des Bismarck Archipel.* Beobachtungen und Studien, der Missionare vom H.I.S.T. Herzen Jesu in der Sudsee. Band. 2., Druck und Verlag, Katholische Mission, Vunapope, P.O., Kokopo, 1930.
43. Omar, Ahmed. Bin. Haji, "Races of the Coco-nut Palm." *Gardens Bull. S.S.*, Vol. II., No. 5, p. 143, Sept., 1919.
44. Papua; Annual Report by the Lieutenant-Governor, Year 1923-24, p. 28. (*See* included Report on Orangerie Bay Govt. Plantation, by Staniforth Smith, Director of Agriculture.) The Parliament, Com. of Australia, Govt. Printer, Melbourne, Victoria.
45. Peteh, T., "The Flower of the Coco-nut." *Trop. Agriculturist*, XLI., pp. 449-455, 1913.
46. Pieris, W. V. D., "Studies of the Coco-nut Palm, I." *The Trop. Agriculturist*, Vol. 82, No. 2, pp. 75-97, Feb., 1934.
47. ——— "Studies of the Coco-nut Palm, II." "On the Relation between the Weight of the Husked Nuts and the Weight of Copra." *Ibid.*, Vol. 85, No. 4, pp. 208-20, Oct., 1935.
48. ——— "Seed Selection (Coco-nuts)." Leaflet No. 1 of the Coco-nut Research Scheme, Ceylon. *Tropical Agriculturist*, 88, No. 4, pp. 216-18, 1937.
49. ——— "Nursery Management and Selection of Seedlings (Coco-nut)." Leaflet No. 2 of the Coco-nut Research Scheme, Ceylon,. *Tropical Agriculturist*, 88, No. 4, pp. 219-24, 1937.

50. Preuss, P., *Die Kokospalme und ihre Kultur.* Berlin Deitrich Reimer (Ernest Vohsen), Berlin, Oct., 1911.
51. Quisumbing, E., Juliano, J. B., "Development of Ovule and Embryo Sac of *Cocos nucifera*." *Bot. Gaz.*, 84, pp. 279-293, 1927.
52. Sampson, H. C., *The Coco-nut Palm.* John Bale Sons and Danielsson Ltd., London, 1923.
53. Santos, J. K., "A Cytological Study of *Cocos nucifera* Linn." *Philip. Journ. Sci.*, 37, p. 417, 1929.
54. Sharples, A., "Coco-nut Research in Malaya." *Malayan Agric. Journ.*, Vol. XVIII., No. 2, p. 71, Feb., 1930.
55. Simmonds, P. L. Quoted by (3). *Tropical Agriculture*, pp. 220-221, London, 1877.
56. Smith, A. C. "Practical Seed Selection of Coco-nuts." *Malayan Agric. Journ.*, Vol. XXI., No. 6, June, 1933.
57. ——— "Sun Blas Coco-nuts in Malaya." *Malayan Agric. Journ.*, XX., No. 11, p. 583, 1932.
58. Smith, H. H., Pape, F. A. G., *Coco-nuts: The Consols of the East.* 2nd Edit., London, 1913.
59. Smith, S., *Handbook of the Territory of Papua* (2nd Edit.). Govt. Printer, Melbourne, Australia, 1909.
60. Stockdale, F. A., "Coco-nut: Varieties of Coco-nuts." *The Tropical Agriculturist*, Vol. LXII., No. 4, pp. 204-9, April, 1924.
61. Thiele, H. H., "Coco-nut Growing in Fiji." *The Tropical Agriculturist*, Vol. XLI., Oct., 1913.
62. Van der Wold. Quoted by Hunger, T. W. F., in *Cocos nucifera*. Amsterdam, 1920, according to Furtado(22).
63. Wardlaw, H. H., Mason, F. R., "An Account of Irrigation and Drainage Control of an Area of Dwarf Coco-nuts." Vol. 24, 6, p. 421, 1936.
64. Wester, P. J., "The Coco-nut Palm—its Culture and Uses" (2nd revised edit.). *Bull. Phil. Bur. Agric.*, No. 35, 1920, also *Phil. Agric. Rev.*, Vol. XI., p. 13, 1918.
65. Burkill, I. H., *A Dictionary of the Economic Products of the Malay Peninsula.* Vol. I. (A–H), pp. 595-615. Pub. for S.S. and F.M.S. by the Crown Agents for the Colonies, 4 Millbank, London, S.W.1, 1935.
66. Cooke, F. C., and Jagoe, R. B., "Further Observations on the Dwarf Coco-nut in Malaya." *Malayan Agric. Journ.*, XXI., No. 4, p. 164, 1933.
67. Govindu Kidavu, M., "Some Experiences with Coco-nut in the West Coast of Madras." *Trop. Agric.*, Ceylon, 19, No. 7, pp. 349-354, 1931. Reprinted from *Madras Agric. Journ.*, July, 1931.
68. Patel, J. S., "Coco-nut Breeding"—Report of Meeting; Association of Economic Biologists, Coimbatore. *Madras Agric. Journ.*, 25, No. 11, p. 357, 1937.

CORRESPONDENCE.

[The Department does not necessarily concur with the opinions expressed, but correspondence and articles are always welcomed.]

Erimahafen Plantation,
Madang, New Guinea,
1st November, 1937.

The Director,
Department of Agriculture,
Rabaul

Dear Sir,

It was noticed in the early issues of the *New Guinea Agricultural Gazette* that the planters were invited to contribute articles to this journal, but I have not as yet read any articles originating outside your Department.

As I consider it the duty of the planting community in general to assist you in establishing this journal—a very necessary publication for the improvement of the Territory in an agricultural sense—I am attaching herewith a small article dealing with the possibilities of dwarf coco-nuts in New Guinea, and should you consider it suitable for publication hope that it will encourage other planters to express their views through your journal.

Assuring you of my assistance at all times,

Yours faithfully,

(Signed) B. G. Hall.

THE POSSIBILITY OF CULTIVATING DWARF COCO-NUTS IN NEW GUINEA.*

By B. G. Hall.

Now that copra has attained a profitable figure, and the majority of planters are able to run their plantations economically and with a fair margin of profit for their capital outlay, it is found that the coco-nut remains as yet the mainstay of the Territory of New Guinea.

However, despite the recovery of the copra market, it should be the duty of every planter who takes an intelligent interest in the development of his property, to investigate ways and means of increasing his returns still more from coco-nuts, and if he has decided to plant a further area of this crop, consideration should be given, where conditions appear suitable, to the planting of Malayan dwarf varieties. It must be clearly understood that the writer by no means suggests that the dwarf variety should be planted in preference to the ordinary "tall" palm, but feels that the dwarf coco-nut offers a most interesting subject for careful consideration, and, no doubt, there are areas in New Guinea, such as Kar Kar Island and Talasea, where it would thrive.

The following opinions and information, which have been obtained from outside sources, may prove interesting to planters who are more or less interested in this variety of coco-nut palm.

Varieties of Malayan Dwarf Coco-nut.

As yet there has been no known variety of dwarf coco-nut classified as being peculiar to New Guinea, and the few odd palms which may be found in the Territory have been obtained in a majority of cases from the Solomon Islands, where several areas of so called "King" coco-nuts have been planted.

In Malaya there are three recognized varieties under cultivation, namely—

Dwarf yellow,
Dwarf red,
Dwarf green,

which are characterized by the colours as specified. The yellow variety appears to be most popular, and the heavier producer, and some remarkable production figures have been obtained from this variety, under ideal conditions, particulars of which will be given later.

Soil.

It appears that the soil must be the best available, in accordance with the usual rules governing coco-nut culture, but no doubt average soils, properly treated by the establishment of cover crops such as *Centrosema pubescens*, *pueraria* or *calopogonium*, or other leguminous covers, together with careful and efficient drainage, and if considered necessary forking, would produce most satisfactory results.

Planting Distance.

This variety is a dwarf in every respect, and its growth is approximately half that of the ordinary "tall" variety, so that the distance of planting may be much closer, and consequently the number of palms per acre is increased and under favorable conditions the output per acre.

* *Editorial Note.*—This subject has been dealt with in detail by the Economic Botanist as a sub-section in his article "Coco-nut Improvement" appearing in this issue. Mr. Hall's article, however, is presented in a popular way.

It is the practice in Malaya, and I have been recommended likewise, to plant approximately 22 feet x 22 feet square giving 90 palms to the acre, but the writer personally would suggest planting 22 feet x 22 feet on the equilateral triangle, thus obtaining more palms per acre, and making greater use of the ground available.

It is an accepted fact that there is nothing to be gained by giving a palm more ground area than it actually requires for its normal development, and therefore, from information obtained from the *Malayan Agricultural Journal*, it appears that 22-ft. planting was quite sufficient when the area was extensively drained and irrigated, with *Centrosema pubescens* established over the whole area, and the matter of planting on the square or triangle is purely a matter of taste. It has been asserted by one authority[1] that spacing 15 feet x 15 feet has given the best results. However, the writer is of the opinion—influenced by personal observations of the coco-nut palm and advice from Malaya regarding the dwarf variety—that the closer planting may give greater yields during the first few years of bearing, but the larger distance would as the palms grow older produce more heavily and have a longer span of life, which is a most important factor to be considered with any crop.

Yield.

Under ideal conditions, some remarkable yields have been obtained, and some very interesting figures were published recently in the *Malayan Agricultural Journal* regarding an area of 41 acres, planted in 1920, which has been extensively drained, irrigated at intervals, and had cover crop established throughout, the cover plant proving most suitable being *Centrosema pubescens*. The soil was coastal alluvial clay, which in an undrained condition was grey in colour on the surface, changing to blue or blue grey a few inches below the surface down to the water table and further. This type of soil is quite common in New Guinea. After proper drainage and efficient aeration of this soil—establishment of cover crops—it was observed that a complete change took place and the soil showed itself as rich in all plant foods, the quantity of which was governed only by the depth of drainage, and was most suitable for the cultivation of coco-nuts. This area, as will be seen from the following figures, responded magnificently to this treatment, and will serve to give some idea as to the possibilities of this variety of coco-nut palm:—

Year.	Number of nuts harvested.	Average number of nuts.	Copra per acre.	Number of nuts.
		Per palm.	Cwt.	Per cwt.
1925	194,530	56	9	508
1926	235,360	67.5	11	509
1927	209,876	60	8	622
1928	386,876	111	17	560
1929	235,444	67.5	10	509
1930	368,056	106	17	508
1931	371,045	106.5	17	503
1932	345,208	99	18	448
1933	514,091	148	30	386
1934	470,028	135	28	387
1935	531,219	152	32	386

It appears that from 1931 onward extensive irrigation was carried out on the area, with the results as illustrated in table above. The average over the eleven years from 1925-1935 was 17.9 cwt. per acre, or 44.7 cwt. per hectare, which is really phenomenal, and it will be noted that when the area first came into bearing in 1925, the output was at the rate of 9 cwt. per acre or 22.5 cwt. per hectare, which when we consider that a New Guinea plantation producing 1 ton per hectare when fully bearing is considered a very good property, exemplifies the fact that the dwarf variety should be given further consideration as an economic crop in New Guinea. When observations were last taken in 1935, this area was producing approximately 4 tons per hectare, and with corresponding care and attention to their cultivation, the writer is of opinion that yields of 3 tons per hectare in parts of New Guinea should not be an impossibility. The cultivation of the dwarf coco-nut in New Guinea is as yet purely a matter for conjecture, and experimental plots would necessarily have to be planted before its adoption by private planters could be recommended.

Despite the aforementioned excellent results obtained in Malaya, the fact must not be overlooked that there are many drawbacks which tend to counterbalance the main advantage offered by dwarf coco-nuts of giving a crop after five years, compared with eight to ten as is the case with the "tall" palms. The chief disadvantage being the fact that the dwarf variety does not remain in bearing as an economically profitable crop nearly as long as the "tall" variety, a factor which is most important, but which may be equalized by greater production per hectare. And again, it is generally accepted that copra produced from dwarf varieties is, as a rule, inferior to that of the "tall" palm, a fact which can reflect in numerous ways.

From information received from the Department of Agriculture, Kuala Lumpur, in regard to the dwarf coco-nut in Malaya, it appears that this variety is very susceptible to any unfavorable factors, and adequate rainfall, suitable soil, efficient drainage, together with careful cultivation, are absolutely essential to its successful cultivation. Where we find the ordinary "tall" palm living in soil waterlogged for a considerable period of the year, and still bearing quite favorably, under the same conditions any attempt to cultivate "dwarf" palms would be disastrous and could not possibly meet with success.

In regard to the possibility of cultivating the dwarf palm in New Guinea, we have, undoubtedly, excellent soils and abundant rainfall, and the matter of drainage and cultivation is a matter which rests in the hands of the person controlling the area, and his attitude towards such matters. The question of drainage is a matter not entirely understood by many planters, and as this is a most important and vital phase of cultivation in connexion with the "dwarf" palms, as well as the "tall", a few remarks on this matter would not be wasted.

Drainage.

It must not be considered that when drainage is referred to, that this means the absolute removal of all water from the soil, but when referred to in connexion with the cultivation of coco-nuts interpreted as simply meaning that there is movement of water in the soil as opposed to stagnation, and it has been well established by such authorities as Copeland and Sampson[2] that movement of soil water is most essential to ensure proper development and growth of the coco-nut palm.

The subject of drainage has been ably described in the *Malayan Agricultural Journal* by Messrs. Wardlaw and Mason[3] in which they state, *inter alia*—

> In the case of coco-nut cultivation the writers would consider a well-drained soil one in which there is a constant soil water movement, but this movement should be very slow, in fact, a bare seepage, and by no means of such a nature as to result in washing the soil, as this might prove to be harmful.
>
> If no movement takes place, then steps should be taken either by additional drains, or the planting of suitable covers to rectify matters. A badly-drained soil will be one in which soil water movement was non-existent, thus giving a "still" or stagnant water table near the surface, conditions under which coco-nuts will not thrive for long.

Taking into consideration the requirements of this variety of coco-nut palm, and noting to what extent they can be satisfied by conditions in New Guinea, there is really no reason why the successful cultivation of this "dwarf" could not be undertaken, and careful research and experiment by the Department of Agriculture or the large planting interests are well warranted, as good coco-nut land in New Guinea, although not scarce, is becoming more difficult to obtain, and the planter is now, more than ever, desirous of obtaining the maximum return from his available land.

LITERATURE CITED.

(1) Duncan—*Pacific Islands Monthly*, 21st December, 1936.
(2) E. B. Copeland—*The Coco-nut*. H. C. Sampson—*The Coco-nut Palm*.
(3) H. H. Wardlaw and F. R. Mason—*Malayan Agricultural Journal*, September, 1936.

REPORT ON SOME DUST AND MUD DEPOSITS RESULTING FROM THE RECENT VOLCANIC ERUPTIONS AT RABAUL, ISLAND OF NEW BRITAIN, NEW GUINEA.

By J. S. Hosking, Division of Soils, Council for Scientific and Industrial Research.

Seven samples representing dust, mud and ash deposits derived from the recent volcanic eruptions at Rabaul have been examined.

The deposits vary in texture from sandy loams to loams bordering on clay loams. The dust deposits from the Vulcan Island Crater, and the rain-washed and sorted material, fall within the former class, and the hardened mud and compacted ash from Matupi Crater, fall within the latter class; the mud layer from Matupi is intermediate in texture. The deposits have an extremely floury consistency, being composed mainly of fine sand and silt; the ratio of fine sand to silt varying from 2:1 to 3:2. The washed and sorted material is the only sample showing any appreciable concentration of coarse pumiceous sand. All materials are highly abrasive.

No free acid is present in the deposits which vary in reaction from slightly acid (pH 5.0) in the Matupi mud layers to slightly alkaline (pH 7.7) in the underlying Vulcan Crater dust layers. The washed and sorted deposit from Vanalea is the most alkaline with a pH of 7.9.

The deposits were examined for soluble salts, 200 gms. of each being extracted with 1 litre of distilled water. The total salt content varied from about 3 per cent. in the more acid deposits from Vulcan Crater to about 1 per cent. in the alkaline Matupi mud layers. The washing of the Vanalea deposit has resulted in marked leaching of this material, less than 0.1 per cent. of salt being present.

Calcium sulphate (gypsum) and sodium chloride constitute the bulk of the soluble salts, although potassium and magnesium salts are also present. The total content of calcium sulphate in the deposits is, undoubtedly, higher than the figures given, since the water extract for those soils showing the greater concentrations have reached approximate saturation. An examination of the figures for loss on acid treatment indicates, however (by subtracting the remaining soluble salts), an upper limit to the content.

While the content of calcium sulphate is a natural result of volcanic activity the high content of sodium chloride is probably due to contamination with sea water.

The effect of heavy rains in the rapid removal of salts is evident when the content for the deposit from Vanalea Village is compared with the remaining samples.

Analytic details for the seven samples are given in the Table.

MECHANICAL ANALYSES OF, AND WATER SOLUBLE SALTS IN, THE VOLCANIC DEPOSITS FROM RABAUL, NEW BRITAIN, NEW GUINEA.

Field Sample Number.	1.	2.	3.	4.	5.	6.	7.*
Waite Institute Number.	5202.	5203.	5204.	5205.	5206.	5207.	5208.
Nature of Deposit.	Dust (protected from rain).	Mud Layer overlying No. 3.	Dust Layer underlying No. 2.	Composite Sample of Nos. 2 and 3.	Hardened Mud.	Compacted Ash.	Deposit washed and sorted by Thunder Storms.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Coarse Sand	7.4	4.5	13.3	6.4	3.0	13.4	32.5
Fine Sand	58.7	47.9	52.0	49.1	37.6	30.3	36.4
Silt	28.1	29.5	29.0	30.7	30.8	23.5	26.1
Clay	4.7	9.6	4.6	8.5	21.0	16.5	4.8
Loss on acid treatment	2.2	6.4	1.8	5.0	6.7	7.8	0.7
Moisture	0.8	2.7	0.7	2.2	2.3	3.0	0.4
Loss on Ignition ..	1.9	3.1	1.7	2.4	2.9	4.5	1.5
Reaction pH	7.3	5.0	7.7	5.1	7.1	5.8	7.9
Soluble Salts†—							
Chloride .. ion Cl' ..	0.46	0.69	0.34	0.49	0.13	0.49	0.035
Sulphate .. ion SO_4 ..	0.37	1.08	0.30	1.01	0.89	1.33	0.020
Calcium .. ion Ca'' ..	0.20	0.50	0.13	0.50	0.46	0.46	0.009
Magnesium ion Mg''..	0.03	0.09	0.03	0.07	0.04	0.15	0.001
Sodium .. ion Na' ..	0.22	0.32	0.17	0.25	0.08	0.28	0.018
Potassium ion K' ..	0.02	0.04	0.02	0.03	0.03	0.05	0.006
Manganese ion Mn''..	0.001	0.006	0.002	0.005	0.004	0.013	0.000
Carbonate ion Co_3 ..	0.001	0.000	0.000	0.000	0.001	0.000	0.001
Total	1.30	2.73	0.99	2.36	1.63	2.77	0.090
Salts expressed as—							
Gypsum $CaSO_4,2H_2O$ ..	0.66	1.93	0.54	1.81	1.59	1.97	0.036
Sodium Chloride NaCl	0.56	0.81	0.43	0.64	1.26	0.71	0.046

* This sample contained 8 per cent. pumiceous stone. † 200 gms. of deposit extracted with 1 litre of distilled water.

By Authority: L. F. Johnston, Commonwealth Government Printer, Canberra.

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6034.

CACAO CULTIVATION, AND ITS APPLICATION TO THE MANDATED TERRITORY OF NEW GUINEA.

By E. C. Green, H.D.A., A.I.C.T.A., Superintendent, Government Demonstration Plantation, Keravat.

Introduction.

The Mandated Territory of New Guinea is in the primary stages of development, and the cultivation of coco-nuts is one of the main sources of revenue. However, the economic conditions prevailing throughout the world during the period 1930-36 were such that the coco-nut industry was scarcely profitable, and, although conditions have since improved, nevertheless it has shown that this country cannot afford to rely solely on one crop.

The argument may be made that investigations to date of the mineral resources of New Guinea show that the Territory has great mineral potentialities. It is pointed out, however, that the "backbone" of a country lies in agricultural and pastoral pursuits, and that mineral wealth merely provides a quick method of economic establishment. Therefore, agricultural and pastoral consideration is important, especially whilst the mineral wealth is available.

The aim of this paper is to set out the methods of establishing a cacao industry as another means of augmenting agricultural development, and the coco-nut industry in particular.

It may be argued that the prices realized for cacao during the "depression" years were barely economic, and that cacao occupies a similar position to copra, so why not consider crops such as coffee or rubber, &c.? The depression period affected other crops in the same manner as cacao and coco-nuts, but so far as this country is concerned, it is known that cacao can be grown in many areas, and there is not the necessity for ample casual labour, specialized labour, and factory costs as in coffee, or the possibility of restriction plus overhead factory costs as in rubber. If New Guinea can produce a high-grade cacao at comparatively low cost the crop should be economical even under moderately adverse market conditions, and, as cacao is a permanent crop, it is essential that the future, and not the present, be considered.

It will be shown later in this paper that the planting material available is excellent and compares favorably with that of Ceylon and Java, whilst it is superior to that of Trinidad—three countries that produce the bulk of the world's high-grade cacao.

In the development of any new industry it is essential that every endeavour be made to profit by the experience of countries in which that industry has already been developed. In this connexion there is the precedent of peasant and estate cultivation in Trinidad, where an Empire Research Scheme is in operation, in Ceylon and Java, where experimental research has reached a high standard of efficiency, and, as a purely native industry, precedent has been established on the Gold Coast, where, in recent years, a great deal of primary investigational work has been carried out.

It will be seen that this country is in a most favorable position for the establishment of a cacao industry, and further, being under the control of the Commonwealth of Australia, it is more than probable that Australia would be

the initial market. The demand for raw cacao, as shown in Table No. 1, is increasing in the Commonwealth, the market is protected for New Guinea beans, and there is a bounty of £14 per long ton on all cacao imported into the Commonwealth from the Territory for home consumption up to the 31st December, 1947.

TABLE No. 1.(*)

Period.	Lb. Imported.
1930-31	7,068,214
1931-32	10,825,965
1932-33	13,927,713
1933-34	14,252,722
1934-35	13,105,012
1935-36	14,752,942
1936-37	14,496,214

Australia imports "fine" cacao from Ceylon, Java, Trinidad, and Samoa, and "ordinary" cacao from the Gold Coast,[26] the quantity of "fine" being comparatively high. The border line separating "choice" or "fine", and "ordinary" cacao, lies at about a tannin content of 6 per cent. Cacao containing less than 6 per cent. tannin in the unfermented state is "choice" or "fine", and that over 6 per cent. is "ordinary".[16]

Selection of the Land.

The selection of the correct type of land is essential for the best growth of the cacao tree, and, together with soil, aspect, and facilities for transport, should be carefully considered.

Shallow soil overlying hard rock or soap stone, heavy impervious clay or very light sandy soil, soils subject to water-logging, and hillsides that have been eroded, are to be avoided as being quite unsuitable for the profitable cultivation of cacao. The most suitable soil is one that is deep, friable, easily drained, and containing a large amount of organic matter. The nearer the soil approaches these characteristics, the better should be the growth of the cacao. Soils derived from pumice, and containing a fairly deep humic layer, such as are found in portions of the Gazelle peninsular, support quite good cacao growth, especially in the early stages. This type of soil, however, retains moisture very badly, and climatic variations have a more direct effect on the crop. Further, once cleared for cultivation the organic matter is depleted rather rapidly, and provision for continual addition is necessary.

The soil can, to some extent, be selected in practice by observing its mechanical nature, and, if the local flora is understood, then the nature of the vegetation helps. Samples of the soil submitted to a qualitative and quantitative mechanical and chemical analysis would be of general assistance in selection. It is, however, rightly pointed out by Hart[13] that land for cacao cultivation should not be selected on chemical analysis alone, as it is possible for soils to contain the essential substances in sufficient quantities required for growth, but such substances may occur in forms unavailable for absorption by the plant. For instance, many soils of volcanic origin contain iron in such a form that, although present in quantity, it is unavailable on account of its combination.

In writing further on soil analysis, Hart[13] quotes Johnston[14] as saying that "chemical analysis of a soil as ordinarily conducted, valuable though it is in some respects, is not of much service in indicating the actual fertilizing matters

at the moment available in the soil. The agencies at work, whereby the elements of fertility are rendered available for the plants' use, are so complicated and numerous that the best test of the soil's fertility is to carry out experiments with the plant itself".

That it is inadvisable for a planter to select an area of land, plant a small portion, and wait to observe the growth of the cacao, is realized. He can, however, note the flora, observe the growth in native gardens in the vicinity and on similar soils, and from such information, as well as local inquiries, plus the physical properties of the land, and, if possible, interpretation of an analysis by a competent authority, decide on its suitability for cultivation.

With regard to aspect, any site that is exposed to heavy prevailing wind, or constantly strong sea breezes, should be avoided unless there are facilities for planting efficient wind-breaks. The ideal spot is one that is sheltered and well protected from prevailing winds by hills and spurs.

The selection of land with easy access to a suitable harbour or anchorage is important, and care should be taken to see that loading facilities, if not available for the whole year, are at least suitable during the greater part of the year. If dried cacao requires to be lightered to the steamer or schooner, then any exposed portion of the sea may prove troublesome, in so far as the produce is liable to wetting. Furthermore, any large capital expenditure necessary for the construction of roads to the loading site or the main road decreases considerably, in the case of the individual planter, the sum available for development.

Felling and Clearing the Forest.

In certain parts of the world, felling and clearing is carried out under contract, or, as in Trinidad, the planter can receive some remuneration from his land by leasing that portion to be planted to individuals for the purpose of felling, and converting the large trees into charcoal.

In New Guinea, the general apathy of the natives makes them unreliable for contract clearing; there is no charcoal industry, and unless the planter can arrange to log or mill his timber he must carry out his own operations.

The writer is of the opinion that the best method of clearing is to concentrate on felling during the wet season, and, in the following dry season, clear the land and prepare for planting at the commencement of the next wet season. This system certainly delays planting to a slight extent, but experience on the volcanic type of soil at the Demonstration Plantation, Keravat, has proved that burning-off is expedited when the heavy timber is dry; also, the soil is improved by the addition of the material resultant from the soft wooded trees, leaves, &c., rotting during the months prior to burning. Furthermore, the short, dense growth of secondary bush which follows the initial felling can be brushed and allowed to rot into the ground whilst the heavy timber is being burnt. The rotting of this secondary material further increases the humus content, and improves the soil. The light-textured, open, volcanic soils in many parts of the Territory are prone to lose a great deal of their initial fertility when exposed for any length of time, and the more protection that can be afforded by the judicious use of softwoods, leaves, &c., the less likelihood of rapid deterioration through clearing.

In felling, the smaller trees, shrubs, vines, &c., are cut first of all, after which the large trees are dropped, lopped so that the foliage lies flat on the ground, and

if desired, whilst still green cut into convenient lengths for handling. Cutting up whilst still green has the advantage that the logs dry out much quicker, an important factor if burning-off closely follows felling.

The question as to whether the heavy timber should be burnt or merely rolled out of the way for lining is rather contentious. Burning kills the weeds, and clears the land of debris that provides shelter and breeding places for insect pests that could be injurious; it also assists greatly in preventing many tropical trees from sprouting from the stumps, reduces to a minimum fungal infection from rotting stumps, facilitates lining and planting the shade and ground cover, and assists in supervision. On the other hand, it is claimed that burning destroys a great deal of the fertility of the upper layers of the soil, the fertilizing effect of the timber is reduced, and on hillsides the loss of soil by erosion is increased.

It is considered that if the heavy timber is arranged in large heaps as far apart as is economical, then the disadvantage, such as loss of fertility in the upper part of the soil, would be reduced, and the effect on weeds, insect pests, and



Plate No. 1.



Plate No. 2.

sprouting of the stumps, would tend to outweigh the loss in fertilizer and erosion. In any case the adoption of some form of soil protection, such as the planting of cover or shade crops, should be practised as soon after clearing as possible, whether the land be burnt off or not, as the case may be.

The removal of stumps is most important, as they provide ideal hosts for fungal parasites such as *Rigidoporus microporus* and *Armillaria mellea*, which can later infect the cacao roots when they come into contact with infested stump roots. Furthermore, fungi of this type can move through the soil for some distance from the host, and so cause infection without actual contact with infected stump roots taking place.

Plate No. 1 shows the virgin forest in the background, heavy standing timber in the left foreground, and fallen bush in the centre foreground.

Plate No. 2 shows the land with only the heavy timber remaining on the ground, leaves, soft-wooded trees, &c., having rotted into the soil.

Plate No. 3 shows the land practically cleared—the few remaining stumps will be grubbed out before planting. It will be noted that a certain amount of rubbish covers the surface of the ground.

In Plate No. 4 the hillside shown in Plate No. 3 has been contour-lined and planted with sweet potatoes to prevent erosion and provide native food for the plantation labour.



Plate No. 3.

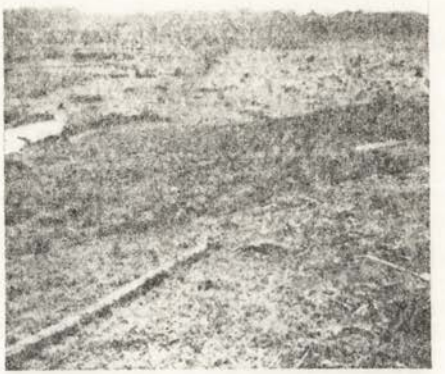


Plate No. 4.



Plate No. 5.



Plate No. 6.

In Plates Nos. 5 and 6 will be seen standing crops of maize and kaffir corn, respectively, planted for quick ground protection in addition to native food.

In some countries[12] it is customary to leave certain of the larger forest trees standing to provide shade for the young cacao. This practice is not to be recommended, because only special trees are suitable, and such shade is not regular. Further, in a climate such as New Guinea, where the rainfall is heavy, the question of shade density must be determined in individual localities, and it is

advisable to plant a cultivated tree that can be pruned, or removed if the occasion arises. Again, the forest trees in many cases having no tap root, tend to be blown down when the surrounding vegetation is cleared; their rooting system is already established, and the young cacao seedlings do not get an equal chance in the competition for soil nutrients.

To leave wind-breaks of natural forest through the cacao fields is not advisable, owing to the risk of the trees falling prematurely due to wind. There are, however, circumstances in which a belt of natural forest may be left along the boundary of the estate, or a beach frontage.

Drainage.

After the forest has been cleared, the contour of the land is more easily seen, and any necessary areas can be drained.

The height of the water table in the soil is important, and it is advisable to ascertain its depth before attempting to drain. This may be carried out in a practical manner during the wet season when the soil is carrying a maximum amount of moisture, by digging numerous holes. Then, when the drains are made they can be dug in such a manner as to maintain the water table at a depth of at least 3 feet.[12] The open type of drain is the most suitable, and care should be taken to see that the sides have a reasonably good batter, especially in soils derived from pumice. It is advisable to utilize natural streams and watercourses as main drains, and the size of the subsidiary drains will depend on the amount of water to be carried.

The idea held by many people that drains are unnecessary on hillsides, especially where the slope is fairly steep, is wrong. Drains must be dug to assist in preventing too rapid a run off following heavy rains. The menace of soil erosion cannot be too strongly stressed, and the extent of erosion is correlated with rainfall intensity and frequency—two factors ever present in this Territory. Therefore, land that is subject to erosion should be protected to the utmost, and in addition to providing vegetative means of soil protection, shallow contour drains should be dug to diminish the velocity of the surface water.

Preparation of the Land for Cultivation and General Layout of the Estate.

It is a recognized fact that tropical soils lose a great deal of their fertility after the forest has been cleared if the land is allowed to remain unprotected.

Reference to Plates Nos. 4, 5 and 6 will show recently cleared land planted with sweet potatoes, maize and kaffir corn, to provide soil protection until the temporary shade is fulfilling this duty. Pea-nuts and cow-pea are two very useful crops that may also be employed as soil protectors in the same manner as sweet potatoes or maize. They have one very great advantage over the other crops in that they are leguminous and improve the soil by their growth. In addition to the foregoing crops, cassava, taro, mammees and bananas may also be planted to provide protection and native food, but these species, together with sweet potatoes, remove a great deal of nutrient from the soil, and, in the case of cassava, difficulty in eradication after harvest is generally experienced.

Many authorities[12, 20] are of the opinion that cassava exhausts the soil, and there appears to be little doubt that this crop does draw to a large extent on the soil nutrients, but apart from its possible effect on the soil fertility, cassava as a

temporary shade has other disadvantages; supervision costs are increased and shade regulation difficult on account of the density of growth, and, once established, eradication is difficult and costly.

Sweet potatoes and mammees, providing the latter are not staked, are worth cultivating; a certain amount of tillage is required prior to planting, the soil is adequately protected, and future eradication is not so difficult. There would be a little extra maintenance necessary to keep either crop from smothering the temporary or permanent shade in its early growth.

There are two types of taro used in this Territory for native food purposes; native taro (*Colocasia* spp.), and Kong-kong taro (*Xanthosoma* spp.) The former may be used as a catch crop, but for weed and grass control it is of little value; the latter is a large stemmed, large leafed species that effectively controls grasses and weeds, but the disposal of the stem portion after harvest is rather difficult, and the crop is a heavy feeder. It is under trial at the Demonstration Plantation, Keravat, as a temporary shade/catch crop, but appears to have very limited possibilities in this direction.

Maize and kaffir corn are quick growing grain crops that are very useful as soil protectors in the early stages of development, and maize provides an excellent native food. The useful period of maize as a shade is three months, by which time the temporary leguminous shade should be established. Kaffir corn will last a great deal longer, at least nine to twelve months, but its dense growth necessitates periodical thinning in order to allow the temporary leguminous shade to come away. Where establishment of the cacao is required quickly, kaffir corn has possibilities as temporary shade instead of leguminous shade, as it becomes established very quickly, and, if need be, the cacao could be planted in the field approximately eight to ten weeks after planting the kaffir corn.

As a grain it is used in other tropical parts of the world, is easily harvested and the grain can be quickly threshed. Limited trials of kaffir corn as a food for native labourers have been made but the introduction of a new crop to the native diet is extremely difficult, and, until extensive trials have been conducted, the usefulness of this crop must remain one of providing quick temporary shade to expedite planting.

Mention is frequently made in standard text books regarding the usefulness of bananas for temporary shade, ground protection, and food. The banana is a heavy feeder, and this factor, plus the difficulty of thoroughly removing the corms when the permanent shade is established, and the constant thinning out that is needed, renders its use inadvisable.

For New Guinea conditions, it is considered that the data available regarding the use of a combined shade and catch crop are as yet insufficient; therefore, it is preferable to rely on the cultivation of known leguminous crops for temporary shade, and, where necessary, food crops may be planted in conjunction, providing, of course, the food plants do not interfere with the necessary care and attention to be given to the young cacao.

There are two types of leguminous crops which provide ground protection, namely—

(*a*) Creeping;
(*b*) Erect shrubby,

the latter type (*b*) being dual purpose in that they are also used as temporary shade.

The following species, of which some are already under cultivation in New Guinea, are described. It will be seen that certain types are not considered suitable, but have been included because they are commonly known, and inquiries relative to their use are often made.

(*a*) Creeping Covers.

Calopogonium mucunoides.—A quick-growing plant which can be easily propagated from seed or cuttings, is a strong grower, grows well on most soils, but requires fairly good drainage, and is intolerant of shade. On account of its rampancy under suitable conditions, constant attention would be necessary to prevent it from over-running the young cacao and shade. It has a decided tendency to die back during certain periods of the year, and in many parts of the Territory is attacked by a disease similar to Mozaic. *Calopogonium mucunoides* is not considered suitable for use in cacao cultivation.

Centrosema pubescens.—Another quick-growing plant that is easily established by seed or cuttings, has a fairly deep rooting system compared with others of the same type, is effective in controlling weeds, and can withstand long periods of dry weather. It prefers the better class soils, and like *Calopogonium mucunoides* requires careful and regular attention to prevent over-running. This rampancy of growth which necessitates frequent checking makes crop establishment costly, and for this reason *Centrosema pubescens* is not recommended.

Dolichos hosei.—Is a quick-growing plant, easily propagated by seed or cuttings, effective in checking erosion on hillsides,[12] is a good soil builder, and gives a quantity of leaf mulch. *Dolichos hosei* is not a rampant grower or climber, will effectively control grass and weed growth if planted on clean ground, and is not affected by shade. Is an excellent ground cover for cacao and recommended for use.

Desmodium scorpiurus.—This plant, which appears to be indigenous to New Guinea, is remarkably quick growing and easily propagated from cuttings. It grows well under even dense shade, does not climb, forms a very dense mat, and controls grasses and weeds. *Desmodium scorpiurus* has only recently been introduced into cultivation, and at the Demonstration Plantation, Keravat, is proving the best permanent ground cover for cacao.

Indigofera endecaphylla.—This plant can be propagated by seed or cuttings, grows quickly and forms a dense cover, does not climb very much, withstands fairly dry weather, and, although periodically attacked by caterpillars, it quickly recovers. It is inclined to be intolerant of shade, and requires some attention during its early stages of growth. *Indigofera* is quite a suitable cover for cacao, but not nearly as efficient as *Desmodium scorpiurus* or *Dolichos hosei.*

Mimosa invisa.—This quick growing, rampant, thorny plant is easily propagated from seed or cuttings. It is one of the finest soil renovators cultivated but should never be planted as a cover in cacao on account of its rampancy and thorniness. It is considered that *Mimosa invisa* has definite possibilities on open grass or kunai (*Imperata arundinacea*) land if allowed to grow unrestrained for two or three years, then cut and ploughed under prior to preparing the ground for cacao.

Peuraria javanica.—Another quick-growing rampant plant which may be established from seed or cuttings. It is a good soil improver, depositing an

enormous quantity of leaf mulch, but, like *Mimosa invisa,* should never be planted as a cover in cacao. *Pueraria* could be used with effect in open grass or kunai land by treating in the same manner as *Mimosa invisa.*

Vigna catiang.—This annual legume is remarkably quick growing, and, in six to eight weeks, forms an excellent cover for protecting the soil. Its usefulness, according to the variety, varies from three to nine months, and it is recommended for use where a quick cover is required immediately after clearing, or where humus deficiency is suspected. When approaching the maximum period of usefulness, cow-pea should be turned into the soil, and replaced by a permanent creeping cover.

(*b*) Erect Shrubby Covers.

Aeschynomene americana.—A quick-growing plant which is easily propagated from seed, grows to a height of 4 to 5 feet, and has spreading branches which commence at ground level. After growing approximately nine months, it seeds profusely and then dies, but quickly re-establishes itself from its own seed. *Aeschynomene* has been in cultivation at the Demonstration Plantation, Keravat, for the past three years, and indications favour its adoption under certain circumstances when a quick cover is required after clearing. The height to which it grows, and its tendency to die off, precludes its use as a temporary shade for cacao.

Crotalaria anagyroides.—This shrub is readily raised from seed, will last from eighteen months to two years, yields a large amount of green material which decomposes quickly, has a moderate rooting system, and will stand frequent prunings when young. *Crotalaria anagyroides* is very susceptible to pink disease (*Corticium salmonicolor*) especially on old wood during its mature stages of growth. It is attacked at all stages by species of hemiptera, and is easily blown down by a moderately strong wind. This species is recommended by authorities as a temporary shade for cacao, but the writer is of the opinion that, as a sole crop, its disadvantages outweigh its advantages, and that it should always be planted in conjunction with *Tephrosia candida* or *Leucaena glauca.*

Cajanus indicus.—This species is readily raised from seed, and will last about two years, the seeds provide an excellent food for human consumption, and the fallen leaves add a lot of humus to the soil. At the Demonstration Plantation, Keravat, where the rainfall ranges from 109 to 125 inches per year, it grows well during its early stages and up to flowering, after which, it becomes most susceptible to pink disease and thread blight (*Corticium* spp.), and the leaves and young pods are heavily infested with insect pests.

Leucaena glauca.—A description of this species will be found under the heading of permanent shade, as it is capable of fulfilling this duty in addition to its suitability for temporary shade or green manuring. As temporary shade, it should be planted at least six months before the cacao.

Tephrosia candida.—This shrubby plant is easily propagated from seed and attains a height of 6 to 8 feet in a comparatively short time. It retains its usefulness up to three years, yields a large amount of green material (Macmillan[19] quotes up to 58 tons per acre from four prunings), stands frequent lopping very well, and has the ability to grow on poor soils. It is subject to pink disease which attacks the older wood in the mature stages, and the seed pods are

attacked by caterpillars. *Tephrosia candida* has a deep and strong rooting system, will withstand heavy wind, and is considered by the writer to be the best dual purpose ground cover temporary shade that can be used for cacao in this country.

Tephrosia vogelii.—This species closely resembles *Tephrosia candida* but does not grow so high, nor is it so permanent, its economic life being about one year. *Tephrosia vogelii* yields a larger amount of green manure when young than *Tephrosia candida,* has large hairy seed pods, and is easily propagated from seed, but as a dual purpose plant, it has the disadvantage of being shortlived and extremely susceptible to pink disease.

In the following table No. 4[7, 20] analysis of the green material of many of the foregoing listed plants is shown:—

Species.	Moisture.	Org. Matter.	Ash.	Nitrate.	Lime.	Potash.	Phosphate Acid.
C. mucunoides [20]	74.7	22.5	2.8	1.1	.79	.46	.14
C. pubescens [20]	65.5	32.3	2.2	1.39	.60	.34	.08
D. hosei .. [20]	79.9	17.8	2.3	.71	.43	.39	.18
I. endecaphylla [20]	74.7	22.1	3.2	.78	.90	.41	.12
C. indicus [7]	54.5	..	1.86	.64	.34	.51	.25
C. anagyroides [20]	72.8	25.4	1.80	1.32	.53	.38	.10
T. candida [10]	64.4	33.8	1.8	1.72	.66	.49	.18
T. vogelii [7]	73.9	..	2.64	1.07	.70	.69	.19
L. glauca [7]	75.0	..	1.55	..	.42	.38	.07

In addition to the consideration of temporary shade which is essential for the growth of young cacao, and/or creeping cover crops, the utilization of permanent shade must also be given attention, and the question arises as to whether it is, or is not, required.

It has been stated[12, 24] that in some countries cacao can be successfully cultivated without shade, and Grenada is quoted as an instance. In view of the fact that climatic conditions in that country approximate those of New Guinea, it may be argued that an industry can be developed in the latter colony without resource to shade.

Investigations have shown that in Grenada it has been found necessary to use windbreaks, to fork and manure the soil frequently, and to have the land thoroughly drained.[25] Further, a great deal of the land in Grenada is hilly, and, during the day much of the land is shaded by the hills themselves. Therefore, the same degree of protection is not required as when level or slightly undulating land is cultivated. Frequent forking and manuring is expensive and costs of production are unnecessarily increased, so, why increase costs when the use of shade, especially leguminous trees, will enrich the soil with nitrogen by supplying humus, and, as one authority says, "Preserve the humus and texture of the soil by the shade they afford".[12]

In discussing shade, Hart[13] states that a densely shaded estate is more subject to the attack of fungus diseases, but points out that when the shade is insufficient insect attack is more liable to occur. Further, cacao comes into bearing quicker under shade and maintenance is cheaper as the weedy undergrowth associated with unshaded land does not appear.

Experience in New Guinea has shown that insect pests such as the grey weevils (*Platyacus ruralis* and *Coptorrhynchus spp.*), and a small chrysomelid beetle (*Rhyparida obscuripennis*), which are quite serious, are effectively controlled by shade.

The writer considers that arguments against shading are inconclusive, and, in a country like New Guinea, where a new industry is being established, it is advisable to adhere to the general practice in cacao cultivation. It is recorded[13] that in 1865 a paper on cacao cultivation was read before the Scientific Association of Trinidad by a Mr. Law, who was about to commence planting cacao on the island. Mr. Law believed that after the third year cacao did not require shade, and he planted according to this belief. He spent a lot of money on establishment and estimated that his 200 acre plantation would be worth about $47,705 at the end of seven years. His plantations failed and were sold, but, at present, are yielding good crops as they are owned by men who believed in, and planted shade. It must be realized, however, that the shade problem has yet to be investigated in New Guinea, and it is preferable to plant leguminous trees whose shade can be regulated, and, if necessary, removed or thinned out without damage to the cacao.

The type of tree favoured in the West Indies and certain central and South American countries, is the *Immortelle,* a large soft-wooded tree of the *Erythrina* species. In Nicaragua the main shade tree is *Gliricidia maculata,* a medium-sized, quick-growing tree that yields a large amount of green material and stands frequent lopping. In New Guinea where, as already mentioned, shade experimentation is essential, even in individual localities (rainfall, &c., is so variable), the *Immortelle* is too large and difficult to control, and *Gliricidia maculata* is so brittle, and appears to develop such a poor root system in light textured soils that a great deal of damage is caused by falling limbs, or trees falling over. It is possible, however, to overcome this weakness to a large extent by propagation from seed.

Inquiries are often received regarding the use of secondary bush as temporary shade, and large forest trees as permanent shade. There appears to be no reason for using secondary bush; even the advantage, if any, of a saving in original clearing expenses, is offset at a later stage when the secondary bush is cut out. Shade regulation is practically impossible; lining is more difficult; the trees are quick-growing softwoods that are easily blown over; they provide a harbouring place for insect pests; there is likelihood of damage to the young cacao when the trees are cut out; they are for the most part non-leguminous, hence, do not improve the soil; and are in constant competition with the young cacao for nutrient. The reasons why large forest trees should not be used for permanent shade have already been given under the heading of felling and clearing.

The following leguminous trees are considered worthy of attention for permanent shade purposes, especially *Leucaena glauca* which at the present time appears to have most of the necessary features.

Adenanthera pavonica.—This tree, commonly known as the "Bead Tree", grows quickly from seed, and is tall and slender with moderately feathery foliage. The growth of *Adenanthera* at the Demonstration Plantation, Keravat, is most promising, although it appears to require a well-drained soil, exhibits a certain susceptibility to pink disease, and occasionally is broken by wind.

Albizzia spp.—Included in this group are *A. moluccana, A. lebbek* and *A. sumatrana.* They are quick-growing trees with fine feathery foliage, and the timber from *A. moluccana* is soft and suitable for tea boxes, &c.[21] *A. sumatrana*

is periodically attacked at Keravat by a small caterpillar which absolutely defoliates the tree.

Erythrina lithosperma.—This medium-sized tree is easily propagated from cuttings 3 to 6 feet long, planted 18 inches deep. It grows quickly, and, if kept free of side branches, will form a head at about 25 feet, will stand lopping about thrice annually, yields a large amount of green material, and has an economic life of ten to fifteen years. *Erythrina lithosperma* is used extensively in Ceylon,[20] but has been replaced to a large extent by *Leucaena glauca* in Java[12] where it is subject to a number of pests and diseases, and the wood has no economic use.

Leucaena glauca.—A smaller tree than any listed above, flourishes from sea level to 4,000 feet, is easily esablished from seed, and during the wet season, may be propagated from cuttings. *Leucaena glauca* is the most popular shade tree in in Java for cacao, is an excellent soil preserver and improver, stands frequent pruning, and is generally not affected to any great extent by diseases or pests, although there are isolated instances in New Guinea of attack by root fungus (mostly traced to rotting stumps left after clearing), and infestation by mealy bug in one instance has proved serious. This possibility of mealy bug infestation of *Leucaena glauca* should not be overlooked, and the advisability at present of establishing a combination shade, rather than a sole shade, is worth consideration.

L. glauca has a feathery type of foliage, the leaves and young branches are readily eaten by cattle, it provides a light filtered shade, the wood makes good fuel, and the seeds, when boiled and crushed, are excellent cattle food. This species may also be used as a temporary shade or green manure, and is useful as a contour hedge on hillsides.

The following interesting comparison between the leaves of *Leucaena glauca* and goat droppings, after conversion into dry matter, is taken from De Sornay's figures,[7] and serves to illustrate the manurial value of *L. glauca*:—

	In 100 parts of goat manure.	In 100 parts of *L. glauca* leaves.
Ash	25.00	9.26
Nitrogen	2.48	2.52
Phosphoric acid ..	1.00	.45
Potash	2.32	2.38

Peltophorum inerme.—This quick-growing, moderately-sized tree, which reaches a height of 25-30 feet in five to six years, is easily propagated from seed, and has a symmetrical top and five bipinnate leaves. *P. inerme* is worthy of consideration as a permanent shade or windbreak, and is under experimentation at the Demonstration Plantation, Keravat, where indications are favorable as a shade, although a certain amount of annual pruning will be required.

The following Table No. 5 shows the analysis of the green material from *Erythrina lithosperma*, *Leucaena glauca*, and *Albizzia lebbek*:—[7]

TABLE No. 5.[7]

Species.	Moisture %.	Org. matter.	Ash.	Nitrogen.	Lime.	Potash.	Phosp. acid.
E. lithosperma (leaves and tender stems)	69.8	28.4	1.8	1.09	.58	.34	.14
L. glauca (leaves and stems) ..	75.00	23.45	1.55	.85	.42	.39	.07
A. lebbek (leaves only)	67.35	30.04	2.61	1.19	..	.98	.18

The method of laying out the plantation will depend on whether the planter desires to—

(*a*) Establish the cacao by utilizing portion of the land between the rows for the production of native food for his labour;

(*b*) Establish the cacao by using another permanent quick-maturing crop such as coffee.

(*c*) Establish the cacao by the use of leguminous creeping and erect shrubby plants:

(*d*) Establish the cacao as an interplanted crop with coco-nuts.

The following systems covering the headings (*a*), (*b*) and (*c*) are suggested for consideration and outlined below; establishment as an interplanted crop with coco-nuts will be discussed separately. As planting distances and systems of lining will be considered later, it is proposed to adopt 15 feet by 15 feet as an arbitrary measurement for the purpose of illustration.

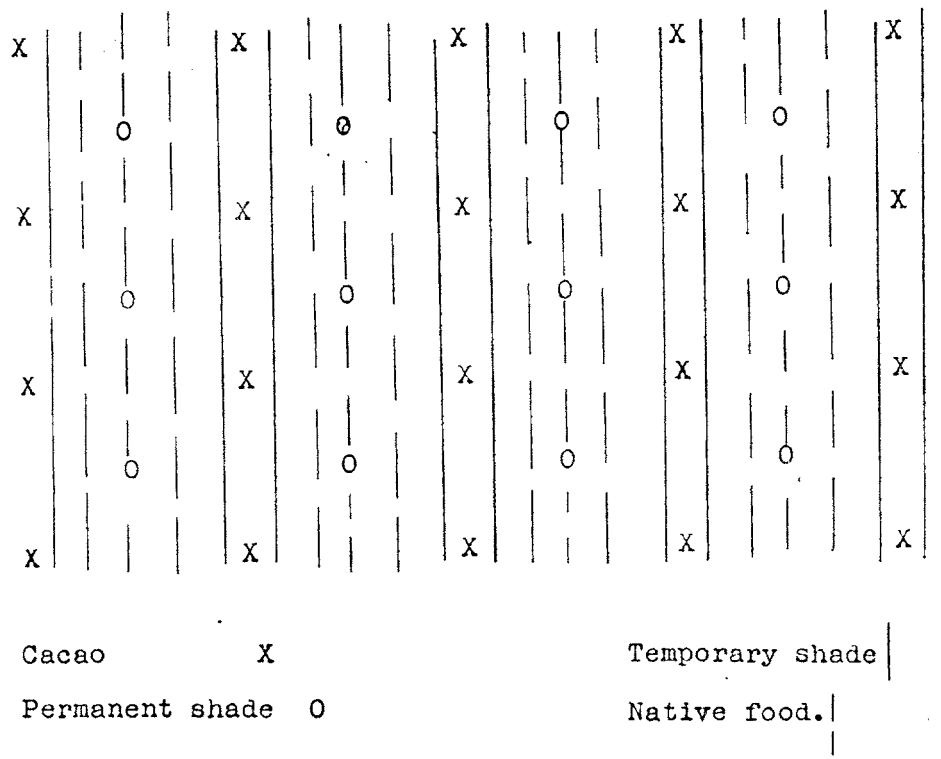


Figure No. 1—Method A.

The cacao is spaced 15 feet by 15 feet, with a row of temporary shade comprising *Crotalaria anagyroides* plus *Tephrosia candida* or *Leucaena glauca*; *Tephrosia candida*, or *Leucaena glauca*, 3 feet distance on each side and planted in the form of a hedge. The permanent shade of *Leucaena glauca, Erythrina lithosperma* or *Peltophorum inerme* is planted between the rows of cacao at a distance of 15 feet in the following manner: *Leucaena glauca* and *Erythrina lithorsperma*, or *Leucaena glauca* and *Peltophorum inerme*, or *Erythrina*

lithosperma and *Peltophorum inerme* in alternate rows. The reason for the alternate planting is that, as the shade density and suitability of species must be determined experimentally on each estate, the three shade trees can be regulated with little difficulty, and, if it proves necessary to thin out or discard one species, then the distance apart of the remaining trees will be reduced to a minimum of 30 feet. Should this distance be too close, then facilities are available for thinning out to 45 feet or even more. It must be remembered that the permanent shade is very dense, and therefore will require constant pruning and lopping until the most suitable shade is evolved.

Although three species of shade trees are mentioned and alternate planting suggested, the planter is not bound to adhere strictly to any of the given methods of layout. The writer has closely studied the merits of *Leucaena glauca* and considers this tree to be eminently suitable for cacao, but it must be remembered that probably *L. glauca* may prove difficult to establish in certain areas and under certain conditions, and a combination including another species minimizes the effect on the cacao by irregularity in shade.

The native food can be planted in rows, in the space intervening between the temporary shade.

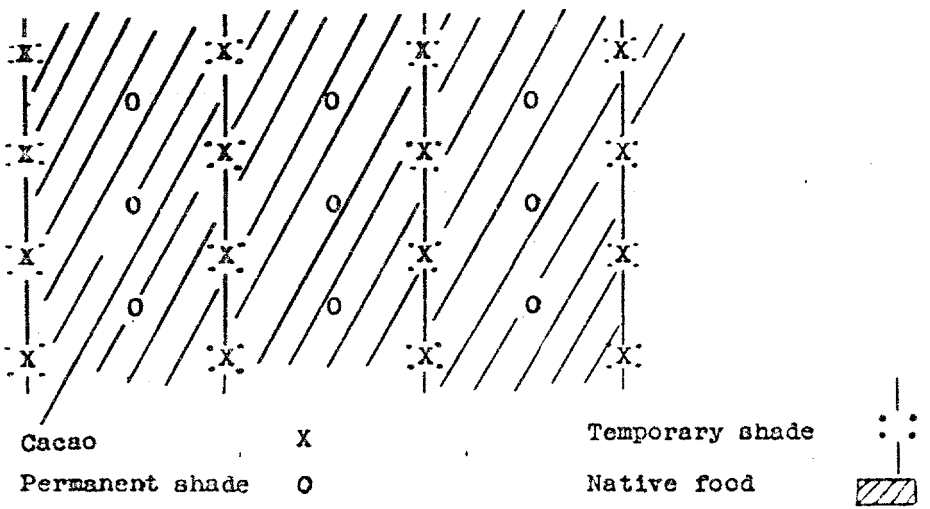


Figure No. 2—Method A.

The cacao and permanent shade are planted in a similar manner to Fig. No. 1. The temporary shade follows the lines of cacao in the form of a hedge, and should the shade be considered insufficient, then a few seeds are sown in a circle of 2-3 feet radius around each cacao seedling. This method allows for quick planting after clearing, as the temporary shade circle around the young cacao can be kaffir corn instead of the customary leguminous shade.

The intervening area between the rows may be planted with native foods, upland rice or maize. If rice be planted it should be sown in rows approximately

1 foot apart with the plants 9 inches to 12 inches apart in the rows. Where maize is planted it should be sown in rows 2 feet to 2 ft. 6 in. apart, with the plants about the same distance apart in the rows.

When using native taro (*Colocasia* spp.), it is advisable to plant in rows 2 feet apart with the plants 2 feet apart in the rows, so that sufficient shade is forthcoming to protect the soil, and at the same time control grass and weed growth.

For maximum yields of tubers, well-grown, healthy suckers should be planted in holes approximately 9 inches deep, and only about one-third of the hole filled with soil after insertion of the tuber.

It might be mentioned that the sowing of temporary shade around the cacao seedlings will depend upon the variety of native food cultivated.

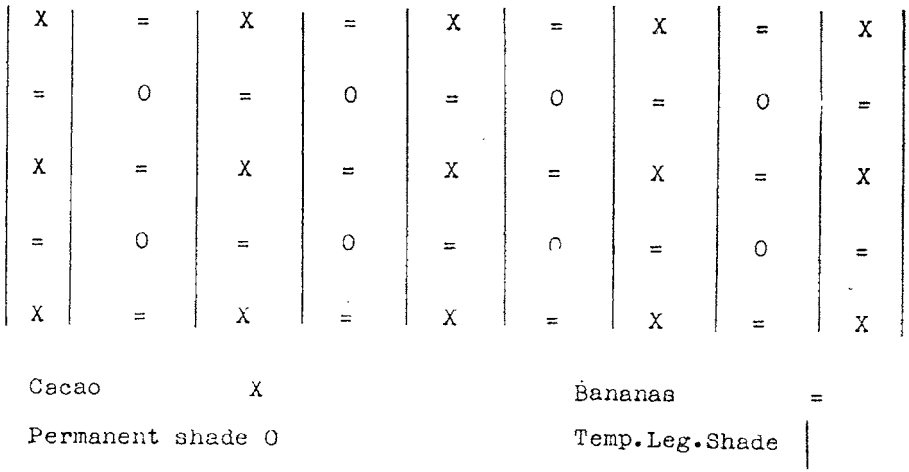


Figure No. 3—Method A.

The cacao and permanent shade are planted in the same manner as in the previous illustrations. Bananas are spaced 15 feet by 15 feet, following the rows of cacao and permanent shade. The reason for including the temporary leguminous shade in this system is to maintain the humus content by green manuring, and as a ground cover until the bananas are fulfilling their duty. Once the duty of the legume has been performed it can be heavily pruned and cut out.

Although this system is included as a possible method of cacao establishment, the suitability of bananas is a most vexed question. A great deal of after-cultivation is essential to keep the stools reduced, and much labour is required for cutting them out after they have fulfilled their purpose. The banana is a heavy soil feeder, and there is ever present the danger of damage to the young cacao from petty larceny of ripe bananas by native labourers, who, following the native custom, cut down the whole plant without thought to where it may fall.

The coffee is planted 15 feet by 15 feet, following the rows of cacao and permanent shade, which is sown in the same manner as outlined in the previous schemes. The temporary leguminous shade is planted the same as in Fig. No. 3, and should be thinned once the coffee has grown to a height of about 2 feet. It is considered inadvisable to cultivate native foods in this system, as it is doubtful whether field foods would provide sufficient humic matter if the leguminous temporary shade were eliminated. However, should the necessity to cultivate native foods be urgent, it is possible that Fig. No. 2 could be modified to suit the requirements, by the addition of another line of temporary shade following the coffee and permanent shade row, thereby enabling the substitution of a suitable food crop for the temporary shade as shown in this illustration.

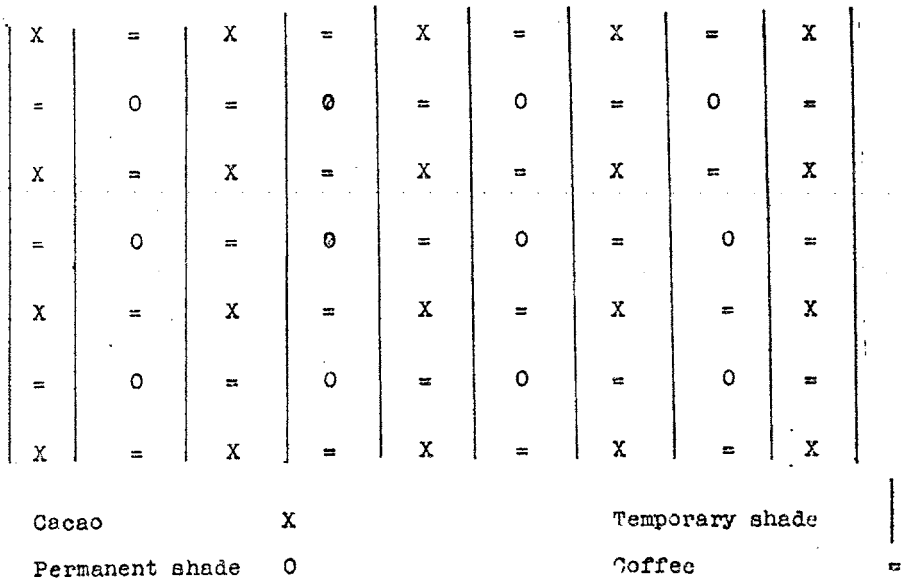


Figure No. 4—Method B.

Should it be assumed that the cacao is yielding an economic return after a period of seven years, then, as the coffee will come into bearing in the third year, the planter should be assured of some return for his investment commencing from the third year. Further, the coffee can be manured for increased yields, and the young cacao would benefit.

There are two important factors to consider when establishing under this system, and they are—

(1) The planter must be prepared to cut out the coffee once the cacao has reached an economic bearing age.

(2) The likelihood of ingress of root fungi if the coffee stumps and roots are not properly removed.

To procrastinate year after year, once the cacao has reached the economic stage, means that both crops will suffer if the coffee is not removed, and, as the coffee

was planted primarily as a catch crop, it should be eliminated once this purpose has been fulfilled unless the cacao does not thrive at all, in which case the coffee might be left and the cacao removed.

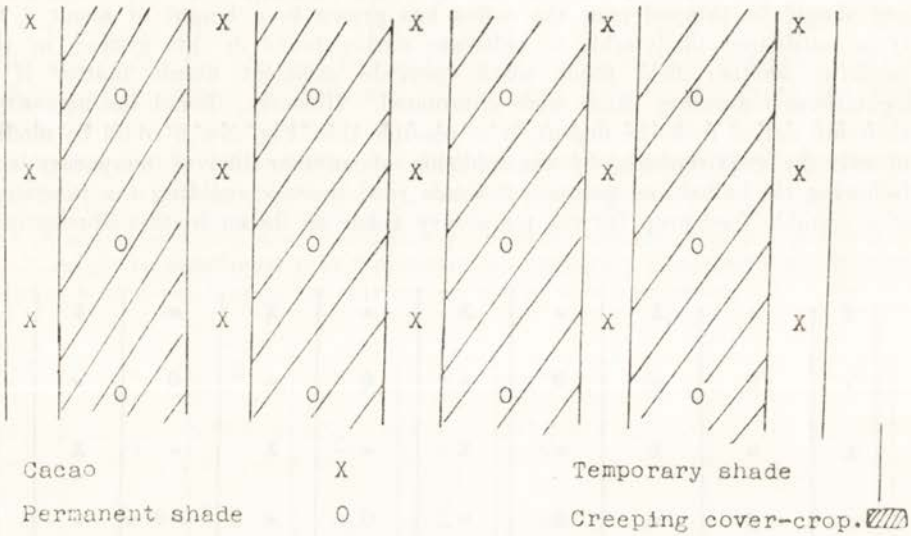


Figure No. 5—Method C.

This scheme is the same as that outlined in Fig. No. 2, so far as the planting of the cacao and permanent shade is concerned, but a creeping leguminous cover crop has been substituted for the native food. In this system cowpea could be planted immediately after clearing and later turned under as green manure and replaced with *Desmodium scorpiurus* or *Dolichos hosei*.



Plate No. 7.



Plate No. 8.

Plate No. 7.—Illustrates land cleared and lined for cacao.

Plate No. 8.—Illustrates the area shown in Plate No. 7 with *L. glauca* on the right, and *T. candida* on the left.

Cacao as an Interplanted Crop with Coco-nuts.

The practice of interplanting coco-nuts with cacao is receiving a great deal of attention in New Guinea at the present time.

The system adopted is to plant the cacao in the intervening spaces between the coco-nuts, that is, in the same line as the coco-nuts and between the line of coco-nuts. The palms are interplanted at all ages from eighteen months to two years up to 30 or 40 years old.

Theoretically, interplanting is not advisable because the soil nutrients are doubly taxed to provide for the growth and production of two permanent crops, but, from the practical aspect, there are certain factors which may justify interplanting. It is argued by many that interplanting is necessary on estates where there are uneconomic sections unless copra is a relatively high price, or where the ground flora is dense Kunai (*Imperata arundinacea*), or where the estate is small, profits are small, and no further land is available for alienation. Other factors, such as the need for the diversification of crops, and the interplanting of sections of a young estate as a catch crop, may also be included.

The interplanting of uneconomic coco-nut areas raises the question as to whether such areas can be interplanted with cacao, so that the yield of copra plus the yield of cacao, in relation to the costs of production and marketing, will convert an uneconomic area into one that is economic. Careful consideration must be given to any proposal to interplant uneconomic coco-nut areas. Land that is obviously unsuited for coco-nuts, that is, heavy impervious soil, water-logged soil, eroded hillsides, &c., is equally unsuitable for cacao, and should never have been planted with coco-nuts in the first instance. On the other hand, where the decline in coco-nut production may be due to the age of the palms, or repeated insect attacks, or too wide spacing in relation to the fertility of the soil, interplanting would probably provide the difference between profit and loss. The income derived from such an area, over and above the cost of maintenance and interest, could be used to improve the rest of the estate by cultivation and manuring, or for future expansion.

The question as to whether coco-nuts should be interplanted because the ground flora is dense Kunai, opens an avenue for a great deal of discussion. Kunai, which is considered one of the worst plantation pests in the Eastern tropics, has a detrimental effect on all permanent crops, and, in this Territory, it is most noticeable on coco-nuts. The elimination, or even partial control of Kunai would materially benefit the coco-nuts, and its replacement by cacao would mean the substitution of an economic crop capable of producing revenue, and improvement in the physical condition of the soil by the cultivation required to establish the cacao.

The ultimate effect on the soil fertility of two permanent crops, growing in combination on land which for years has supported a dense growth of Kunai, cannot be accurately gauged without the aid of experimental research, and any statement in regard to soil effect must, at the present juncture, remain one of conjecture based purely on observations. From observations made by the writer in various parts of the Territory, where coco-nuts have been interplanted with cacao for periods ranging from two years up to twenty-three years, it is believed that economic returns are possible for a limited period only, and such returns depend on the existing age of the coco-nuts at the time of interplanting, the locality, and the soil origin.

The eradication or control of Kunai can be successfully accomplished by the use of erect, shrubby plants, or creeping cover plants, and species belonging to the order *Leguminosae* improve the fertility of the soil. Where the locality and physical condition of the soil is suitable for cacao, the problem facing the planter whose estate supports a dense growth of Kunai, is whether to control the Kunai by interplanting with cacao, the future effect of which cannot be gauged, or control the Kunai by leguminous plants which are known to benefit the soil.

In instances where the estate is small and yielding a small profit, and no more land is available for alienation, interplanting is wholly justified and a system of sectional interplanting is worthy of consideration.

During the years of depression planters throughout New Guinea suffered considerably from the low prices, and, although other crops such as cacao, coffee, rubber, &c., were equally low in market price, nevertheless, a narrow margin of economic safety was established on those few plantations where there was a small cacao crop in addition to copra. Where cacao is interplanted, and the necessity for weed and grass control considerably reduced, labour units previously employed in grass cutting gangs become available for the cacao, and no marked increase in the normal plantation strength is needed, hence the revenue derived from the cacao is nearly all profit.

For centuries primitive races have followed a system of crop diversification in their food gardens, with the object of minimizing losses due to adverse seasons. In civilized countries where monetary returns are of primary importance, systems combining agricultural crops only, or agriculture and stock-raising are in vogue. Thus, in temperate climates will be seen orcharding and market gardening, or wheat and sheep. In instances where diversification is pastoral the object is the same, namely, to provide some source of revenue should the main crop fail.

In tropical countries, a system of crop diversification is an essential feature of any agricultural policy, and the inauguration of some system in New Guinea is of primary importance to provide some measure of safety should another economic depression occur, or some factor arise which is likely to jeopardize the coco-nut industry. The suggestion is made that consideration be given to the establishment of other crops in conjunction with coconuts, and should economic or other reasons preclude the establishment of a small sole area within the estate, then interplanting would be justified.

In many countries, long-term permanent crops are established and brought into bearing by means of a quick growing catch crop. Thus in Java, coffee is used as a catch crop in rubber. Coco-nuts generally take about ten years to reach the stage where they produce an economic return, and, as cacao commences bearing in the third to fourth year and should be yielding a good return towards the end of the fifth year, it is worth considering as a catch crop to be cut out when the coco-nuts are in full bearing.

There are two factors associated with cacao as a catch crop which require attention. First, proper provision must be made for permanent top shade when the temporary shade has fulfilled its duty after eighteen months to two years, and secondly, the shade needed for the cacao tends to cause "legginess" in the coco-nuts. The writer interplanted twelve to eighteen months old coco-nuts in a manner similar to that usually adopted on estates, that is, adequate provision was made for temporary shade, but no shade of a permanent nature was planted. At the present time the coco-nuts are three and a half to four years old and the cacao two and a

half years old; the coco-nuts show a marked tendency to "legginess", and, although the cacao made excellent growth during the first two years, it is now in the generally poor condition as shown by Table No. 6.

TABLE No. 6.

Original Number Seedlings.	Dead.	Healthy and Bearing.	Unhealthy and Bearing.	Healthy non-Bearing.	Severe Die-back.	Slight Die-back.
210	16	6	10	14	120	44

The "legginess" in the coco-nuts may be attributed to the shade being planted in full rows close to the coco-nuts, hence normal trimming did not prevent over-shadowing, and the poor condition of the cacao is entirely due to the lack of sufficient top shade when the trees became fairly large and the temporary shade commenced to die through age.

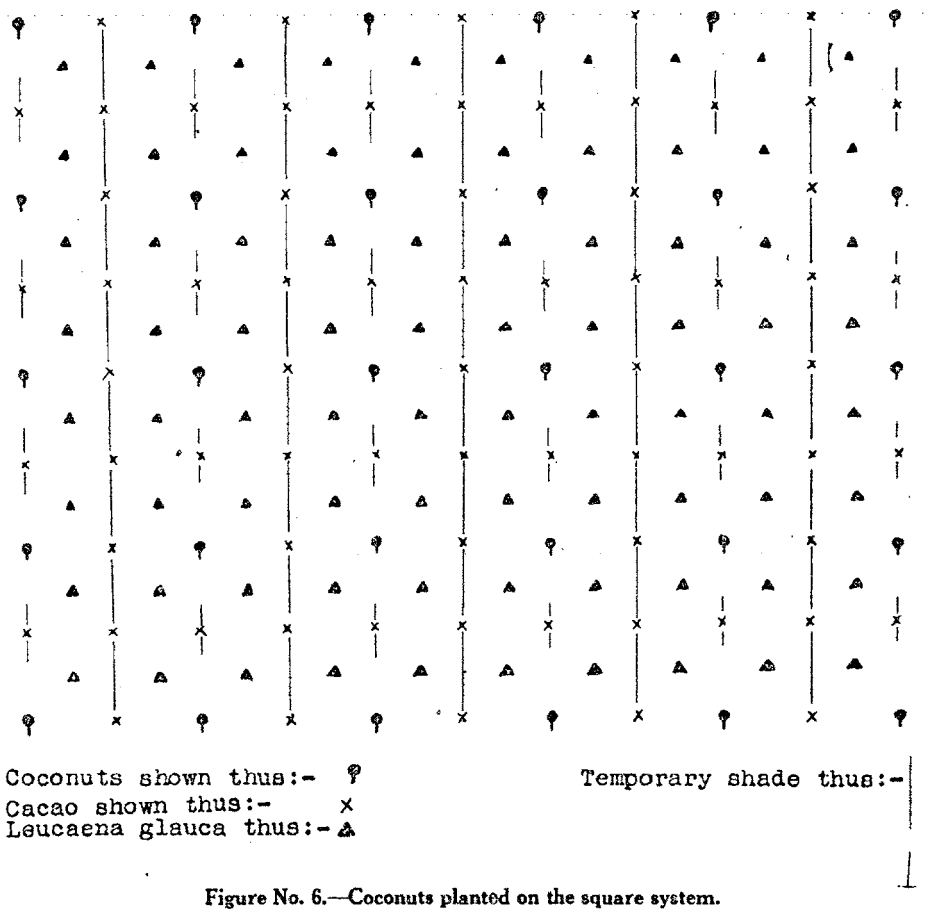


Figure No. 6.—Coconuts planted on the square system.

Should interplanting be necessary for some of the reasons outlined, then it is suggested that a lay-out as shown in these diagrams is worthy of adoption.

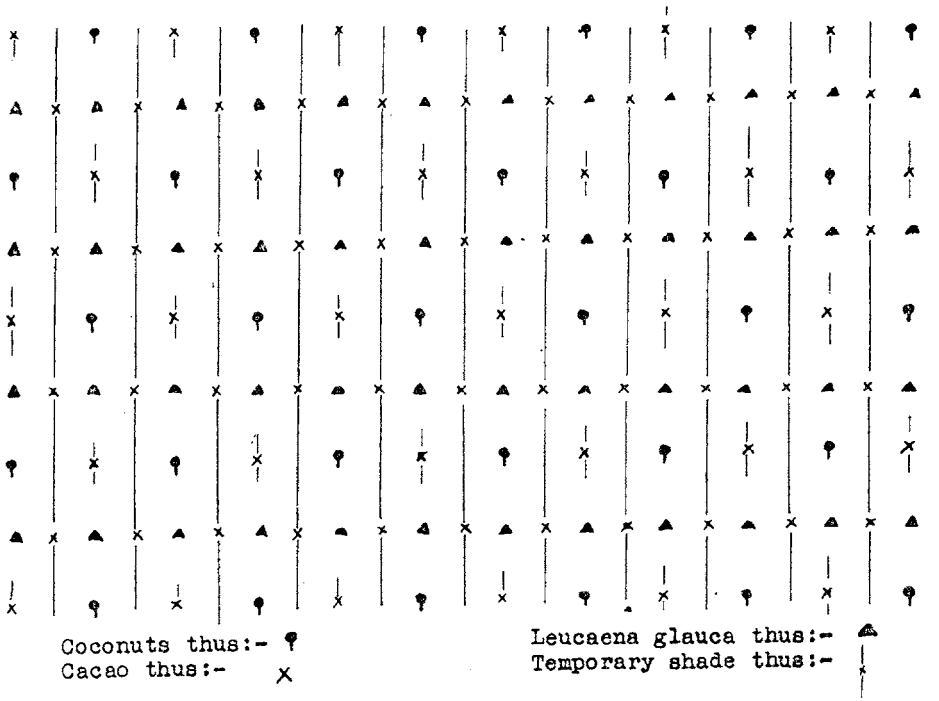


Figure No. 7.—Coconuts planted on the equilateral triangle system.

The foregoing lay-outs are adapted for permanently interplanting large palms. The permanent shade of *Leucaena glauca* is heavy, but this is intentional, as the planter will have to regulate the shade to suit local conditions of soil, climate, and coco-nut growth, and it is preferable and easier to reduce shade than it is to increase it, if insufficient. Fig. No. 6 (square system) allows for alternate shade trees in alternate rows to be cut out, and Fig. No. 7 (equilateral triangle system) allows for alternate trees only to be cut out. When interplanting as a catch crop in young coco-nuts, the permanent shade should be reduced to about 50 per cent. of what is shown for the old palms.

Tephrosia candida, or a 60/40 mixture of *Tephrosia candida* and *Crotalaria anagyroides* is recommended as temporary shade.

Systems of Lining.

The usual system of lining is that known as the "square", although another system known as the "equilateral triangle" has a great deal to recommend it, and it is considered that this system is superior to the "square" system.

It is often stated that the "square" is used because it is easy to lay out, but the writer opines that the "equilateral triangle" is just as easy, besides having the advantage of allowing more trees per acre (approximately 15 per cent.), and, as each tree is surrounded by six others equidistant from it, the tendency is towards greater uniformity in shape.

Should a prismatic compass or some other instrument suitable for the purpose be unavailable, when it is necessary to lay out a right angle in the field, then the simple 3, 4, 5 formula can be used in the following manner, using Figure No. 8 as an illustration.

Suppose the line A B is the base line from which at a point C it is desired to run another line C D at right angles. Mark along A B from C towards B a point Y four yards from C, then along the proposed C D line a point X three yards from C. The line X Y should measure exactly five yards if the angle at C is to be a right angle. If not, then move the point X until X and Y are five yards apart and X and C still three yards apart. Thus if X C is three yards long, C Y four yards long, and X Y five yards long the angle at C is a right angle and a line produced through X from C is at right angles to A B.

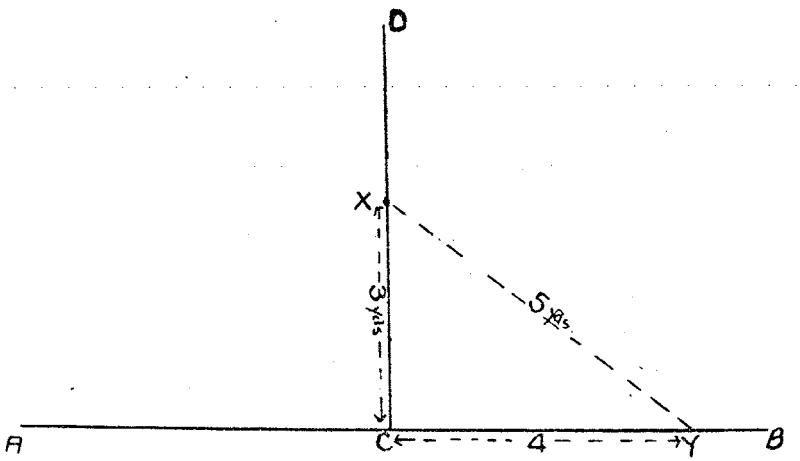


Figure No. 8.

Lay-out for "Square" System.

Take a piece of land A B C D as shown in Fig. No. 8A. Mark off a suitable base line E F and at a point G a line G H is offset at right angles. Should no instruments be available then the 3, 4, 5 formula just described can be used for setting out the right angle.

The line G F is now marked according to the distance apart required and stakes inserted at the points a, b, c, d, e, &c.; the line G H is then marked in a corresponding manner and stakes inserted at the points 1, 2, 3, 4, 5, &c.

Another right angle is now laid off at the point a on the line G F and the line a K is marked in the same manner as G H, stakes being inserted at the points b, c, d, e, &c. There are now two parallel lines at right angles to G F, and lining is continued by sighting through the two stakes 1, and b, and marking the line 1, b, c, d, &c., then through 2, and c; 3, and d; and so on until complete.

Once two or three lines have been completed, if so desired, lining can be carried out either horizontally or vertically to the base line. Lining is expedited by stretching along the line a wire or tape marked at the requisite distances (rope

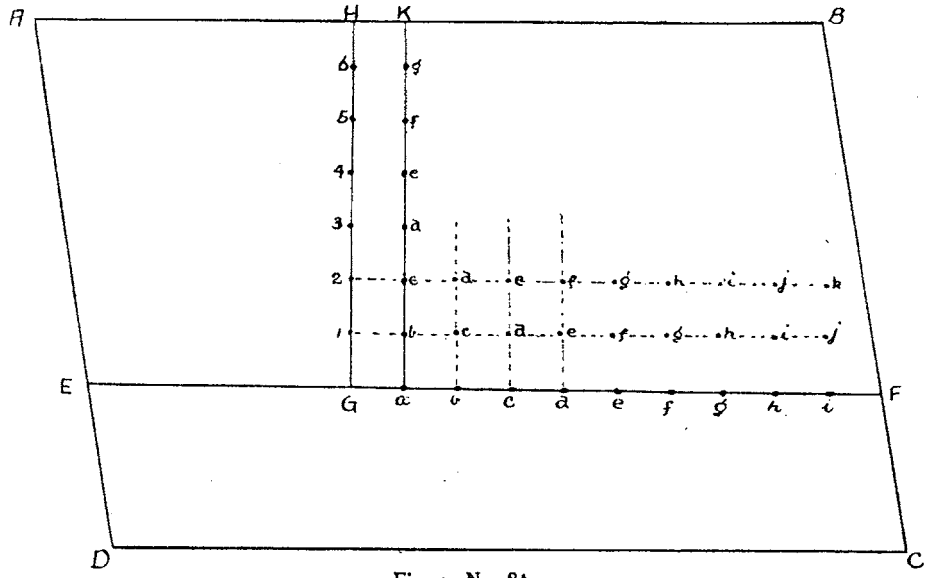


Figure No. 8A.

should be avoided for this purpose as it tends to stretch too much). At least three labourers are necessary, one at each extremity of the wire or tape, and one to place the stakes in position.

Lay-out for "Equilateral Triangle" System.

Take a piece of land A B C D as shown in Figure No. 9.

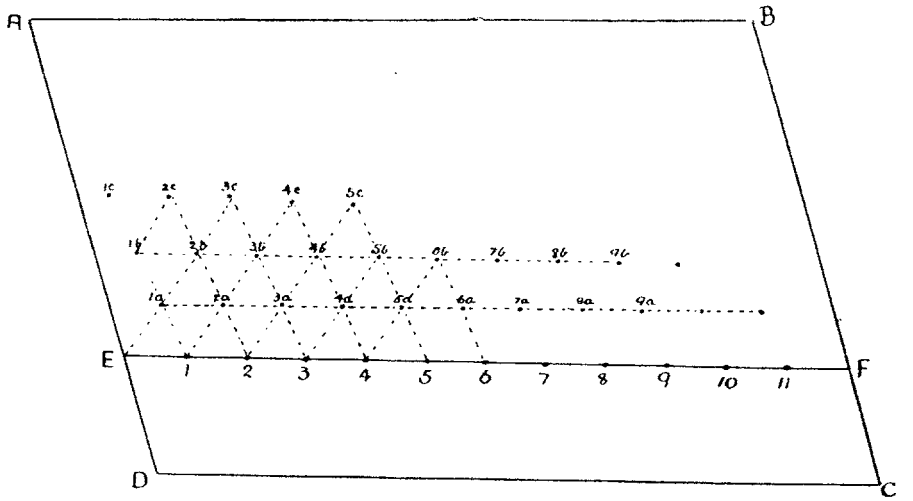


Figure No. 9.

Mark a suitable base line E F and insert stakes along it at the distance apart it is required to plant, moving from E through 1, 2, 3, 4, 5, &c.

Take a piece of flexible wire, attach a ring to each end and one ring in the centre so that the overall length of the wire is double the planting distance. For example, if the planting distance is 15 feet the length of the wire from outside ring to outside ring is 30 feet, as shown in Figure No. 10.

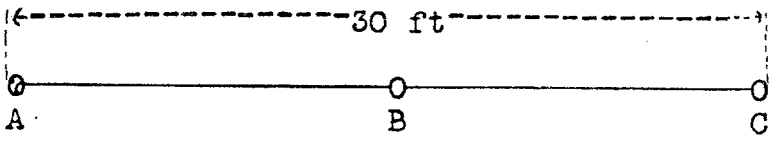


Figure No. 10.

Place the end ring A at E, and the other ring C at 1, tighten the wire by grasping the centre ring B and insert stake through the ring at 1a (Fig. No. 9), then move along E F, placing ring A at 1, and ring C at 2, tighten the wire and insert stake at 2a, and continue until the base line E F has been traversed and the line 1a, 2a, 3a, 4a, &c., marked. The line 1b, 2b, 3b, &c., is lined in a similar manner except that the first stake inserted is at 2b, and the position of 1b is found by keeping ring A at 1a, and moving ring C to 2b. Lining of the area can proceed as requisite and it is not necessary to return to the E end of the land each time, but work backwards from the last two stakes on the line just completed.

When the area enclosed by the lines A B E F is finished the same line E F is used for marking the area enclosed by E F D C.

It should be noted that a fixed bamboo or light wooden triangle with each side equal to the desired planting distance, may be used instead of the single wire as described and illustrated.

To ascertain the number of stakes required, or the number of seedlings per acre, the following formulae may be used:—

N = number of stakes or seedlings.

"Square system"

$$N = \frac{43560}{\text{square of planting distance (in feet)}}$$

e.g. planting distance is 15 ft. x 15 ft.

$$\therefore N = \frac{43560}{15 \times 15} = 193$$

"Equilateral Triangle system"

$$N = \frac{43560}{\text{square of side of triangle (in feet)}} \times 1.155$$

e.g. planting distance is 15 feet.

$$\therefore N = \frac{43560}{15 \times 15} \times 1.155 = 222$$

Variety to Plant.

It is obvious that the variety to plant will be that species which produces the best quality and at the same time yields a sufficient quantity for economic cultivation. The type to be preferred from the aspect of quality is Criollo, but this "fine" variety requires a particular soil and climate, careful cultivation, is susceptible to disease, and, unless conditions are ideal, does not yield heavily. Theoretically then, the species to be cultivated in New Guinea should genetically contain, as closely as possible, the attributes of Criollo, but without that specialization in respect to soil and climate, susceptibility to disease, and propensity towards low yield.

Practically, however, from the view point of economic production, it must be remembered that English and Continental manufacturers of cacao products have, in recent years, developed the technique of manufacture to such a degree that a high class article can now be evolved from "ordinary" cacao. Further, the recent world-wide economic depression materially affected the purchasing power of the general public, with the result that, as the demand for high grade, high-priced chocolate decreased, there was a corresponding increase in the demand for the medium and lower-priced articles.

Australia, which presumably will be the market, at present imports annually a large quantity of "ordinary" and "fine" cacao. The former from West Africa, and the latter from the West Indies, Java and Ceylon. It has already been mentioned that manufacturing technique has reached a high degree in recent years and it is quite within the bounds of possibility that, in the near future, less "fine" cacao will be required. To guard against this contingency it will be necessary to cultivate that species producing a cacao superior to "ordinary" cacao, and having a yield sufficiently high to successfully compete with the "ordinary" type from the aspect of cost of production in relationship to market price.

The small area of New Guinea cacao at present under cultivation belongs to the Trinitario group, which, according to Cheesman,[5] "consists entirely of hybrid forms, from which any type can be selected from something near Criollo to something almost pure *Th.leiocarpa*".

In discussing the complexity of constitution of the Trinitario group, Cheesman[5] cites Van Buren,[3] who described and classified a progeny of 609 trees from a single parent tree which was described as a "*Forastero Cundeamor*", a heavy yielder containing white as well as purple seeds in the pods. Van Buren's classification was as follows:—

Angoletas	194
Cundeamor	357
Amelonado	58
	609

The cacaos of Eastern Venezuela, Trinidad, Grenada, Costa Rica, Ceylon and Java belong to the Trinitario group, which constitutes about twenty per cent. of the world's output.[5]

The Venezuelan Trinitario consists of the finest Angoleta and Cundeamor types through to Amelonado and Calabacillo[12], and the same applies to the Trinidad Trinitario.[5] In Java, the Djati Roenggo hybrids, which form the bulk of the cultivation, are the result of crossing a single cundeamor plant, introduced from Venezuela in 1888 with the local Criollo. The entrance of what is known as Java Criollo is unrecorded, but it is supposed to have travelled from Ceylon, where it was introduced via Trinidad about 1934, and became known as the "Old Red" variety.

The history of New Guinea cacao tends to show that it came from Ceylon and Java by way of Samoa. Van Hall[12] states that Criollo cacao was introduced into Samoa from Ceylon and Java in 1883, and later, in 1889, Forastero hybrids were imported from Ceylon. After the annexation of New Guinea by Germany in 1884, large numbers of natives were sent to Western Samoa as plantation labourers, with the result that by 1900 shipping communications between the two colonies had become well established. The largest company operating in New Guinea during this period had its head-quarters in Samoa, and was establishing cacao estates in the latter country. Therefore, there is every likelihood that the operations of this company were responsible for the introduction of cacao into New Guinea, and that the planting material was brought by the transport required for the recruitment and repatriation of the labourers. Furthermore, the first recorded cacao exports of any importance from both Samoa and New Guinea occurred in the year 1905. From the foregoing paragraphs it will be seen that the cacao in New Guinea is linked through Samoa with Java, Ceylon, Trinidad and Venezuela. This correlation being further substantiated by certain Australian manufacturers who state that the New Guinea beans are similar to the beans of the West Indies, Java and Ceylon.

From the writer's experience of cacao, he opines that the material available in this Territory is superior to that of Trinidad, and at least equal to that of Java. Further, there are a small number of pure Criollo trees in the Botanic Gardens, Rabaul, that are available for breeding purposes.

Bearing in mind the varietal complexity of the Trinitario group, *it is essential that before establishing a large-scale industry in New Guinea, a thorough investigation be made of all the available planting material,* and mother trees for seed supply should be selected throughout the Territory wherever cacao is under cultivation. Excellent primary material is available in New Guinea, and the importance of seed selection, together with a policy of breeding and future improvement cannot be too strongly stressed.

Distance to Plant.

The spacing of cacao differs in various countries, and depends mainly upon local soil conditions, shade used, type cultivated, and climatic conditions which govern the size and growth of the tree. Where the soil is fertile, the spacing should be wider than on poor soil in order to allow for the expansion of the tree, and, if no shade is used, then the distance should be close. For example, in Grenada, where shade has not been planted, the cacao distance is 9 feet by 9 feet.

Experiments carried out at River Estate, Trinidad, with trees planted 6 feet by 6 feet, 8 feet by 8 feet, 10 feet by 10 feet, 12 feet by 12 feet, 14 feet by 14 feet, 16 feet by 16 feet, 18 feet by 18 feet, show that the trees planted at the

closed distance of 12 feet by 12 feet gave the highest yield from the fourth to the tenth year, but from the eleventh year onwards, the trees at 14 feet by 14 feet surpassed the yield of those at the closer planting, with the result that the total production at the end of eleven years was identically the same.[12] In 1934 those planted 16 feet by 16 feet, were yielding more than the 12 feet by 12 feet, or the 14 feet by 14 feet.

In certain areas of some cacao growing countries, where the young seedlings grow easily and do not require much attention, they are closely planted,[12] the reason for this system being that there are more trees to harvest during the first few years of production, and they very quickly shade the soil. The system has its advantages, but the superfluous trees must be thinned at the correct time, otherwise those which have to remain permanently will have adapted their leaf and branch system to their confined space and will not acquire their correct form, with the result that future production is definitely impaired. Unless the planter is prepared to thin out when the time comes, and it is known that the cacao grows easily, the system is not to be recommended.

Generally speaking, the usual planting distance in most countries varies from 12 feet to 17 feet. So far as New Guinea is concerned, the distance selected will depend on local conditions of soil and climate. The writer, however, considers that, until the results are available from distance experiments already commenced at the Demonstration Plantation, Keravat, 15 feet by 15 feet is quite suitable for general adoption.

Planting of Windbreaks.

The cacao tree is very susceptible to wind effects, and protection from prevailing winds is essential if the cultivation is to become an economic proposition.

It has already been pointed out that the utilization of strips of natural forest is not advisable, and that the cultivation of more adapted trees is to be preferred. No hard and fast rule, however, can be laid down in respect to the width and distance apart of the windbreaks throughout the estate, as the strength of the prevailing winds varies in different localities.

Many trees are recommended by various authorities, and the following may be mentioned:—*Mangifera indica* (Mango), *Peltophorum inerme* (Peltophorum), *Cedrela odorata* (Cedar), *Pithecolobium saman* (Saman or Rain Tree), *Tamarindus indica* (Tamarind), *Artocarpus integrifolia* (Jak Fruit). There are also certain indigenous trees such as *Canarium* spp. (Galip), and *Pterocarpus indicus* (Rosewood or New Guinea Teak), which would provide useful windbreaks.

Should slow-growing trees such as *Mangifera indica* be selected, then several years must elapse before the duty of an efficient windbreak is being fulfilled, and it is recommended that quick-growing trees such as *Leucaena glauca* or *Erythrina lithosperma* be planted to serve as temporary windbreaks. Annatto (*Bixa orellana*) is also useful, and bamboo along creek or river banks is invaluable, both as a windbreak and in the control of erosion.

Some species have a tendency to lose their lower branches as they mature, and, in this case, it is advisable to inter-plant a low-growing type of tree to afford protection from ground level up to the lower branches of the large tree.

In the writer's opinion, consideration should be given, when establishing windbreaks, to species that have some economic value, and, where possible, indigenous rather than exotic trees should be used.

Methods of Planting.

There are two methods of planting which may be adopted, namely:—

(1) Planting at stake.
(2) Nursery.

1. *Planting at Stake.*

This system has been used in many countries, and was the main system adopted when establishing the cacao industry in Trinidad.[9] It is very simple, four seeds are planted in the form of a rectangle or square at the base of the "lining" stake, and when the plants are well above ground, the weakest are removed, allowing the strongest one to remain. In localities where diseases and pests are not troublesome this method may be used with success, but where enemies are present control measures become difficult. When compared with the nursery system there are many disadvantages; selection is limited, the seedlings do not grow so well as those transplanted at the correct period of the year, i.e. the commencement of the wet season, four times the quantity of seed is required, and there is the likelihood of damage occurring to the remaining seedling when the other three are removed. The question of pest and disease occurrence on cacao seedlings has yet to be thoroughly investigated in New Guinea, and this factor, plus the disadvantages already outlined, tends to preclude for the present planting at stake unless absolutely necessary. It should be mentioned, however, that this aspect of planting is under consideration by the Department of Agriculture, and at the Demonstration Plantation, Keravat, an area has already been laid down for experimental purposes.

2. *Nursery System.*

The site selected for the nursery should be close to the area to be planted, also to water, and if bamboo pots or baskets are not used, then the soil should be fertile to permit strong development of roots, stem and leaves.

Shade is necessary for the nursery, and this may be accomplished artificially in the following manner:—Strong posts are sunk in the ground at convenient distances apart, in order to support a temporary roof of palm leaves at a height of approximately 7 feet above ground level.

The soil is thoroughly turned over by means of a hoe or fork, and worked into a fine tilth, care being taken to remove any stones or roots that are liable to interfere with the development of the young seedling. The presence of any hard substance such as stones, or roots in the soil, easily and quickly causes a physiological condition known as "bench rooting", i.e. the roots become distorted. Van Hall[12] is of the opinion that a heavy soil is to be preferred to a light one, because of the capacity of the former to adhere to the roots, thereby allowing for a ball of soil when the plants are transferred to the field. The writer has seen instances of "bench rooting" occurring in the heavier soils of the Territory, and considers that heavy soils such as are found on the Island of New Hanover, for instance, should be mixed with sand and compost to make them suitable for nursery conditions.

Narrow beds, 3 feet to 4 feet wide and raised at least 6 inches above ground are now made, and each bed should be separated by a pathway one to two feet wide in order to facilitate watering, weeding, spraying (if necessary), and removal of the plants for transplanting purposes.

The seed is normally planted in rows 1 foot apart, and 1 foot distant in the rows, but if it is proposed to remove the seedlings when quite small, then the distance apart in the rows can be reduced to 9 inches. The seed should always be planted with the hilum or scar end downwards or sideways in the soil, never upwards otherwise the seedlings are distorted and germination impaired; the depth of planting is 1 to 2 inches below ground.[10]

The use of pen manure or compost is beneficial; the first application should be made when the soil is primarily forked, and a further application, when the plants have reached a height of 6 inches to 8 inches.

Should dry weather be experienced then watering is essential, and, prior to transplanting, it is advisable to thin out the shade to some extent in order to accustom the plants to field conditions, although, when palm leaves are used as a covering over the nursery, they automatically reduce the shade as they dry. The seedlings are ready for transference to the field after a period of four to five months, when they have attained a height of 12 inches to 18 inches, and have at least five permanent leaves. The plant holes should be dug at least two to three months in advance of transplanting.



Figure No. 11A.

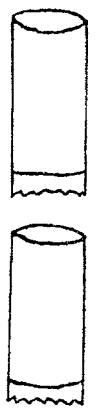


Figure No. 11B.

The use of bamboo pots or baskets is often preferred, because transportation to the field can be accomplished without danger of injury to the plants, and, also, the necessity for having the nursery close to water is not so essential. For New Guinea, where the labourers tend to be untrustworthy, the utilization of bamboo pots or baskets is recommended.

Bamboo pots are constructed by taking lengths of bamboo, and cutting off immediately below the node, Fig. No. 11 (A), so that a complete section open at one end, and closed at the other, is made, Fig. No. 11 (B).

After cutting, a small drainage hole is made in the closed end of the pot, and it is filled with soil; pure compost makes an excellent media for cacao germination, and after growth of the seedlings, should compost not be available, then use, as far as possible, a soil rich in organic matter; the top soil taken from underneath the temporary shade in the field gives results commensurate with compost.

When the seedlings are ready for transplanting, the pot is well watered and transported to the planting hole, where it is split longitudinally, the sides removed, and the young seedling planted with the soil adhering to the roots. Should

baskets, which are made of plaited palm leaf be used, then the seedling is not removed, but planted basket and all. The basket method is very simple, allows for the young plant remaining undisturbed, and the basket soon rots in the soil; the disadvantages, however, are that the baskets are liable to attract white ants which may damage the young plants,[12] and, where bamboo is plentiful, the pots are cheaper (a labourer will make about 600 bamboo pots per day if the bamboo is supplied to him).

When transplanting, it is advisable to adhere as closely as possible to the following general principles:—

1. Care should be taken when removing the seedlings from the nursery that the root system is not damaged, and that a large ball of earth is allowed to remain attached to the roots, and covered with a piece of banana leaf or some other material. This may easily be managed, if the nursery is watered just prior to removal.

2. If the nursery soil is very loose then wash the roots with water, loosely place the plants in bundles, and keep the roots wet during transportation.



Plate No. 9.

Plate No. 9.—Illustrates a nursery, showing the manner in which the palm leaf roof automatically "hardens-off" the seedlings as it dries.

3. Transplant in the early morning or late afternoon, or during a cloudy or drizzly day; never when the sun is hot during mid-day.

4. Transport carefully to the field to avoid undue shaking.

5. If the seedlings are large, then reduce some of the leaves to prevent excess transpiration.

6. After transplanting into the field, cover the seedlings with palm leaves or some suitable medium, and allow the covering to remain until the plants have struck.

7. Do not plant too deeply; place the seedlings the same height above ground as they were in the nursery.

8. When filling the holes, place the best soil in the bottom of the hole, around the roots.

Estate Management After Establishment.

Weeding.

The weed and grass growth may be divided into two sections—(1) detrimental, and (2) non-detrimental. *Imperata arundinacea* (kunai, blady grass or lalang), *Paspalum conjugatum* (thurston grass), and *Chrysopogon aciculatus* (seedy or love grass) should not be allowed in the cacao fields; they form a dense mat which interferes with soil aeration, thereby retarding the activities of soil organisms and movement of soil moisture. On the other hand, soft weeds such as species of *Amaranthus,* may be termed non-detrimental, particularly if cut before seeding, when a large amount of nutrient that has been gathered from the soil is secreted in the tissues, and is, therefore, returned to the soil to become re-available.

The extent of the weeding will depend to a large extent on the planter and his finances. "Clean weeding" is recommended by many authorities and, when compared with "permanent weeding" i.e. continual grass control, shows to advantage as cultivation costs are lowered and the soil is maintained in good tilth. The writer considers that the utilization of leguminous creeping ground covers such as *Dolichos hosei,* or *Desmodium scorpiurus* is even preferable to clean weeding as cultivation costs are further reduced, the soil is protected from erosion, and a great deal of humic material is being continually added to the soil.

Maintenance of Soil Fertility.

Recent experiments carried out in Trinidad[22] have shown that in poor cacao soils there is a lack of nutrient balance. Phosphate particularly, and potash in some cases are deficient, and, so far as nitrogen is concerned, the results obtained tend to show that indiscriminate nitrogenous manuring may be harmful unless phosphate and potash deficiencies are first remedied.

No investigational work has been carried out in regard to the nutrient status of the New Guinea soils except in a few instances by the unsatisfactory method of trial and error, and it is impossible to arrive at any conclusion as to the amount of phosphate or potash present. It is, however, recognized that green manure plants absorb phosphate and potash from the soil for their own benefit,[20] and that to obtain the maximum amount of nutrient to be returned to the soil by the growth of a green manure plant, it is essential that it be pruned and the green material turned in from time to time. In this way, the phosphate and potash held by the plant will become re-available in the soil. Therefore, it is considered that the judicious planting of leguminous crops at the commencement of cultivation, and correct management of these crops should tend to maintain fertility until facilities become available for a full investigation of the soil nutrients.

The soils derived from pumice and volcanic ash in the Gazelle peninsula of New Britain, tend to quickly lose their fertility once the virgin bush is felled, and it is essential that some soil protecting crop be planted immediately following clearing, and maintained throughout the whole period that the cacao is under cultivation.

It is suggested that all prunings and loppings should be trenched in the following manner, providing the soil is not too heavy. Shallow trenches are dug down the centre of alternate rows in alternate years, running longitudinally for two years, and laterally for two years, and in this way a four-year rotation of trenching is developed throughout the estate.

Where weeding is practised, the material can be collected and "composted", i.e. stacked in moderately long, narrow heaps about 3 to 4 feet high and allowed to rot, the heaps being turned every three to four weeks to facilitate aeration and bacterial activity. Under fairly heavy rainfall conditions the heaps should rot down in three to four months, even if no activator such as animal urine, night soil, cattle manure or sulphate of ammonia is used. This system of handling weed and grass growth is being used with success at the Demonstration Plantation, Keravat, where a small quantity of previously made compost is used for activating new heaps.

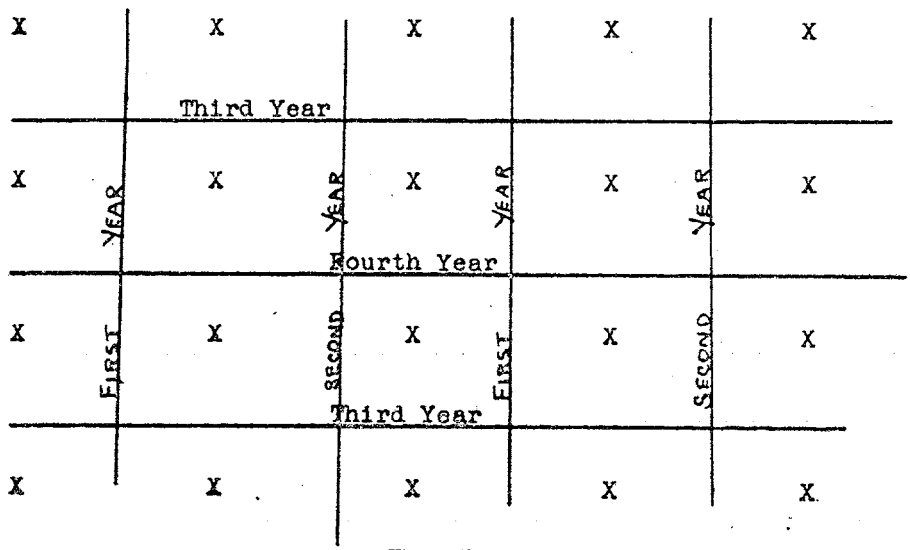


Figure No. 12.

CULTIVATION.

Tillage increases the uniformity of the soil and, generally speaking, is beneficial. Bacteria, particularly the nitrifying type, should multiply when free access of air is increased; cultivation also assists in keeping the soil sweet and allows for a more rapid conversion of the green material, resultant from pruning and lopping, into humus.

If, however, forking or hoeing is practised, care should be taken not to cultivate too deeply, or too closely to the base of the tree otherwise the feeding roots are severed or damaged in such a way as to retard growth and cropping. It is advisable then, that a space be allowed to remain untouched around the base of the tree, and the operation carried out towards the end of the wet season so that the tree has the opportunity of restoring its root system before the onset of the dry season. One authority[12] recommends that the practice of "alternate forking", i.e. tilling of every other space in a row, be adopted in areas where the dry season is rigorous and prolonged; it is considered, however, that this practice should not be necessary in many parts of New Guinea, as the rainfall appears to be quite sufficient during the drier period of the year. Where *Dolichos hosei* or *Desmodium scorpiurus* is used as a ground cover, it may be turned in from time to time, alternate rows at each turning, and not buried too deeply.

Pruning.

The aim of this operation is to modify the growth of the tree by removing all unnecessary branches, twigs and shoots in order to obtain a regular conformation.

When pruning, all water shoots and suckers, dead or diseased branches or twigs, non-bearing branches, and branches or twigs interfering with the well-shaped canopy of the tree are removed. The ends of the lateral branches which are running out and will not produce pods, are cut back to the nearest strong growing subsidiary branch which is growing upwards and outwards, and not inwards towards the centre of the tree. All secondary branches and twigs growing from the laterals inwards are removed, or cut back to smaller growing twigs which are strong and healthy.

On account of the rapid growth of water shoots and suckers especially under the conditions prevailing in New Guinea, every endeavour should be made to remove them at least two to three times per year, at the same time removing any diseased or dead branches or twigs.



Plate No. 10.



Plate No. 11.

Plate No. 10.—Illustrates young cacao growing under the correct density of shade.
Plate No. 11.—Illustrates the effect on young cacao when the shade is too dense.

The tree should not be allowed to develop secondary and tertiary ramifications, and it is advisable to maintain the tree at such a height that picking, and pest and disease control is made easy. Theoretically, the correct period of the year to prune, is when the tree is resting, i.e. the dry season, but experience in this Territory has shown that the tendency is for the tree to bear throughout the whole year, hence, a certain amount of pruning is essential at all times.

During the period that the young seedling is growing, all water shoots and ground suckers, which absorb a large amount of nutrients, should be removed, and, as far as possible not allowed to grow so that they cannot be "thumbed off", i.e. brushed off with the thumb and fingers. From the beginning it is advisable that an endeavour be made to evolve a tree which, when mature, has a good canopy, and the crown is such that there is no interference with the suitable penetration of light and air.

As a general rule, there should only be three or four primary branches allowed on the tree, and these should be encouraged to grow outwards and upwards. The secondary and tertiary branches should be allowed to develop at regular intervals. Every endeavour must be made to keep the tree balanced, so that a lop-sided effect is not produced by having certain branches growing more rapidly.

When pruning, make all cuts on an angle so that rain water is shed, and treat the larger wounds with coal tar followed by a little sand or earth, or some other antiseptic dressing. Bush knives or cacao hooks should not be used for pruning; proper pruning knives attached to a rod and fitted with a lever are needed for the upper parts of the tree, and secateurs for the small lower branches and twigs. All large branches should be sawn, and it is advisable to make the first cut about 1 foot above the required position, then later cut off at the correct place.



Plate No. 12.



Plate No. 13.

Plate No. 12.—Illustrates a well grown two year old tree before pruning.
Plate No. 13.—Illustrates the tree shown in the previous plate after the initial pruning.

A contributing factor regarding the future height of the tree is that of shade, which if too dense results in high ramification of the cacao, and, if too light, then low. The most desirable height for ramification is approximately 3 ft. 6 in. above ground level.

Rejuvenation.

Where a tree becomes barren or worn out it may be rejuvenated provided, of course, that the rooting system is sound. A number of "chupons" or suckers are allowed to come away from the base as close to ground level as possible, as they grow the number is gradually reduced until only the strongest one remains. This "chupon", which will eventually replace the parent, is now treated in the same manner as a seedling.

During the growth of the "chupons", the parent tree should be gradually reduced until only the stump remains, when the single "chupon" is left. As the larger branches of the parent are removed, the cut surface should be treated with coal tar and earth, or some other antiseptic dressing.

Picking and Breaking.

Once the cacao trees have commenced bearing, they must be harvested and the product prepared for market. The ripening of the pods is indicated by a change in colour, and as knowledge of the correct stage of picking can only be gained by experience, it is essential that special labourers should be trained to perform this skilled operation. A pod that is red or green when unripe, changes to a lighter or darker red, reddish yellow, or yellow when ripe, and one that when unripe is red-green, turns reddish yellow when mature. Furthermore, the seeds in a ripe pod adhere to the "placenta" of central core only, and, if the fruit is shaken, the seeds can be heard moving against the inside of the husk; also, if the outside of the pod is tapped with the fingers, a hollow sound results.

It is necessary that care be taken when removing the fruit that only mature pods are harvested, and a clean cut of the stem of the pod made in order not to injure the cushion. The pod should not be cut off too near the cushion, and the jointed portion of the pod stem left attached to the tree; the reason for this, is, that healing of the wound is quicker, and there is less danger of fungal infection. The necessity for careful harvesting cannot be too strongly stressed, damage to the cushion results in reduction of crop and possible ingress of disease organisms. Unripe beans produce an inferior grade of cacao[19] which cannot be remedied by curing, whilst over-ripe beans have commenced to germinate and when dry, there is a small aperture in the end of the bean for insect pests to enter.

Once the crop season commences, the picking gang should be sent frequently into the fields in order to reduce the harvesting of unripe or over-ripe pods. The implement generally used for the removal of the higher pods is known as a cacao hook, and is attached to a length of bamboo; in New Guinea it would be preferable to use a long-handled tree pruner to obviate damage to the cushion by the cacao hook in the hands of an unskilled labourer. The lower pods may be removed by means of a sharp knife or secateurs; if the latter are used, then they must be kept sharp so that the stem is cut without bruising, the knife must also be kept sharp so that the cut is cleanly made.

After picking, the pods should be gathered into heaps preparatory to breaking, which is accomplished by means of a straight or slightly curved knife. Should it be found that, through inexperience, the labourers are cutting the beans at the time of cutting the pod, then the pod may be broken by hitting it with a short stick. After the pods are split open, the contents are removed, and the beans separated from the "placenta" or central core. They are then placed in receptacles suitable for transporting to the fermentation house. It is important that no placenta be mixed with the beans, otherwise fermentation is impaired and the quality of the cured product reduced.

Fermentation.

Should the beans after extraction from the pod be immediately dried, then the resultant product has a tendency to absorb atmospheric moisture, become sticky, and, when in this condition, is quickly susceptible to mould growth.[18] Furthermore, an essential oil which gives the cacao its aroma must be developed, the bitter taste lessened, and, in addition, other changes should occur which assist in

imparting the qualities desired by the manufacturers.[12] Therefore, in order to produce a stable product, which can successfully compete on the market, it is necessary that the mass be subjected to a process known as fermentation.

Fermentation is carried out in a series of containers known as "sweat" boxes, which should be constructed of wood. In some instances, concrete receptacles have been used, but experiments have shown that concrete inhibits the growth of yeasts, bacteria, &c., essential for the process. The size of the boxes and the arrangement of the series, will depend on the amount of crop.

A box measuring 15 feet by 4 feet by 3 feet, divided into three compartments, each 5 feet by 4 feet by 3 feet, would handle about 3,000 lb. of wet cacao in each section. Should a smaller quantity of beans be harvested each picking, then the boxes could be made relatively smaller, remembering that 1 cubic foot of wet beans weighs about 50 lb. A good standard type of box suitable for small crops is one measuring 8 feet by 4 feet by 2 feet, divided into four sections each 4 feet by 2 feet by 2 feet (*see* Figure No. 14).

It is important to know that the depth of beans in the box should not exceed 3 feet, otherwise aeration is impaired, and improper fermentation occurs.

When constructing the boxes, only seasoned timber should be used, otherwise warping, with resulting difficulty in removing the sides, is experienced. The dividing wall between each section should be removable to facilitate transference of the mass from box to box. The ends could also be removable to assist in filling and discharging.

There are various systems in operation regarding the layout of the fermentation boxes. Van Hall[12] describes one in vogue on Djati-Roenggo estate in Central Java, which the writer saw in 1930. In it, the containers are arranged in tiers, the top boxes are filled first, the mass is then transferred to the box below, each day, and from the last box at ground level, the fermented beans are shovelled into the washing basin. This system is easily installed on sloping land, and facilitates handling during fermentation.

Another system is illustrated by the following series of diagrams, which are reproduced with the permission of Mr. J. de Verteuil,[8] and consists of boxes placed side by side at the same elevation. This method is suggested for consideration in preference to the former, from the point of view of simplicity of construction and low initial cost.

The lower walls of the fermentation house are of stout planks or concrete to a height of 4 feet to 5 feet from ground level; if the latter is used, then the inside must be lined with boards otherwise fermentation is retarded. Boarding is continued to within 2 feet of roof, and from here upwards stout wire netting is used. The bottom of the house is concrete with a slight fall towards a gutter, so that the sweatings can flow away (*vide* C and D). The enclosed space for the sweat boxes is divided into two or more compartments by means of removable boards fitted into a groove, and the bottom of the boxes consists of a removable grate in two or more pieces to facilitate cleaning. The grate is constructed of laths $\frac{1}{2}$ inch apart, resting on runners approximately 9 inches above the floor. For the purpose of ventilating the boxes, the walls below the level of the grates are provided with openings about 18 inches wide (*vide* Figure No. 13).

A third system is that shown in Fig. No. 14 and was designed by the writer for small estates or estates coming into production, where the planter need not be under the expense of building an elaborate fermenting house until he is able to gauge his production accurately. Even then, this type of box is easily increased in depth and series.

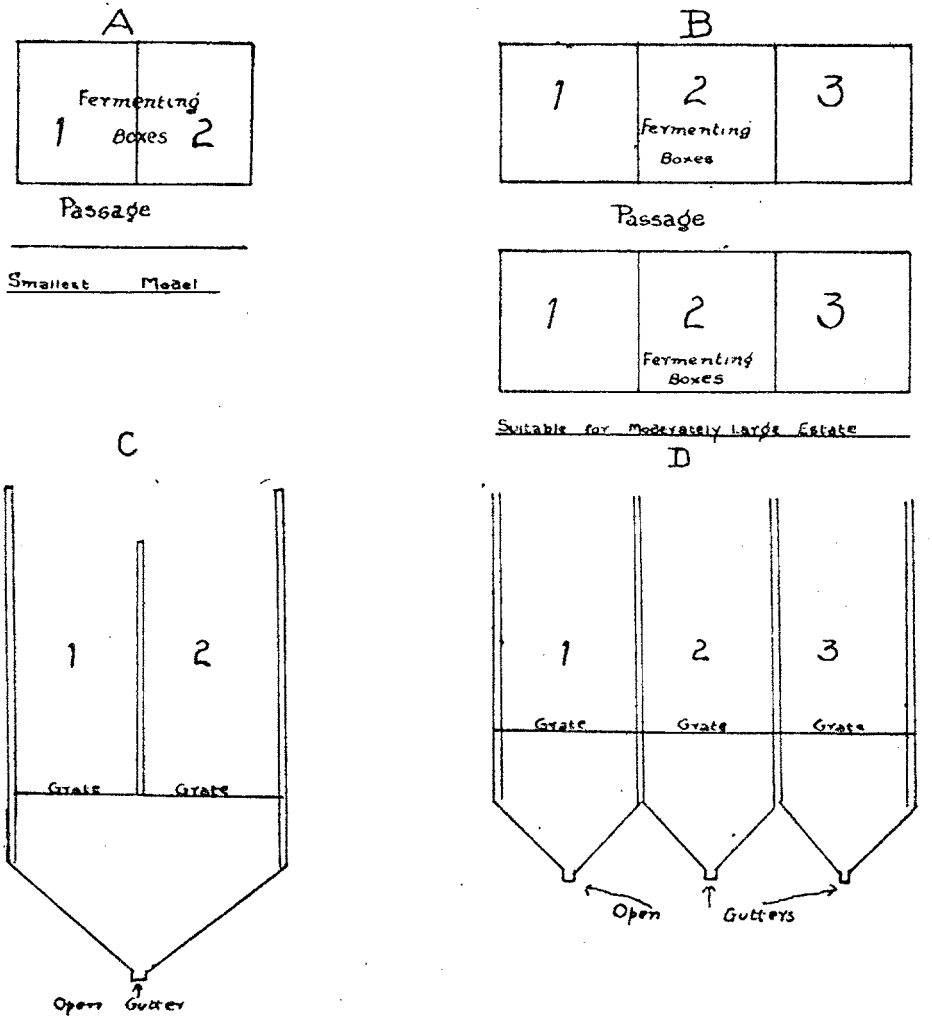


Figure No. 13.

The box measures 8 feet by 4 feet by 2 feet, the sides are fixed, and the ends are removable with internal sliding panels which provide for sectioning within the box itself, so that it may be divided into four compartments, each measuring

4 feet by 2 feet by 2 feet, thereby allowing for a small quantity of beans to be efficiently fermented. Well seasoned hardwood, 12 inches by 1 inch, is used, the

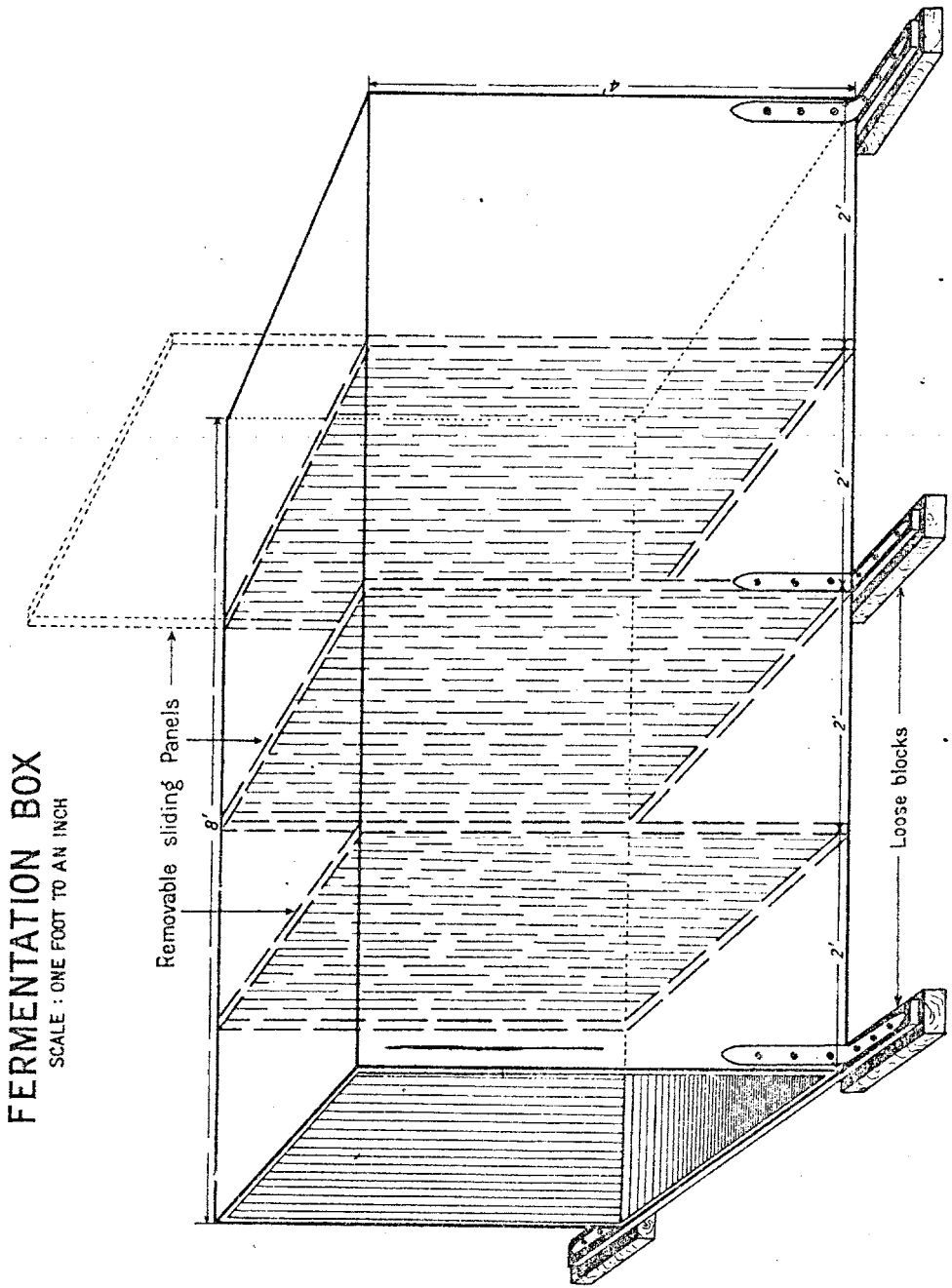


Figure No. 14.

joins are fixed with brass screws, and iron brackets at each end and the centre hold the sides rigid. The bottom consists of fixed hardwood boards with three-eighth inch holes bored 6 inches apart on the equilateral triangle system. A removable grating (similar to that described in system No. 2) could be substituted for the fixed bottom providing it was in four sections, and at the junction of each section, suitable runners were inserted. The box is mounted on concrete or wooden blocks 9 inches to 15 inches above a concrete or earth floor; if the latter, then provision must be made to drain away the "sweatings". The box is housed in a native material or sawn timber building with the back and two sides enclosed.

The Ferment.

The beans should be placed in the "sweat" box to a depth of 2 feet to 3 feet, although quite a good ferment is possible in a 4 feet by 2 feet by 2 feet box at a depth as low as 15 inches. After placing in the box, the beans are covered with banana leaves and fermentation allowed to proceed. Every endeavour should be made to fill the primary box each time. If this is not possible, then the beans in the partially filled box should be spread out as thinly as possible, and covered with banana leaves. When the cacao from the following day's breaking is brought in, it should be placed in another box which is filled with fresh beans, until there is sufficient quantity to completely fill it, when the beans from the previous day are included. The transference of the small quantity from the previous day should be made on the afternoon of the second day or the morning of the third day. The box can now be covered with banana leaves, and fermentation allowed to proceed in the normal manner.

As fermentation continues, transference of the beans from box to box is carried out each alternate day until the process is completed. It is essential that this transference from box to box be carried out in order to get uniform fermentation, and the operation should be accomplished as quickly as possible, otherwise a big reduction in temperature occurs and fermentation is retarded. Further, the beans during the change over should be mixed as thoroughly as possible with a *wooden shovel*. The writer has observed that a common practice adopted in the Territory is to turn every day, and sometimes twice a day. Turning twice per day is unnecessary and detrimental, in that the temperature is reduced each time, whilst every day increases handling, and does not give such good results as alternate days. There are times, however, when it may be essential to turn every day for the first few days in order to raise the temperature, if it is found that alternate days result in a too low temperature.

A fairly high temperature is necessary during the early stages to kill the bean germ, and later to promote and assist in the growth, multiplication, and duties of the various organisms that are responsible for the external and internal changes which the bean undergoes; the rise in temperature accompanying acetic acid fermentation is above the thermal death point of the bean.[2]

The following observations made at the Demonstration Plantation, Keravat, give some indication of the noticeable factors associated with fermentation, and are included as a guide for the planter.

TABLE No. 7.—NOTICEABLE FACTORS ASSOCIATED WITH FERMENTATION.

Hours Period.	Aroma.	Amount Sweatings.	Ferment Flies.	Pulp Colour.	Bean External.	Bean Internal.
0	Sweet ..	..	..	Pink/white..	..	..
8–12	Alcoholic..	Profuse ..	Fairly plentiful	Whitish ..	..	..
24	Acetic ..	Fairly profuse	Plentiful	Creamy/red	Slightly swollen	Dry
36	Acetic fairly strong	Profuse ..	Plentiful ..	Creamy/red	Slightly swollen	Dry
48	Acetic strong	Less profuse	Plentiful ..	Reddish/cream	Swollen ..	Dry
60	Acetic strong	Very little	Decreased	Reddish ..	Swollen ..	Fairly dry slight moisture
72	Acetic strong	Practically none	Very few..	Red/brown..	Swollen full	Fairly moist
84	Acetic strong	None ..	Very few..	Red-brown ..	Swollen full	Fairly moist cotyledons opening
96	Acetic strong	None ..	Very few..	Rich red/brown	Swollen full	As above
108	As above..	None ..	Very few..	As above ..	As above ..	As above
120	Less acetic	None ..	Very few..	As above ..	As above ..	Moist cotyledons open more
144	Faint acetic	None ..	Very few..	As above ..	As above ..	As above
156	Very faint acetic	None ..	Very few..	As above ..	As above ..	Moist cotyledons open

Van Hall[12] states that the "maximum temperature of the fermenting heap remains as a rule under 50 degrees C., and is generally situated between 46 degrees and 48 degrees C.", and Knapp[18] is of the opinion that the maximum temperature should not rise above 50 degrees C. The late Dr. H. R. Briton-Jones,[2] when discussing temperatures during fermentation, says that "normally the temperature does not rise above 50 degrees C., above which the growth of the yeasts and acetic acid bacteria would be greatly inhibited. In fact, after the temperature has risen to 50 degrees C., cessation of growth by acetic acid bacteria is desirable rather than, as some authors suggest, a disadvantage", and as Knapp points out, acetic acid within the cured beans is undesirable from the manufacturing aspect. This writer is of the opinion that the "bite", or acetic flavour, noticeable in New Guinea beans after drying, is probably due in the main to lack of temperature during the later stages of fermentation.

It will be seen, from the above remarks on fermentation temperature, that careful attention must be given to temperature control if a high-grade article is to be produced.

With the strain cultivated in Trinidad, the period of fermentation is up to eight days. Venezuelan Criollo is fermented for one day only,[12] and the Criollo-Forastero hybrid at Djati-Roenggo estate, in Java, for three and a half days. It will be seen, then, that the period of fermentation varies according to the type of cacao grown. Curing experiments conducted by the author on New Guinea cacao, show that the period varies from five and a half days with selected cacao, to six and a half days with bulk plantation cacao. These experiments are by no means complete, and the data available to date shows that climatic conditions and the method of drying influences the period of fermetation. It should, therefore, be clearly understood that until the relationship

between type, climatic conditions, and drying methods has been subjected to further study, no definite period or periods can be given. However, it is considered that as a guide to planters at the present time, a fermentation period of 5½–6½ days in properly constructed boxes should produce a good marketable product.

The fermentation process may be said to be completed when mitigation of the astringent taste of the bean occurs, aroma is developed, the internal colour changes to yellowish or reddish-brown depending upon the percentage of Criollo or Forastero in the strain, the bean is swollen, the shell becomes leathery and loose from the kernel, the cotyledons have opened, and when the bean is depressed, they close, and, on releasing the pressure, re-open again, and the bean contains a reddish-brown fluid inside which follows the knife when the bean is cut in cross section. On the other hand, insufficiently fermented beans, when compared with those well fermented, are not so rounded and swollen, more astringent, aroma is slight, the shell is soft and close fitting, the inside of the bean is very light coloured or purple according to the relationship of the strain to Criollo or Forastero, they are dry or contain very little liquid inside.

A bad fermentation is further manifested in many instances by the lack of heat developed in the mass, no uniform change in the colour of the bean, mildew of the beans in the boxes, beans stuck together in clumps, a bad odour, and the external colour of the bean very dark bordering on black. The main causes of a bad fermentation, as described, are lack of aeration in the boxes, or the beans become wet with rain before placing to ferment. Should lack of aeration be the cause, then this may be easily remedied by increasing the number of drainage holes in the bottom of the box, elevating the box more above ground level, or inserting bamboo rods into the mass.

It is essential that the boxes after changing be thoroughly cleaned and scraped to remove any mucilage adhering to the sides; sponging with a weak solution of potassium permanganate in wet, humid weather prevents undesirable mould growth in the boxes.

In some countries such as Ceylon, Java, and Samoa, the general practice is to wash the beans after fermentation, to remove the mucilagenous covering on the beans. The question of washing, however, is the centre of a great deal of discussion; it certainly cleans the beans of pulp, making them less liable to become mouldy during drying and after bagging; but, on the other hand, there is a loss in weight, and the shells are more brittle and friable, making them subject to damage in drying, curing, and shipping,[12] more susceptible to insect attack after drying, and from the manufacturers' point of view, the aroma suffers.[16] Knapp[11] puts forward some very sound reasons in favour of washing, and points out that, in some countries like Ceylon and Java, it may be done to assist in the removal of the pulp because of the short period of fermentation, whilst again, on the other hand, it may be "to give the bean a pretty appearance".

Australia, which will presumably be the primary market for New Guinea cacao, imports beans from countries like Ceylon and Samoa which wash, and Trinidad which does not wash. If the market demands a washed cacao, then that requirement must be fulfilled. It is considered, however, that the Australian manufacturers buy on quality or type, and the fact of the cacao being washed or unwashed is a very secondary consideration provided, of course, that the

percentage of mucilage adhering to the beans is not excessive. Nevertheless, until experiments are carried out in New Guinea relative to the costs of production, market price, and storage qualities of washed and unwashed cacao, no definite conclusions can be drawn.

Drying.

When the fermentation process is completed, it is necessary to dry the cacao beans, and there are many methods adopted. Most of the world's cacao is dried by the rays of the sun, and the "methods range from the simplest arrangement, such as, laying out the cacao in a thin layer on a tray or mat, to elaborate drying floors of wood or concrete in a specially constructed building (boucan, barbecue) fittted with movable roofs, which can be readily run on rails to protect the cacao from the sun when it is too hot or from rain ".(2) There are also artificial drying machines which are somewhat extensively used in the Cameroons, Ceylon, Grenada, Bahia, San Thome, and Costa Rica.(18)

Sun Drying.

For estate use there are many types of sun driers which may be used, but for preference one with a large wooden platform covered with a movable galvanized iron or sac-sac roof, or a series of trays which slide one above the other, and covered with a long, narrow, fixed roof. The former type reduces handling to a minimum, allows for constant and efficient turning of the beans, and, if elevated, then the space underneath may be used for grading, storing, &c. It is desirable that the drying floor or trays be some height above ground level as an additional aid in controlling mould growth.

The following diagrammatic sketches illustrate a very suitable type of drying house. A small one, on the same principle measuring 30 feet by 18 feet, was erected at the Demonstration Plantation, Keravat, and gives very good results, another similar dryer measuring 35 feet by 16 feet, with a sac-sac roof has been erected on an estate in the Baining District, and dries 1 ton of cacao. The galvanized iron roof requires one labourer to move it, is mounted on double, ball-bearing wheels running on greased iron rails; the sac-sac roof requires three labourers to move it, and is mounted on large kiln wheels running on hoop or (sarif) iron.

When constructing a drying house of this type, the space necessary to dry 1 cwt. of cacao is about 30 square feet.

During the first half to full day after placing the beans to dry, they should be spread fairly thinly so as to drive off quickly as much surplus moisture as possible. As drying proceeds, the depth of beans should be increased in order to reduce to a minimum the percentage of flat and shrivelled beans occasioned by quick drying.

Throughout the whole period of drying the cacao must be constantly "walked" or agitated with a wooden rake, so as to get uniform drying. "Walking" may be described as follows:—A labourer moves through the beans first in one direction and then in the opposite direction, the beans being thrown into ridges with the feet and a portion of the floor is always exposed, thus the beans are exposed on all sides to the sun, and the floor is kept dry.

It is advisable to heap the beans during the first two nights, so as to aid the additional slow fermentation which takes place during drying and assists greatly

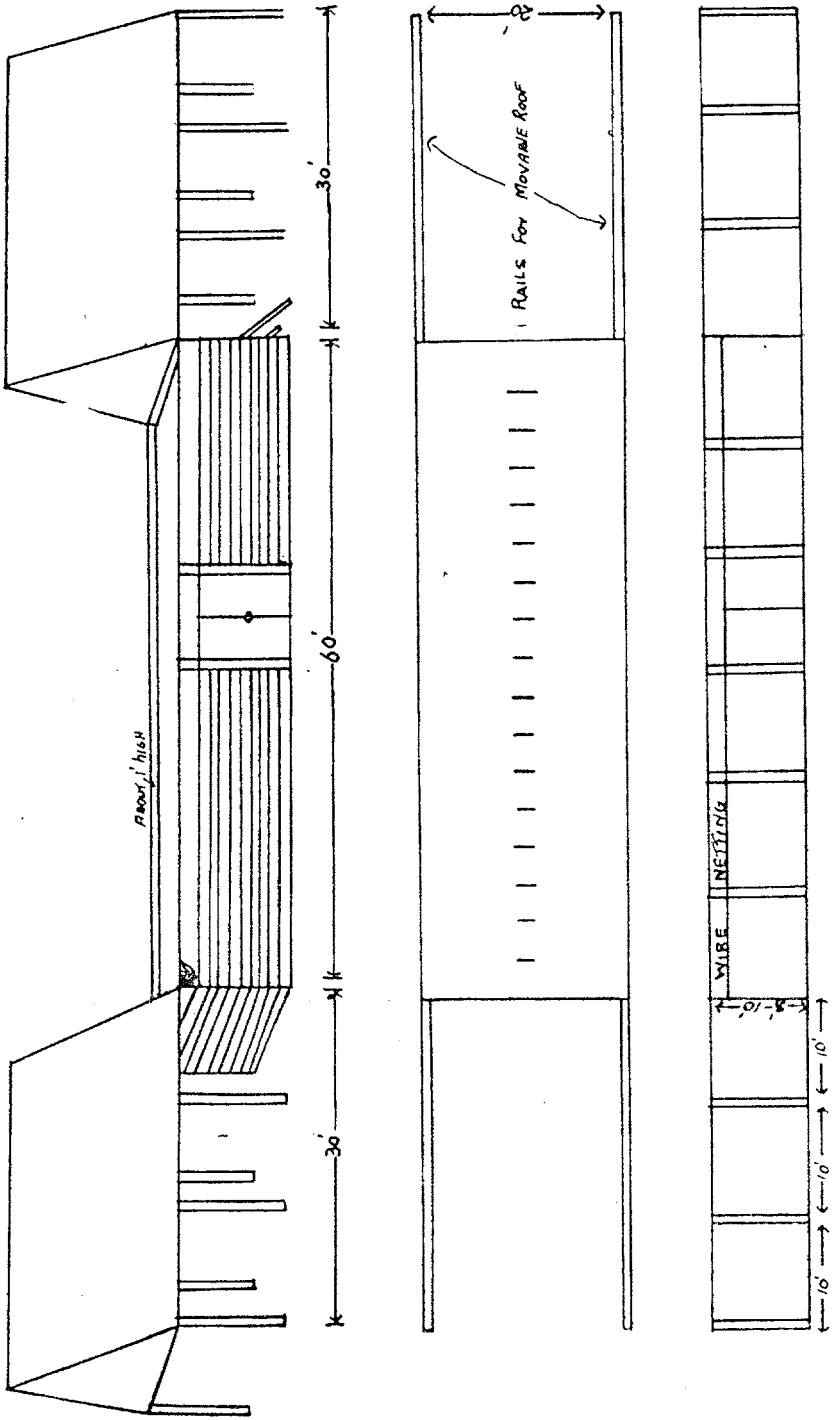

30'
60'
30'
ROOF 1' HIGH
RAILS FOR MOVABLE ROOF
WIRE NETTING
10'
10'
10'

Figure No. 15.

in obtaining a uniform product. Do not heap the beans at night in wet weather, and when exposed during the day, if the sky is overcast, then the beans must not be spread so thickly as in sunny weather.

In some cacao-producing countries such as Trinidad, it is customary to "dance" the cacao, and the operation is carried out in the early morning three to five days after drying commences. The object of "dancing" is to spread the mucilage adhering to the beans evenly over the surface, give greater strength to the shells, give the beans a polish, and to remove mildew. The correct time to "dance" depends on the experience of the planter, and can only be ascertained by tests. Should the beans be too soft, they may become unduly flattened, and, if drying has proceeded too far, then breaking and cracking are liable to occur.

The method adopted is to make conical heaps each containing about 4 cwt. of beans, they are lightly sprinkled with water from time to time, and lightly walked over with a sliding foot movement of the operators. It is important that the beans be continually shovelled back into the centre of the heap, so as to retain the conical shape, otherwise the beans are unduly flattened and subjected

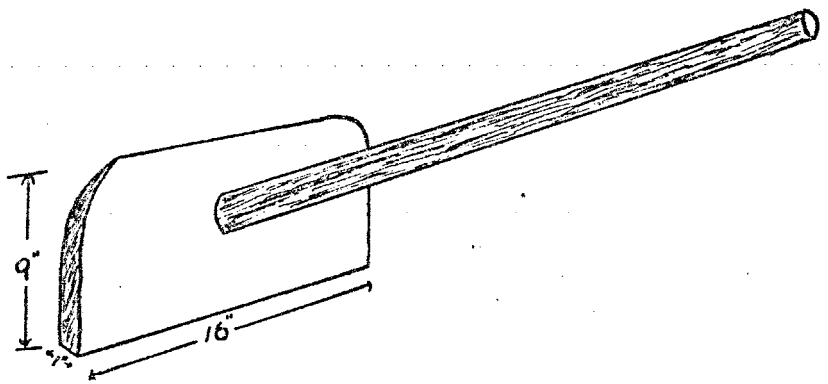


Figure No. 16.—Cacao Rake.

to an unequal amount of "dancing". The amount of water required will depend on the appearance of the beans and the knowledge of the planter; usually it is about 1 gallon per 112 lb. beans. Should mould growth be severe, then it is advisable to add a little lemon juice to the water, or use a very weak solution of permanganate of potash. As dancing proceeds, the beans must be carefully watched, and, as soon as they exhibit a polish, the operation should cease, otherwise a dull colour will result. "Dancing" generally takes about 30 to 45 minutes and it is estimated that ten labourers will dance about 4 cwt. in this period.

When the process is completed, the beans are re-spread in a comparatively thin layer over the surface of the drying floor, and the drying is allowed to proceed fairly rapidly. As the beans are wet, they must be frequently turned, but it is not advisable to "walk" them during the first half-day, therefore, a type of wooden rake is used (Fig. No. 16) until "walking" can be practiced, and maintained until completion of drying. Although the second period of drying is allowed to proceed fairly rapidly during the first stage, it must not be too fast, otherwise the finished product consists of too many wrinkled or flat beans with a split outer shell. In order to obviate this defect, it is often necessary to spread the beans more thickly after the first one and a half to two days, and allow drying to take place less quickly.

The period of drying depends on the weather; under normal conditions six to seven days are sufficient, and this stage is judged from a practical point of view when the beans crackle, will break with a snap in the early morning, and the moisture content is within the limits of 5-7 per cent. After drying, the beans are allowed to cool and may be graded before bagging.

It is essential that the utmost cleanliness be practiced during drying, in order to prevent undesirable mould growth, and the drying floor or trays should be scraped free of mucilage, especially for the first two to three days of drying and after "dancing".

Artificial Drying.

Sun drying is to be preferred, but where conditions are unsuitable, hot air can be utilized. There are several manufacturers of artificial drying machines, the best known, perhaps, being the Gordon Caca Dryer as illustrated by Van Hall.

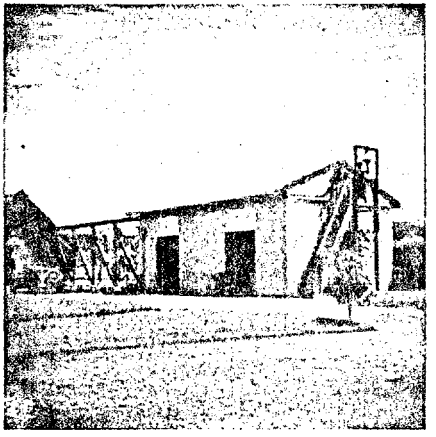


Plate No. 14.

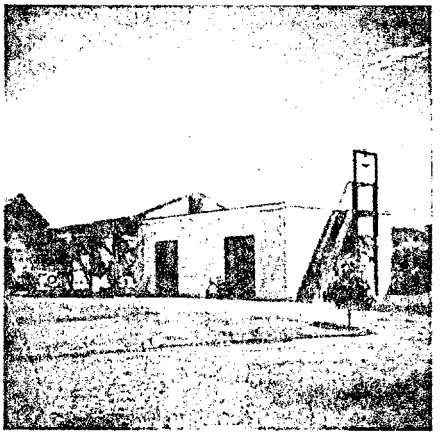


Plate No. 15.

Plate No. 14.—Illustrates a combination drying-house, bulk and seed store at the Government Demonstration Plantation, Keravat. Dimensions are 30 feet long, 18 feet wide, 10 feet high.

Plate No. 15.—Illustrates the movable roof on the building, shown in Plate No. 14.

It is generally agreed that the changes which occur during fermentation are continued during drying. However, if the temperature is too high (and it can quite easily occur during artificial heating) no continuation of fermentation takes place, and the percentage of inferior beans is increased. Should artificial drying be necessary, then an even temperature must be maintained, and the beans constantly turned as in sun drying. A rotary type drier allows for turning of the beans which is more efficient than in sun drying.

The drying of cacao together with copra, or, in driers constantly used for copra, or by means of open smoke driers, is not recommended for many reasons, such as—

(*a*) There is absorption of copra odour by the cacao.

(*b*) The period of drying for copra is, in the majority of instances, much faster than cacao.

(*c*) At no stage during drying should the beans come into contact with metal such as is used for copra trays.

(*d*) The type of copra driers used in the Territory does not permit the constant turning that cacao requires.

(*e*) Smoke and other odours are absorbed by the cacao in open smoke driers.

Marketing.

Market competition is so high that, when a commodity is offered for sale from a newly producing source, it is essential that the commodity should be of the highest quality if it is to successfully compete with the known standards of older producing countries.

The concensus of opinion amongst Australian chocolate and cocoa manufacturers is that New Guinea cacao beans are not comparable with those of Ceylon, Brazil, Ecuador, Panama or Trinidad, and that, generally speaking, they are not equal in quality to West African beans (Accra).

The origin of New Guinea cacao, as already outlined in a previous section of this paper, shows it to be definitely linked with the cacaos of Ceylon, Trinidad, Java and Samoa, hence the type must be comparable to that grown in these countries, and superior to that of West African or Accra cacao.

Reports received from various manufacturers in Australia, regarding different consignments of New Guinea cacao beans, show that up to 9 per cent. are weevily, 13 per cent. hard and flinty, 7½ per cent. mouldy (internal); in an appreciable percentage the husk is shrunken and the beans flat, and in most beans there is an acid component which imparts a "bite". Further, it is recorded that unfermented beans have been submitted, beans with a "smoky" aroma, beans with a "copra" taint, and beans with a "tar-like" aroma.

The following table shows a comparison in individual bean weights of five separate consignments of New Guinea cacao, with average bean weights of Ceylon, Trinidad and West African (Accra) cacao.

TABLE No. 8.

Origin of Beans.	Weight of beans in grammes.
New Guinea Consignment No. 1	1.34
New Guinea Consignment No. 2	1.27
New Guinea Consignment No. 3	1.28
New Guinea Consignment No. 4	1.17
New Guinea Consignment No. 5	1.20
Trinidad	1.295
Ceylon (Caracas cacao) [16]	1.27
Ceylon (Forastero-Cundeamor) [15]	1.133
Ceylon (Amelonado) [15]	1.05
West Africa (Accra) [17]	1.020

From the above table, it will be seen that the New Guinea beans compare very favorably with the best Ceylon and Trinidad beans, and are superior to the Ceylon Forastero-Cundeamor, and Amelonado types of cacao, also the West African type.

Another point raised by the manufacturers is that New Guinea beans arrive in small, irregular consignments, and as they import their stocks in large consignments from the country of origin, there is no necessity for them to purchase small lots of New Guinea cacao from time to time. The following example might be cited in this connexion:—In January and February, 1937, the imports of cacao beans into New South Wales from West Africa and New Guinea were, January 500 tons, February 580 tons from West Africa, and January 2 tons 9 cwt., February 13 tons from New Guinea. The West African beans were in six consignments and five consignments respectively, and the New Guinea beans in three consignments and four consignments respectively. It is interesting to note that in 1936-1937 the imports of New Guinea beans into New South Wales alone constituted only 3.66 per cent., compared with 81 per cent. from West Africa, and 15.4 per cent. from other countries.

It would appear that the main factors affecting the New Guinea bean are, the very high percentage of weevily, hard, flinty, and mouldy beans, plus the shrunken appearance and acid component they contain; also the cacao, in general, is affected by the small, irregular shipments. The writer considers that the control of these factors rests with the producer, and that the acid component is a feature of fermentation and curing, rather than of type or ecological conditions.

The grading of cacao would ensure standardization of size, shape, and freedom from foreign matter, whilst inspection ensures that the product has been prepared for sale, in such a manner that the quality is commensurate with the standard required. The shipping of small and irregular consignments creates one of the biggest difficulties when establishing a new industry, and the inauguration of a central marketing board, even at this stage of production, is worthy of consideration. Such a board could be constituted with or without Government representation, and modelled on similar lines to the Cocoa Producers Association of Trinidad. Its function, in addition to shipping, could also be the control of grading and inspection.

TABLE No. 9.

Territory of New Guinea.

	lbs.
1932-33	109,340
1933-34	197,637
1934-35	235,180
1935-36	267,406

Diseases of Cacao.

In this section an endeavour has been made to describe, as simply as possible the cacao diseases that are present, or likely to occur, in New Guinea. Facilities for disease investigation in the Territory are, as yet, somewhat limited, and a great deal of the information has been obtained from publications by the late H. R. Briton-Jones,[2] Arnold Sharples,[23] and Melville T. Cook,[4] to whom the writer gratefully acknowledges the source of this information. Other information is from observations made by the writer at the Demonstration Plantation, Keravat, and on several estates in the Territory where cacao is under cultivation; also during his period of study under the late H. R. Briton-Jones at the Imperial College of Tropical Agriculture, Trinidad, British West Indies.

Root Diseases.

Rigidoporus Microporus (Swartz) van Overeem.

This root fungus is dealt with rather fully by Sharples,[23] as *Fomes lignosus*, and Briton-Jones[2] as *Rigidoporus microporus*. According to Petch, who is quoted by Briton-Jones,[2] two different species of fungus have been confused under the name of *Fomes lignosus*; recently De Jong has identified the fungus known as *Fomes lignosus* in the Eastern Tropics as *Rigidoporus microporus* (Swartz) van Overeem.[2]

Rigidoporus microporus has a great variety of host plants such as rubber, coffee, cacao, coconuts, mango, breadfruit, cassava, &c., and many species of forest plants. In New Guinea this fungus has been observed on cacao and coffee.

Trees are usually attacked singly or in small groups throughout the estate, above ground the leaves wither, turn yellow or brown, and drop off, followed by a general die-back of the twigs. This defoliation and die-back may occur suddenly, being complete within a few days, or occur gradually over a period of several weeks. If the primary infection takes place on the tap root, then the tree may be blown over before the symptoms are noticeable above ground.

On the roots, the mycelium of the fungus is very apparent, the young mycelium strands as the fungus advances are white, branched, and may exhibit a fan-like appearance; the older strands are stout and cord-like up to ¼ inch in diameter, and adhere closely to the surface of the root. These cords may be white to brownish-yellow, sometimes tinged with red, they follow the roots in a longitudinal manner and constantly unite to form a network.

If the dead tree is not removed, the fungus fructifies in the form of brackets which may be single, or in groups, or fused together. These brackets vary in size from a few inches up to 1 foot in width, and about ¼ to ½ inch in diameter, the marginal end being thinner than the basal end attached to the tree stump or trunk. Fresh brackets exhibit a zonation on the upper surface which has concentric grooves running parallel to the outer edge, and, in the young fructifications, the outside margins are bright yellow. The underside of the bracket is bright orange in colour, pitted with minute holes in which the spores are produced; as the bracket ages, the colour becomes paler. On cross section, the bracket shows two distinct layers, the lower layer is reddish-brown and pitted, whilst the top layer is white and fibrous.

Rigidoporus microporus not only produces the bracket fructifications for spore production, but the fungal strands which caused the initial infection of the roots are able to use the host for penetrating a few feet through the soil until contact is made with a further source of food, such as a piece of dead wood, or living roots.

The writer has observed that, in New Guinea, *Rigidoporus microporus* does not appear to attack the cacao until it is about eighteen months old, and trees from this age upwards to at least seven years of age, are liable to infection. The worst period, however, seems to be from two years to five years.

Brown Root Disease (Fomes Noxius Corner).

This disease has been recorded on cacao from Ceylon, Gold Coast, Samoa, New Guinea,[2] and this writer has also observed its presence in New Guinea. Although Brown Root Disease is not considered a very serious disease of cacao at the present time, nevertheless, it has been known to cause considerable loss in Hevea Rubber.

The symptoms of the disease are most characteristic, and field identification is fairly simple. The diseased roots are encrusted with soil to a thickness of 3-4 mm., and a similar encrustation may be found at the base of the stem for a few inches. This layer of soil, which can also contain small stones, is so firmly held to the root by the tawny brown threads of the fungus, that it cannot be washed off with water. In the later stages, the brown hyphae or threads has a black, brittle covering which gives the root a black appearance.

The diseased wood is also characteristic; when soft, it contains a network of thin brown lines consisting of hyphae; when hard, the brown colour is in broad bands. The roots decay, and, when an advanced condition has been reached, the brown lines exhibit a honeycomb structure. This is particularly noticeable if the wood is soft.

Fomes noxious, unlike *Rigidoporus microporus*, cannot travel through the soil, hence its spread is entirely by root contact, and its appearance in the estate occurs only in single cases.

The fungus rarely fructifies, as it seems that special climatic conditions are required. The fruiting body is a hard bracket which, when growing, is purplish-brown to almost black with a yellow margin; when mature and dry, it is purplish-brown to blackish-brown, with concentric narrow black or yellowish-brown zones towards the margin, smooth, and sometimes concentrically furrowed. The underside is dark brown to almost black in colour, and often covered with a greyish bloom. The brackets are 3 to 4 inches wide and approximately ½ inch thick, and may be produced in large groups running several feet in length, and joined together on the lower surface. On cross section, the tissues consist of a thin, dark, hard top crust, brownish or yellowish brown internal tissue usually zoned with curved lines, approximately parallel to the margin, and a lower dark layer of vertical tubes in which the spores are produced on the hymenium, or skin.

Red Root Disease (Sphaerostilbe Repens).

This fungus attacks Hevea rubber, paw-paw, canna, *Erythrina* spp., hibiscus and citrus, in addition to cacao, and was first recorded from Ceylon.[2]

In attack by *Sphaerostilbe repens* there is no mycelium seen on the surface of the bark of diseased roots. The cortical tissues of the roots are decayed and the bark can be peeled off; this diseased bark has a most objectionable sour smell, which is also noticed in the surrounding soil. On the inside of the bark and the surface of the wood are black, reddish, or yellowish branching strands of mycelium which measure up to ¼ inch in diameter, and are white on cross section; these rhizomorphs or mycelium produce the hyphae or threads which enter the tissues of bark and wood, setting up decay.

Wet Rot (Ganoderma Pseudoferreum (Wakef) van Overeem et Steinmann).

This fungus has been reported from the Dutch East Indies as causing severe damage to cacao in addition to coffee, rubber, tea *Albizzia* spp., *Tephrosia* spp., *Crotalaria* spp., &c.

According to Briton-Jones,[2] there is no record of the fungus attacking cacao outside the Dutch East Indies, but it is present in Malaya, where it causes Wet Rot of hevea rubber.

The symptoms of the disease are, that in the larger roots the woody tissue becomes a soft spongy mass out of which water may be squeezed with the fingers. The attacked roots have characteristic red rhizomorphs on the outer surface, and these rhizomorphs are formed by red mycelial strands, which fuse and form a continuous membrane. The membrane and individual strands are not easily seen when the roots are first taken from the ground, as the soil remains attached, being held by the mycelium, hence, it must be washed away before the membranes and strands can be recognized. When the roots have decayed, the membranes are a blackish-violet colour and single separated rhizomorphs are rare. When young, the strands and membranes are light red, but as they dry the colour fades to a dirty white, but reappears on moistening; when mature, the colour is dark red and remains unchanged when dry.

In surface roots, the disease is more pronounced on the under side, the lower portion may be rotted whilst the upper portion remains untouched.

The fructifications sometimes develop at the base of the diseased trees, and, in the early stages, appear as a round or spherical knob-like proliferation up to 2 inches in diameter, on which yellow or brown spots appear when it is touched. As development proceeds, the basal portion turns grey, then brown, and eventually brownish-black, whilst the crust becomes practically smooth. The knob grows into a hood, and if very little growth takes place at the base, then a stalk is formed; usually, however, no definite stalk is formed. The upper surface of the bracket is smooth, or maybe grooved with irregular excrescences on the surface, is dark coloured, with cinnamon, brown, or khaki coloured narrow wavy zones with a bright chestnut-brown zone which is subresinaceous, up to 10 mm. wide and situated near the margin; eventually, the upper surface becomes a dull brown from deposited spores. The margin is white, thin, and often lobed.

Armillaria Root Rot or Collar Crack (Armillaria Mellea).

This disease has been recorded on cacao in Togoland, where severe loss has been caused. Its distribution is general on the Gold Coast, it is recorded from Uganda and St. Thomas Island, and is known to attack tea in Ceylon and Java.

Infection occurs per medium of the lateral roots, the fungus spreading upwards towards the crown, where it attacks the stem and tap root. The white mycelium travels from the bark into the wood tissue, where, eventually, the medullary rays section is occupied by the mycelium which develops into white sheets of xylostroma or fungus tissue that increase in thickness exerting a lateral pressure on the tissues causing cracks. Internally, the cracks are numerous, but only the large ones are noticeable externally, and these have the xylostroma protruding in the form of white, cream, or dark brown frills. The cracks may extend to some distance up the stem, but by the time they have reached a few feet, the tree is usually dead.

Cracks are to be seen in the tap root, and later, due to secondary infection by other fungus and organisms, it becomes a vile smelling, bright yellow pulp. This destruction of the tap root causes the tree to fall over, hence, it is seldom that defoliation occurs before the tree falls.

Control of Root Diseases.

The measures of control for the foregoing root diseases are essentially the same. Stumps of forest trees that are allowed to remain and rot after clearing provide the host for the fungus, as it is able to derive nourishment from the roots of the stump as it moves along them to infect the roots of growing plants, which are attacked as soon as they come into contact with the infected stump roots. The fungus, after attacking the new host, follows its root system, and so infects any more healthy roots that are contacted, thus disease is spread throughout the estate. Certain fungus, such as *Rigidoporus microporus,* have the ability to move through the soil for some distance from the host, and so attack healthy plants without contact with infected roots being necessary.

Fungi also produce spores, which can cause infection, and, as one authority[2] points out, it is possible for root disease outbreaks on land that has been stump free for years. Most of the root disease fungi depend on soil factors and moisture, some favour clayey soils, others fairly wet soils or soils rich in humus, whilst others show preference for acid soils.

It is recommended that diseased trees be removed and burnt in situ, also that trenches be dug around the trees to a depth of at least 18 inches. The soil, and sections of roots removed in digging should be thrown inwards towards the diseased tree, as the soil and roots may be infected, and, if thrown outwards, the disease is spread if conditions be conducive to its development.

The writer suggests the following procedure in dealing with diseased trees:— Tentatively mark off an area 8 feet to 10 feet square around the infected tree, then remove the tree making a hole approximately 5 feet square and at last 3 feet deep, throw the soil outwards from the hole but inside the 8 to 10 feet square. Place the cut up portions of the tree (roots, stem, branches, &c.) in the hole and burn, then throw back the soil, dig the isolation trenches, throwing the soil removed also into the hole. As this operation is being carried out, treat the soil in the hole as it fills with a 2 per cent. solution of copper sulphate (bluestone).

Do not replant for at least twelve months, and before replanting, re-open the hole, apply a liberal amount of lime, and allow the hole to remain open for some time before planting the new seedling. Any forest stumps in the vicinity must also be removed.

Stem Diseases.

Die Back (Diplodia Theobromae Nowell).

Die Back is a debility disease which affects cacao wherever it is grown. In New Guinea the writer has observed the presence of Die Back on every estate visited, and considers it the most important "above ground" disease of cacao in this country at the present time.

According to one authority,[2] a fungus belong to the genus *Phomopsis* is often associated with *Diplodia theobromae,* and that the first invasion in many cases may be *Phomopsis* spp. which is later followed by *Diplodia theobromae.*

The symptoms of the disease are that the tree may produce small dark green or yellowish coloured leaves, which later die and drop off, leaving the ends of the branches and twigs exposed. These small leaves coincide with each growth flush and gradually appear lower down on the branches as the disease progresses, and

the twigs die back further from their tip. In many instances the attack can be quite sudden, and in which case the leaves quickly die and drop off, leaving the ends of the branches and twigs exposed, and these rapidly die back in their turn.

Die Back depends largely on the nature of the factor or factors responsible for a set back in the growth of the cacao. Some of these factors may be chronic, whilst others of a temporary nature can be most drastic while they last. External factors such as prolonged dry weather, waterlogging of the soil, poor drainage, wind exposure, soil deficiency, injudicious pruning, bark injury by knives, hoes, &c., lack of shade, very shallow planting, and diseases such as root rots, branch and stem cankers, thread blights, &c.

In the case of prior infection by root fungi, it is possible that only one side of the tree may exhibit the symptoms of Die Back if only one side of the root system is affected, also it may be rapid or gradual, depending on the speed of invasion by the fungus.

The control of Die Back is of a general nature by improving the conditions in which the plant is growing; hence, attention must be given to factors such as shade, drainage, diseases and pests, exposure, maintenance of soil fertility, &c. Dead and diseased branches should be removed to make way for new growth, which is allowed to develop in the correct position on the branches, and in the direction most suited for fruit production and disease avoidance. The pruning of living branches and the removal of dead and diseased tissue alone does not control the disease, it merely brings about a temporary alleviation of the condition, hence, the Die Black problem can only be solved by remedying the predisposing causes.

Pink Disease. (Corticium Salmonicolor B. and Br.)

Pink disease is very prevalent in the Mandated Territory, and attacks a large number of hosts such as cacao, coffee, lime, *Crotalaria* spp., *Tephrosia candida*, orange, mandarin, grapefruit, pomelo, tripetalum, &c. Although prevalent, the disease causes very little damage to cacao in New Guinea, but *Crotalaria anagyroides* and *Tephrosia candida*, the two species of temporary shade that are used in cacao cultivation, are severely attacked when twelve months to eighteen months old.

Corticium salmonicolor is readily diagnosed on account of the salmon-pink encrustation which surrounds the branch or twig up to a distance of a few feet. The bark splits and rots away, and the infected branches become defoliated and die. As the age of the fungus increases the salmon-pink colour changes to greyish-white.

Abnormally wet conditions are necessary before the fungus develops to any extent on cacao, although the writer has observed that young seedlings appear susceptible if the disease is allowed to spread on the temporary shade, especially *Crotalaria anagyroides* which is attacked to a greater degree than *Tephrosia candida*.

For the control of pink disease all affected branches should be removed and destroyed, and at the same time, the remainder of the tree should be "opened up" if necessary by judicious pruning. Attention must also be paid to the conditions of moisture and humidity which depend on drainage, overhead shade, canopy of the cacao tree, and exposure of the locality in addition to the rainfall. The evidence of the disease on the temporary shade must also be considered, and suitable control measures adopted.

Thread Blights. (*Corticium spp. and Marasmius spp.*)

Thread blights affect a large number of plants in the virgin bush in addition to cultivated crops, such as cacao, coffee, rubber, tea, &c. In general, they belong to the species Corticium and Marasmius, and although the threads vary in colour depending on age and species, the symptoms are so characteristic that field identification is very simple.

The threads, which run longitudinally up and down the branches and twigs, invade the leaf by travelling along the leaf stalk on to the surface of the leaf itself. By the time the threads have reached the leaf they have branched considerably, and the surface of the leaf may be covered with very fine threads. In wet weather the threads are easily removed from the twigs and leaves, but in dry weather they are brittle. The fungus penetrates the cortical tissues which are killed, the diseased leaves die and either drop off, or remain suspended in the air by means of the threads; and in wet weather a dark brown fluid may drip from the leaves as they decay. The fungal threads are usually found on the under surface of the leaf, and this factor, plus the mid-air suspension of the leaf, makes diagnosis very simple.

The disease is spread by means of dead leaves, &c., on which the fungus is growing, being blown through the plantation and lodging on healthy trees. Wet, humid conditions are most favorable for thread blights, hence the worst infection is likely to occur during the wettest periods of the year.

Control of the disease consists of removing and destroying affected leaves and twigs, and attention to the pruning of the permanent shade at the beginning of the wet season, so that a dense shade canopy does not result.

Thread blights are to be seen throughout the whole of New Guinea, but the writer has noticed that the damage occasioned to cacao is very slight, the attacks occurring sporadically in the estates.

Red Rust or Algal Disease (*Cephaleuros Mycoidea Karst., C. Virescens Kunz., Mycoidea Parasitica Cunn.*).

This disease is very wide spread throughout the world, and is present in New Guinea. It appears mostly on the upper surface of the leaves, in patches more or less circular in shape, and up to one centimetre in diameter. The patches vary in colour from orange-yellow to a rusty-red, and may be found singly, in groups, or scattered over the surface of the leaf. When young, the patches are slightly raised, and later the centre may be depressed due to the death of the underlying cells.

The injury to the leaves is not great, but if conditions are suitable, then the twigs may be attacked, causing them to slough away. The effect of the disease is cumulative, and the severity of attack increases as the trees are weakened.

The best method of control is by improving the conditions under which the cacao is growing, so that the vigour of the trees is sufficient to ward off any attack. Loss of vigour may be due to one or more factors, such as bad drainage, insufficient windbreaks, lack of pruning, soil exhaustion, &c., and when these conditions have been improved, then pruning to reform the heads of the trees should be carried out.

Pod Diseases.

Pod Rot, Canker, Chupon Wilt (Phytophthora Palmivora Butler; or Phytophthora Faberi Maubl.).

Phytophthora palmivora is one of the most destructive diseases affecting cacao, and is present wherever cacao is grown. In New Guinea, it has been observed by the writer, but no infection assessment has yet been made. Bryce[1] has recorded and described the disease, in its application to the Territory.

Pods of all ages are liable to attack, from the very smallest cherelles to fully ripe pods. Infection may take place through wounds, and if the moisture conditions are suitable, then healthy, uninjured pods are readily attacked. Any section of the pod surface can be primarily infected, although in half or fully grown pods the attack generally occurs at the stem end or tip of the pod. The point of attack on the pod is clear brown in colour, and the boundary between the infected and healthy tissue is quite distinct. This discoloured area rapidly extends so that in wet weather, the whole pod may turn brown in a few days, and be covered with a white mass of fungal growth. Examination of this growth has shown that frequently very little mycelium, conidiophores, or conidia of *P. palmivora* are present, and that the white covering consists mainly of *Fusarium* spp.[2]

As the disease progresses the pods turn black, and may be covered with a whitish fungal growth. Should the pods be attacked when the beans are still against the inside of the shell (immature pods), then the fungus, after moving through the pod husk, attacks the beans and completely destroys them. When the pods are fully grown, the beans are free and may not be affected at all, even if the husk is destroyed.

Generally, the diseased pods do not fall from the tree, and the mycelium of the fungus is able to pass through the pod stem into the branch or trunk tissues and cause canker. There is not much indication of canker in its early stages, and frequently the first noticeable factor is the discharge of a darkish coloured fluid which runs down the surface of the bark and dries a rusty-red colour. The fungus spreads under the outer bark layers, through the inner cortical tissues and the cambium, and when the diseased parts are exposed they are brown or claret-red in colour, have an unpleasant odour, and are separated from the healthy tissue by a dark brown line. One or more cankers may surround the branch or main stem, causing the section above the infection to die. As a general rule, cankered trees have an unhealthy appearance, and certain of the main branches are either dead or dying.

When a chupon or sucker is attacked it usually dies back from the tip. Infection generally occurs in the axil of a leaf, but it can also take place on the leaf blade, or petiole, and move backwards into the stem. The affected section has a water-soaked appearance in the first instance, and later, becomes sunken and the colour darkens. The disease travels upwards, downwards, and around the stem, which is finally girdled, and the portion dies above the lesion.

In controlling *Phytophthora palmivora,* it should be remembered that the chief source of infection is from the diseased pods that remain on the tree; hence, treatment of this material is of primary importance. According to the late H. R. Briton-Jones,[2] canker is not a "direct source of infection to pods on other branches because it rarely, if ever, produces spores of *P. palmivora*". The control

recommended against canker, is to cut out the diseased tissue, and paint the surface with a fungicide. In excising the canker spots, it is important to use a sharp knife and trim properly, as the fungicide provides only a temporary protection until the tree forms an effective barrier by the production of callus.

The removal and destruction of diseased pods is not effective, because the conidia of the fungus are produced before the pod turns black on the tree; hence, spraying with bordeaux or burgundy mixture to protect the healthy pods is recommended by many authorities. The removal of diseased pods at frequent and regular intervals is essential, however, in the prevention of canker. Removal and destruction of the pods provides little difficulty, but spraying has many undesirable factors. Spray efficiency depends largely on the weather conditions, which, in the tropics are most variable, and the point at which spraying is economic in relationship to disease control, cost of application, and yield, is a matter of contention. From a practical aspect, the most satisfactory method of dealing with *Phytophthora palmivora,* is to reduce atmospheric humidity by efficient drainage and shade balance, excision and treatment of cankered spots, and regular and frequent collection and destruction by burning of diseased pods.

Diplodia Pod Rot (Diplodia Theobromae Nowell).

The writer has noticed the presence of this disease on a number of estates in the Mandated Territory, and, although it is widespread wherever cacao is grown in the world, it is not considered serious.

Diplodia, theobromae differs from *Phytophthora palmivora,* in that it is unable to infect healthy pods, hence, is dependent mainly on wounds for its entry. It is possible, however, for infection to occur on over-ripe pods, or pods previously attacked by *P. palmivora.*

The disease is manifested by the formation of small pustules under the epidermis in the early stages of attack. These pustules are numerous all over the affected tissue, which becomes slightly raised, giving the pod a roughened appearance. The pustules contain numerous spores, which, in wet weather, are released in the form of white, grey, or black tendrils, the colour depending on the stage of maturity. The fungal mycelium rots the pod and penetrates inside to destroy the beans.

The control of diplodia pod rot depends on the reduction of pod damage by insect pests, wounding of immature pods during harvest, and picking of all pods when they are fully ripe.

Referring to cacao diseases in general, it will be seen that ecological conditions are the biggest factors in the development, spread, and control of fungus. The utilization of fungicides in the prevention and control of fungus diseases in the humid tropics plays a very small part in comparison to general growth factors, and it is doubtful, with cacao prices fluctuating so much in recent years, whether spraying is economic on large-scale crop production.

Diseases such as Phytophthora Pod Rot, Thread Blights, Pink Disease, &c., are at their worst during the wet periods of the year; hence, any measure of control by spraying would mean frequent and regular applications.

Disease control must, in the first instance, be approached from the ecological aspect, any improvement in the conditions under which the cacao is growing, enables the tree to not only maintain, but increase, its vigour and subsequent disease resistance. A study of the local conditions, and the trees themselves, with a view towards effective drainage, shade balance, humidity control, and maintenance of soil fertility, allied to estate sanitation provide to a large extent, the most essential factors in disease prevention and control.

The selection of planting material from strong, healthy trees, and the rigorous culling of unsuitable nursery seedlings, is also important and cannot be too strongly stressed. The planting out of undesirable seedlings from undesirable sources, creates, from the outset, a major difficulty in the prevention and control of disease.

BIBLIOGRAPHY.

1. Bryce, Dr. G. "Cacao Diseases." Leaflets Nos. 3 and 4, T.N.G. Dept. of Agric., Rabaul, 1924.
2. Briton-Jones, Dr. H. R. "Diseases and Curing of Cacao." 1934.
3. Buren, H. L. van. "An examination of the type forms of fruit present in the progeny of a single Forastero cacao." *Tropical Agriculturalist*, 71, 1928.
4. Cook, M. T. "The Diseases of Tropical Plants." 1913.
5. Cheesman, E. E. "The Economic Botany of Cacao." Supplement to *Tropical Agriculture*, June, 1932.
6. Commonwealth of Australia, Bureau of Census and Statistics, Canberra. *Overseas Trade Bulletin.*
7. de Sornay, P. "Green Manuring and Manuring in the Tropics." 1916.
8. de Verteuil, J. "Preparation of Cacao for Market." Bulletin of Dept. of Agric., Trinidad and Tobago, 1933.
9. Green, E. C. D. "The possibility of developing an economic cacao industry in the Mandated Territory of New Guinea after a study of the industry in Trinidad, and a suggested policy for development." Bulletin No. 2, T.N.G. Dept. of Agric., Rabaul, 1934.
10. Green, E. C. D. "The Germination of Cacao for Planting." The New Guinea *Agricultural Gazette*, Vol. 3, No. 2, Dec., 1937, T.N.G. Dept. of Agric., Rabaul.
11. Gordian, Vol. I.-VI., 1925. pp. 423-424.
12. Hall, C. J. J. van. "Cacao." 2nd edition, 1931.
13. Hart, J. H. "Cacao, its Cultivation and Curing." 1911.
14. Johnston. "Elements of Agricultural Chemistry." 17th edition.
15. Johnson, W. H. "Cocoa, its Cultivation and Preparation." 1912.
16. Kaken, O. F. "The Order of Cocoa Tree Types for the purpose of Cultivation and Classification." Gordian Essays on Cocoa, 1936.
17. Knapp, A. W. "Scientific Aspects of Cacao Fermentation." Bulletin Imperial Institute, No. 2, 1936.
18. Knapp. A. W. "Cocoa and Chocolate." 1920.
19. Knapp, Wiehr, Olivier. "Journal of Office International des Fabricants de Chocolat et de Cacao." July, 1933.
20. Manual of Green Manuring. H. W. Cave & Co., Colombo, Publishers.
21. MacMillan, H. F. "Tropical Gardening and Planting." 4th edition, 1935.
22. MacDonald, J. A., Hardy, F., Rodriguez, G. "The Cacao Soils of Trinidad, Montserrat District." 1933.
23. Sharples, Arnold. "Diseases and Pests of the Rubber Tree." 1936.
24. Wright. "Cacao." 1907.
25. Williams, R. O. "Cacao Cultivation in Grenada." Bulletin of the Dept. of Agric., Trinidad and Tobago.
26. *Year-Book.* Commonwealth of Australia, Canberra, 1932.

APPENDIX A.

YEARLY RAINFALL IN INCHES FOR 1937, AND ANNUAL AVERAGE RAINFALL AT ALL STATIONS IN THE TERRITORY.

District.	Number.	Locality.	Rainfall, 1937.	Years recorded.	Average.
New Britain ..	1	Arawe Plantation	204.82	4	175.89
	2	Gasmata ..	267.73	20	244.53
	3	Keravat ..	103.29	8	104.74
	4	Kokopo ..	65.41	11	83.10
	5	Kolai ..	225.04	5	209.50
	6	Lindenhafen ..	308.60	18	225.75
	7	Notre-Mal ..	158.07	9	164.46
	8	Palmalmal ..	200.62	6	205.37
	9	Pondo ..	199.93	11	176.58
	10	Rabaul ..	98.90	24	88.75
	11	Rapopo ..	74.46	5	80.12
	12	Ring Ring ..	337.72	3	297.76
	13	Sum Sum ..	200.95	5	146.32
	14	Talasea ..	200.40	20	172.24
	15	Tobera ..	83.50	7	81.07
New Ireland ..	1	Kalili ..	227.18	14	192.44
	2	Kavieng ..	116.04	21	120.34
	3	Namatanai ..	143.43	20	136.90
Kieta	1	Hakau ..	89.61	2	111.18
	2	Kieta	95.72	21	119.19
	3	Rugen ..	113.34	5	102.47
Manus	1	Lorengau ..	143.19	20	150.60
Sepik	1	Aitape ..	110.12	17	99.23
	2	Wewak ..	97.10	9	88.11
	3	Angoram ..	106.34	3	95.08
Madang	1	Madang ..	119.16	20	140.11
	2	Kulili	136.71	3	143.60
	3	Urit-Kurum ..	134.41	13	115.07
Morobe	1	Baiune ..	74.09	4	67.65
	2	Bulwa ..	63.88	3	60.20
	3	Bulolo ..	61.78	7	56.06
	4	Edie Creek ..	114.65	8	106.58
	5	Kaiapit ..	93.87	10	85.15
	6	Ramu	75.47	4	77.56
	7	Sattleberg ..	188.76	13	176.55

APPENDIX B.

MONTHLY RAINFALL AND WET-DAY AVERAGES AT ALL METEOROLOGICAL STATIONS IN THE TERRITORY.

MONTHLY RAINFALL AND WET-DAY AVERAGES.

—		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Average.
NEW BRITAIN.														
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for thirteen years.														
Gasmata	*R.	5.28	5.79	6.50	10.83	25.26	33.94	37.13	44.50	33.70	19.54	13.36	7.48	243.31
	*W.D.	10.6	11.2	12.0	13.8	20.4	23.5	23.4	15.2	23.5	17.3	14.4	10.4	205.7
Monthly Rainfall Average for seven years—Monthly Wet-Day Average for seven years.														
Keravat	*R.	12.19	7.20	10.57	11.96	8.06	5.93	7.52	5.61	7.01	9.56	11.57	9.06	106.27
	*W.D.	22.0	16.6	21.6	21.7	20.3	15.1	19.0	18.0	16.1	18.6	19.9	21.7	230.6
Monthly Rainfall Average for ten years—Monthly Wet-Day Average for ten years.														
Kokopo	*R.	10.46	6.65	10.68	7.20	5.86	3.78	6.63	7.05	3.70	5.21	6.54	11.09	84.85
	*W.D.	15.5	15.0	17.7	15.9	11.6	9.8	13.0	12.1	9.0	9.9	11.7	13.2	154.4
Monthly Rainfall Average for four years—Monthly Wet-Day Average for four years.														
Kolai Plantation	* R.	7.24	7.31	7.90	9.71	18.42	23.63	33.54	42.18	19.50	18.10	13.09	7.44	208.06
	*W.D.	12.3	10.0	10.0	11.7	17.7	17.5	20.2	20.5	18.0	15.3	15.3	11.0	179.5
Monthly Rainfall Average for seventeen years—Monthly Wet-Day Average for six years.														
Lindenhafen	*R.	7.14	6.31	5.73	11.75	27.69	35.18	39.65	44.98	31.57	20.34	14.07	8.22	252.63
	*W.D.	10.4	12.8	12.8	16.4	19.4	21.4	20.2	24.2	24.6	14.8	15.0	12.0	204.0
Monthly Rainfall Average for eight years—Monthly Wet-Day Average for eight years.														
Notre-Mal	*R.	31.88	16.42	19.81	13.83	8.71	8.26	7.23	7.93	6.34	7.05	9.88	15.33	152.67
	*W.D.	24.7	19.4	21.2	18.6	17.7	16.7	16.5	16.6	15.0	16.1	17.6	19.0	239.1
Monthly Rainfall Average for ten years—Monthly Wet-Day Average for ten years.														
Pondo	*R.	35.75	24.33	19.02	16.97	9.02	7.85	10.41	9.91	7.95	6.95	8.70	17.83	174.69
	*W.D.	20.1	19.2	17.1	17.5	14.2	12.4	13.8	17.2	13.7	12.9	11.1	16.7	185.9

* R = Rainfall in inches. W.D. = Wet Day.

APPENDIX B.—MONTHLY RAINFALL AND WET-DAY AVERAGES AT ALL METEOROLOGICAL STATIONS, ETC.—*continued.*

—		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Average.
NEW BRITAIN—*continued.*														
Monthly Rainfall Average for 24 years—Monthly Wet-Day Average for 21 years.														
Rabaul	*R.	14.22	10.43	9.69	10.15	5.23	3.43	5.83	4.11	3.77	4.99	6.29	10.14	88.28
	*W.D.	20.9	12.0	19.0	18.7	13.5	12.7	15.0	14.4	13.0	12.6	15.3	18.3	185.4
Monthly Rainfall Average for four years—Monthly Wet-Day Average for four years.														
Rapopo	*R.	11.04	6.37	10.05	6.89	5.75	3.97	4.75	8.03	3.89	6.21	6.54	8.14	81.63
	*W.D.	12.7	9.0	13.2	11.2	11.2	9.0	12.2	12.5	8.0	10.0	12.2	12.0	133.2
Monthly Rainfall Average for four years—Monthly Wet-Day Average for four years.														
Sum Sum Plantation ..	*R.	6.86	4.51	7.20	6.90	14.25	6.79	20.34	21.80	12.19	11.93	10.14	9.51	132.42
	*W.D.	15.2	9.5	15.2	10.0	18.7	17.7	22.7	19.2	21.0	15.7	16.0	14.5	195.4
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for thirteen years.														
Talasea	*R.	32.20	28.81	23.46	19.53	7.82	5.15	5.49	4.99	5.45	8.04	11.09	19.18	171.21
	*W.D.	23.0	20.2	18.6	15.3	10.0	7.4	7.6	7.6	7.6	9.1	10.8	16.5	144.7
Monthly Rainfall Average for six years—Monthly Wet-Day Average for six years.														
Tobera	*R.	8.98	7.72	9.61	10.52	4.21	2.81	7.07	6.69	3.50	4.61	8.10	6.96	80.78
	*W.D.	19.7	17.5	21.7	19.5	11.0	12.2	14.2	13.3	13.2	11.7	17.5	18.5	190.0
Monthly Rainfall Average for thirteen years—Monthly Wet-Day Average for thirteen years.														
Watnabara	*R.	12.78	10.25	10.03	11.81	8.15	8.77	11.69	11.32	8.76	9.79	8.31	9.02	120.68
	*W.D.	21.0	16.9	18.7	17.4	14.7	11.1	19.8	18.3	14.8	15.2	13.8	15.3	197.0
MOROBE.														
Monthly Rainfall Average for six years—Monthly Wet-Day Average for six years.														
Bulolo	*R.	4.24	4.07	6.06	5.92	2.91	2.29	3.70	4.25	4.77	4.39	6.20	6.26	55.06
	*W.D.	13.8	11.8	14.8	15.0	12.3	12.7	16.0	15.8	15.8	13.2	15.8	15.2	17.22
Monthly Rainfall Average for three years—Monthly Wet-Day Average for three years.														
Baiune	*R.	4.08	8.09	8.06	5.43	4.25	2.37	4.51	3.33	6.44	4.04	8.16	6.63	65.90
	*W.D.	13.5	16.0	17.5	14.7	13.7	9.3	14.0	13.0	18.0	13.3	14.7	14.3	172.0

* R = Rainfall in inches. W.D. = Wet Day.

APPENDIX B.—MONTHLY RAINFALL AND WET-DAY AVERAGES AT ALL METEOROLOGICAL STATIONS, ETC.—*continued.*

——		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Average.
MOROBE—*continued.*														
Monthly Rainfall Average for seven years—Monthly Wet-Day Average for seven years.														
Edie Creek	*R.	8.22	7.97	12.46	12.16	6.67	4.38	6.32	5.92	8.71	8.26	10.57	14.66	106.30
	*W.D.	†	†	†	†	†	†	†	†	†	†	†	†	†
Monthly Rainfall Average for nine years—Monthly Wet-Day Average for nine years.														
Kaiapit	*R.	8.91	8.75	13.59	12.46	5.24	2.17	2.40	2.49	3.54	5.15	7.46	11.97	84.13
	*W.D.	19.4	15.2	21.6	20.3	15.8	9.7	11.7	13.9	14.2	12.2	15.4	21.4	190.8
Monthly Rainfall Average for three years—Monthly Wet-Day Average for three years.														
Ramu	*R.	5.56	7.04	9.50	8.04	4.80	9.35	3.49	3.93	4.28	3.77	8.04	10.77	78.57
	*W.D.	†	†	†	†	†	†	†	†	†	†	†	†	†
Monthly Rainfall Average for thirteen years—Monthly Wet-Day Average for thirteen years.														
Sattleberg	*R.	4.98	5.93	6.82	8.63	20.05	17.92	25.78	28.68	26.22	12.95	11.85	6.74	176.55
	*W.D.	16.2	17.0	17.6	20.4	23.0	22.7	25.9	26.2	24.0	21.7	20.0	18.6	253.3
MADANG.														
**Monthly Rainfall Average for two years—Monthly Wet-Day Average for two years.*														
Kulili Kar Kar	*R.	14.43	14.60	17.73	11.09	11.33	6.52	4.83	6.41	6.33	12.97	23.38	16.51	146.13
	*W.D.	25.5	22.0	14.5	19.0	20.0	14.0	14.5	16.0	17.0	21.0	21.5	16.6	251.5
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for nineteen years.														
Madang	*R.	12.05	11.69	14.64	17.03	15.15	10.32	7.79	4.62	5.19	9.38	18.92	14.48	141.26
	*W.D.	19.4	17.8	20.7	20.4	19.4	17.3	14.0	9.0	14.2	13.2	16.3	19.5	201.2
NEW IRELAND.														
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for seven years.														
Kavieng	*R.	11.23	11.39	10.72	12.04	10.70	8.97	9.74	9.82	7.56	8.84	9.37	10.33	120.71
	*W.D.	16.3	16.4	16.9	16.4	15.9	15.5	16.9	16.5	14.3	15.6	15.4	16.5	1921·6

* R = Rainfall in inches. W.D. = Wet Day. † Not recorded.

APPENDIX B.—MONTHLY RAINFALL AND WET-DAY AVERAGES AT ALL METEOROLOGICAL STATIONS, ETC.—*continued.*

—		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly Average.
NEW IRELAND—*continued.*														
Monthly Rainfall Average for thirteen years—Monthly Wet-Day Average for thirteen years.														
Kalili Plantation	*R.	21.64	13.63	16.69	11.53	11.65	12.34	21.13	15.98	15.19	17.22	12.97	19.81	189.78
	*W.D.	21.1	18.3	18.6	16.1	15.9	17.2	20.8	22.0	16.9	17.7	15.4	16.6	216.6
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for thirteen years.														
Namatanai	*R.	19.46	17.45	15.85	14.19	8.98	7.53	9.10	6.73	5.79	8.86	10.54	16.99	141.47
	*W.D.	20.2	18.8	18.4	15.5	13.0	11.2	12.8	11.5	10.6	11.1	13.6	16.1	172.8
Monthly Rainfall Average for four years—Monthly Wet-Day Average for four years.														
Put Plantation	*R.	9.05	8.05	12.48	16.66	11.74	9.72	15.33	14.75	14.65	12.50	11.09	10.93	146.95
	*W.D.	18.7	17.7	20.5	23.5	20.0	21.2	24.0	23.7	20.7	20.7	15.3	15.7	241.7
KIETA.														
Monthly Rainfall Average for twenty years—Monthly Wet-Day Average for twenty years.														
Kieta	*R.	10.71	11.16	10.52	11.57	9.62	9.50	11.11	10.50	8.47	10.82	9.16	9.48	122.62
	*W.D.	19.3	19.7	19.2	17.6	17.1	16.9	17.7	15.9	16.1	17.1	15.9	16.9	209.4
Monthly Rainfall Average for five years—Monthly Wet-Day Average for five years.														
Rugen Plantation	*R.	12.60	15.15	12.28	6.39	6.20	4.70	6.08	5.97	4.61	9.59	10.51	8.39	102.47
	*W.D.	20.6	19.0	16.0	13.2	14.6	13.8	19.3	18.6	12.8	17.6	13.2	16.8	195.5
SEPIK.														
Monthly Rainfall Average for sixteen years—Monthly Wet-Day Average for thirteen years.														
Aitape	*R.	10.00	10.66	10.77	10.72	8.01	6.22	6.75	6.53	4.83	6.22	7.65	10.16	98.52
	*W.D.	16.2	15.8	15.8	15.1	12.7	10.4	12.3	12.7	11.2	13.7	14.9	16.2	167.0
Monthly Rainfall Average for eight years—Monthly Wet-Day Average for eight years.														
Wewak	*R.	4.93	3.14	8.38	9.42	8.20	7.04	8.70	5.83	9.59	8.64	6.78	7.34	87.99
	*W.D.	8.7	7.0	10.4	12.3	10.2	7.6	7.1	8.5	10.5	12.0	9.1	9.9	113.3
MANUS.														
Monthly Rainfall Average for nineteen years—Monthly Wet-Day Average for nineteen years.														
Manus	*R.	10.42	11.89	11.97	14.48	10.97	13.84	17.12	16.01	10.77	11.09	11.47	10.94	150.95
	*W.D.	18.7	14.8	19.0	18.8	18.8	15.3	20.0	18.6	16.7	17.1	17.1	17.7	213.5

* R = Rainfall in inches. W.D. = Wet Day.

SUGGESTIONS FOR THE IMPROVEMENT OF NEW GUINEA COPRA.

By E. Caulfield Kelly.

THE EMPLOYMENT OF SULPHUR DIOXIDE GAS IN THE CURING OF COPRA.

Introduction.

The poor general average quality of New Guinea copra, as compared with Ceylon estate copra, to quote a single example, is due, primarily, to faulty drying and careless and improper handling of the product during the whole process of manufacture from the time the shell is split.

There are two methods of curing in general use in the Territory, viz.:—(1) Hot air drying, and (2) sun drying. Smoke drying may be disregarded for the purpose of this paper for the reason that a product, cured by this method, cannot presume to attain any category other than low-grade in the international markets, and if copra dried by hot air and sun methods were of sufficiently and consistently good quality as to command the market price of, say, Ceylon estate copra, no planter who at present advocates and adheres to the smoke-drying method could afford to disregard the advantage of discarding that crude and primitive process in favour of the more modern and lucrative hot air and sun-drying processes.

A great deal of the difficulties of turning out a really good, high-grade copra, can be traced to the handling of the product during the first few hours, after the cutting of the nuts. The extraordinary rapidity with which moulds form on freshly cut coco-nut meat must never be lost sight of, if stain or discolouration—or even worse defects—in the final product are to be avoided. This is especially so in the case of the sun-drying method, as it is not always possible to make provision for the immediate commencement of the drying process after the copra has been cut, and so counteract the growth of moulds.

Even in the case of hot air drying method, many hours frequently elapse between the cutting of the nut and the commencement of drying, especially where the copra is cut in the various paddocks of the plantation, and has to be carried in to the drier. Rainy weather adds to the trouble in such cases, as fresh water and a rain-saturated atmosphere increases the rapidity of mould action.

The Process.

The value then of some process which will at once arrest mould growth in freshly cut coco-nut meat will be appreciated and it is proposed to deal here with a simple method, which was developed some years ago by the Philippine Bureau of Science, viz., the preparation of the product by treatment with sulphur dioxide gas.

Messrs. Brill, Parker and Yeates,[1] Officers of the Bureau's Laboratory of Organic Chemistry, in describing the sulphuring process, state that the fumes not only destroy the mould spores, but remain in the meat for a sufficient time to allow for the escape of water, and prevent the growth of new mould spores. Further,

during the process of sulphuring, there is a very considerable loss of water, due to the softening of the cell walls through the action of the sulphur dioxide, which has a marked affinity for water.

Freshly cut coco-nut meat treated by this gas, may be successfully dried under cover, even without exposure to the heat of the sun or artificial heat, in two weeks (provided that there is free access of air to the product during that time), and no mould action, stain, or discolouration will take place. Naturally, of course, spreading of the meat in the sun, will greatly hasten the drying as will also the use of a hot air drier after treatment.

The Apparatus.

The sulphuring process is a very simple and inexpensive method of ensuring the out-turn of a high-grade product, and the preliminary experiments made by the Bureau of Science have been furthered by Messrs. Wells and Perkins, the Senior Officer and Chemist, respectively of the Bureau, to make possible the commercial application of the process, on small estates or plantations.

The apparatus consists of a wooden box provided with a door in one end to admit a four-wheel truck or trolley mounted on wooden or steel rails. The track is twice the length of the box. The car is provided with a framework to take a number of trays to hold the coco-nut meat to be treated. These trays may be made with split bamboo bottoms, wicker work, or even woven wire, as used in hot air driers, and they should be sufficiently separated to allow of free circulation of the gas. When the trays are loaded the car is pushed inside the box on its tracks and one kilogram (approximately 2½ lb.) of sulphur is placed in a shallow pit between the rails and under the car. If the box is made comparatively tight this amount of sulphur, when ignited, will burn for about 4 hours, liberating sufficient sulphur dioxide gas for the treatment.

At the end of the sulphur treatment the car is rolled into the open and the sulphurated material is then dried by any desired process. If spread out under cover with free access of air for a period of two weeks, it will dry slowly and produce a clean white copra, free from mould or any discolouration, which will yield an oil which is practically colourless, and free from rancidity and acidity.

The residual sulphur dioxide after one month's time may be completely disregarded, as only very slight traces will be found, and no traces will be detected in the expressed oil.

The period of two weeks for drying, mentioned above, is described only to demonstrate the preserving effect of the gas on freshly cut coco-nut meat. Naturally, if sun or artificial drying is used, the period will correspond to that required to dry copra, in the ordinary way, as if the sulphuring process had not been used.

Dimensions of Apparatus.

Wells and Perkins[2] describe in detail a handy size apparatus, capable of dealing with the meat of 3,000 nuts at one charge.

The sulphuring box inside measures 4 feet wide by 8 feet 10 inches long, by 7 feet high, made with 1 inch tongued and grooved timber, and was erected in a shed with a galvanized iron roof and dirt floor.

The whole of one of the 4-feet ends comprised a well-fitting door. Seventeen feet of wooden track was laid in a trench 8 inches deep, running into the box to take two pairs of bogey wheels of 2 feet gauge.

Sixteen trays, outside measurement 7 feet 8 inches x 3 feet x 2 inches deep, were constructed of light timber, the bottoms being made of bamboo strips, placed so as to leave a mesh of ½ inch. A light frame work was constructed on the two pairs of bogey wheels to carry these sixteen trays, with just sufficient space between them to allow of free circulation of air.

The sulphur is burned on a pan which may be made from a cut down kerosene tin or other suitable container, placed on the dirt floor under the car, when in position in the box. The loaded truck is rolled into the box, the sulphur ignited and the door tightly closed. One kilogram of sulphur is usually sufficient for one charge, and six hours in the box are sufficient for the full effect of the fumes, although the sulphur itself may only burn for four hours. It is important to note that the box should be comparatively (but not absolutely) air-tight, to permit of the slow combustion of the sulphur.

Advantages of Treatment.

Sulphured copra, properly dried, has a lighter appearance than the whitest sun-dried copra, because the sulphur partially bleaches the dark outer skin of the meat as well as preserves the natural whiteness of the inside surface. The moisture content when the copra is later dried is about 5 per cent., and the free fatty acid content less than 1 per cent. The sulphur dioxide partly evaporates during drying and partly oxidizes into sulphuric acid, but the sulphuric acid thus formed, does not remain in the oil or injure it in any way.

The direct protection afforded by sulphur dioxide does not last more than a month, but this is more than ample time to complete drying even by the most lengthy process.

Time of Treatment.

Sulphuring should be done very soon after the nuts are opened if rainy weather prevails or is anticipated. If coco-nut meat is rained upon unexpectedly, it can be sulphured even if slight mould growth has started; the mould can thus be killed and further damage prevented, but the fullest protection is afforded if nuts are cut near the box, and the meat sulphured within an hour or two of exposure.

Sulphuring is valuable, chiefly as an adjunct to the sun-drying process of curing. With well-built and systematically-operated hot air driers in good weather conditions, and where the copra is cut at the drier, it should not be necessary, but it can well be employed to supplement hot air drying in adverse weather conditions, or with home-made or faulty kilns.

It frequently happens too, that through circumstances of labour, or weather conditions, a fresh batch of meat is cut and ready to be dried before the preceding batch has been sufficiently dried to remove it from the kiln. In such cases the fresh batch of meat can be preserved against mould or discolouration by sulphuring at once, when it can be stored aside to await its turn in the drier.

Drying.

It must not be inferred that the sulphuring process in itself will dry copra, or that meat which has been treated may be bagged or even stored in heaps with impunity. Whilst sulphured coco-nut meat requires no artificial heat, or exposure to the heat of the sun for a long period after treatment, it must have free access of air, in a covered place, free from rainy weather, or extreme damp. It follows therefore, that until drying has been completed it must be spread out on a dry floor or on trays where the air can freely circulate through the pieces.

Cost of Sulphur.

The expense of sulphuring is negligible when the superior quality of the copra obtained is considered. The sulphur need not be of very refined grade; in fact crude sulphur is preferable, as impurities retard the rate of combustion, and so prolong the period of treatment, from a given weight of sulphur.

Sulphur is available in quantity either from Japan or the Philippines, and could be landed in New Guinea for approximately 15s. per cwt.—a sufficient quantity to treat about 25 tons of copra. There are also sulphur deposits in the territory itself, which could be made perhaps to yield crude sulphur at a very low cost.

REFERENCES.

(1) H. C. Brill, H. O. Parker and H. S. Yeates; "Copra and Coco-nut Oil"—*Philippine Journal of Science*, XII. A; 11, 1917, 80.

(2) A. H. Wells and G. A. Perkins; "Use of Sulphur Fumes in Copra Drying"—*Philippine Journal of Science*, XXI., 1, 1922, 49.

PESTS OF COCOA IN THE TERRITORY OF NEW GUINEA.[1]

By John L. Froggatt, B.Sc., Entomologist.

Although cocoa has been planted for a number of years in various parts of the Territory, it is only in the last few years that any appreciable expansion in the planting of this crop has taken place.

To date, this crop has been comparatively free of serious insect pest infestation, some of the trunk, stem and branch borers being the only ones of major economic importance.

Pests of the Trunk, Branch and Stem.

The most serious pest of cocoa recorded to date is the weevil or snout beetle, *Pantorhytes plutus, Oberth.*[2] (*Curculionidae*). Although this species has been collected in most parts of the Territory, it has, so far, only been recorded as a cocoa pest on portions of New Britain.

Owing to the difficulty, in many cases, of attacking the pest with mechanical measures, inquiries are in hand in reference to possible biological control.

Damage occasioned to limbs and branches by larvae of *Cerambycinae* is sufficiently common as to need careful watching. *Dictamia sp. near rugosa Pasc.* has been bred from such infested timber, but it would appear, from reports received, that there is at least one other species concerned.

The introduction of small quantities of *Paradichlorbenzene* into the grub channels will kill the larvae, the alternative being the use of a piece of thin wire inserted as a seeker into the borings to puncture, or so kill, the grubs.

Occasionally *Lepidopterous* larva and the grubs of *Orthorrhinus patruelis,* Pasc. (*Curculionidae*)[2] have been found boring in the branches, neither of which, however, appear to be numerous. The former has also been bred from the stems and main laterals of coffee trees.

Calotermes papua, Desneux (*Isoptera*) at times attacks the trunks of well-grown trees and may cause appreciable damage. This is a very large " white ant ", the workers measuring three quarters of an inch in length and the adult, males and females, an inch and three quarters from the head to the tip of the folded wings. This species has also been found in the stems of old Annatto (*Bixa orellana*) bushes. A solution of paradichlorbenzene in Kerosene (in the proportion of 2 lb. to 4 gallons) poured into the workings has killed the termites without apparently harming the tree.

In Malaya, termites attacking rubber trees are treated by the fumes from arsenic and sulphur burning together being blown through the workings in the trunk. These machines cost £5 to £6 sterling.

Pests of the Foliage.

Several species of the genus *Rhyparida* (*Eumolphidae*) including *Rhyparida obscuripennis,* Jac., attack the young foliage, and where present in any numbers may affect the growth of the young twigs.

These are small brown or black beetles, which have the habit of dropping from the foliage when disturbed.

When the attack occurs on small trees this habit may be used for their collection by hand, by holding a net or tin under the infested foliage and shaking the twig, when the beetles fall into the container and can then be readily destroyed.

Platyachus ruralis, Fst. (*Curculionidae*) is a small grey weevil, which at times also feeds on the young foliage.

There are four species of moths, all belonging to the family *Noctuidae,* which have been bred from caterpillars collected on the foliage, namely *Tiracola plagiata* Wlk., *Prodenia litura,* F. and a species of the genus Erias, while a species of *Limacodidae* (Cup Moths) (as yet unidentified) has been found feeding on cocoa foliage in the Kieta district.

Tiracola plagiata is a reddish brown moth measuring about 2 inches across the outspread wings; the caterpillars are dark in colour and about 2½ inches in length.

Prodenia litura measures approximately 1¾ inches across the outspread wings, and is brown in colour with white tracery markings on the upper wings.

Erias sp. is a small yellow moth.

Two species of "*Froghoppers*" are not uncommon in both nymphal and adult forms on cocoa, but apparently do no damage to the trees; these are *Euricania splendida F* (*Ricaniidae*) and *Euphanta pokiana, Dist., (Flatidae)*. These insects have the habit when disturbed of "jumping" as well as flying.

Euricania splendens is generally dark brown with a green tinge in colour with transparent areas in the wings, and is about ¾ inch in length, over the folded wings. *Euphanta pokiana* is green in colour, the wings folding in rather a "tent shape"; it is also about ¾ inch in length over the folded wings.

Aphids and "*mealy bugs*" are occasionally seen on young tip foliage, but are negligible as a pest.

A small dark-coloured species of *Thysanoptera* ("Thrips"), as yet unidentified, has been collected on the foliage of young cocoa bushes on one plantation on New Britain, but has not caused any material damage; control has been obtained by spraying.

Yellowish-brown patches on the leaves indicate the presence of this insect, which is readily seen with the aid of a lens under the light covering of webbing formed by the thrips; all stages may be present at the one time. The nymphal stages are marked with two red bands across the middle of the body.

Insects Damaging the Pods.

Lepidopterous larvae have been occasionally found tunnelling in the hard casing of the pods, but difficulties have been met with in breeding out the adults; the channellings made by these caterpillars may lead to the introduction of fungous rots. "*Mealy bugs*" are sometimes present on the outside of the pods, but apparently do no material damage.

Two species of *Rutelidea, Parastasis inconstans Frm.*, and *Parastasia marmorata, Gestro.*, have been recorded as eating off the surface tissue of the pods, but are of comparatively rare occurrence. These beetles are about ¾ inch in length and have the wing covers dark reddish brown, and the thorax and head dark biscuit colour.

Control (General).

Beetles and caterpillars feeding on the foliage can be controlled by spraying or dusting with arsenicals, such as arsenate of lead; sap-sucking insects, if present in plague quantities, can be controlled with a quick-breaking type of oil spray, kerosene emulsion or lime-sulphur spray fluid.

Insect Specimens Required.

It would be of material assistance if owners of cocoa plantations would co-operate with the technical officers of the department in forwarding specimens of insects damaging *any* part of the trees; beetles and other hard-bodied insects could be forwarded in spirit; caterpillars could be placed in a ventilated box, with sufficient feeding material to enable them to live through the period of transport.

(1) We are indebted to the Imperial Bureau of Entomology for insect identifications.

(2) *Vide New Guinea Agricultural Gazette*, Volume 4, No. 1, 1938, *Weevil Pests of Cocoa.*

RELATIONSHIP BETWEEN THE WEIGHT OF HUSKED NUTS AND THE WEIGHT OF COPRA.

By E. Caulfield Kelly.

Plantation owners in the Mandated Territory of New Guinea who take a keen and intelligent interest in their properties, are probably conversant with the yield of their individual plantations, in terms of—

(*a*) Average number of nuts per ton of copra.

(*b*) Average yield of the property in terms of tons (per mensem or per annum).

When one considers, however, the very wide variation which exists on different plantations in New Guinea, in the correlation between the number of nuts dried, and the weight of copra produced, and applies this variation to an individual property, the question may well arise, as to what portions or paddocks of a property are the most profitable, and which the least productive—and why. To cite a case in point where statistics are available in the Department of Agriculture, Rabaul, one property in the North Bainings produces a ton of copra per 10,000 nuts (approximately) whilst another, on the South Coast of the same island in the Gasmata area, requires less than 5,000 nuts to produce a ton—a variation, in the coefficient, of more than 100 per cent. Still another property in the Western Islands requires 15,000 nuts per ton of copra.

Whatever may be the differences of environment as regards rainfall and soil, between the properties under consideration, it must be inferred that the major part of the discrepancy introduced is due to the variability in the size of the nuts from different palms, and more especially from different varieties of palm, in the three areas. Some varieties produce small nuts which, although present in large numbers, may produce no more copra than half the number of larger nuts from other varieties.

In the early days of European occupation of the Territory, most of the present-day fully bearing properties were planted out and hard pioneering spadework was necessary. The difficulties of the planter were both numerous and serious; hostile natives, lack of shipping facilities, lack of road communications, and slow, primitive methods of transport, made his task an enormous one. Plantations, therefore, grew by easy stages of a few hectares at a time, until a property was fully planted. Little or no attention was paid to selection of seed nuts, or to the suitability of a particular area for a specific variety of palm. Seed was obtained when required, and from whatever source available; a good deal was imported; some was purchased from native groves; and later on some was obtained from newly-established plantations in this Territory and from Papua. Most of the older properties, therefore, are a collection of small blocks of palms of different varieties, and varying slightly in age.

As the European settlement increased, and further areas were cleared and planted, the owners of the new properties looked to the newly-established plantations for their supplies of seed. Naturally, their selection fell on those properties which were yielding well, and they purchased their seed nuts accordingly. But, whereas a property might have had a satisfactory average yield, it did not follow

not only to help on the young seedlings, but to prepare for the time when there arises a struggle for existence between the old and the young trees. The soil of the planting holes for the young trees should therefore be mixed with manure. This will help the seedlings to become established quickly and get beyond the dangerous age of the unsplit leaf. Before they get beyond this age they are very liable to suffer from the drip of water from the leaves of the old trees, and being grown in the still shade of the old plantation are also more liable to suffer from fungus disease. This manuring, however, causes the roots of the old trees to find their way into the manured soil in which the seedling has been transplanted, and the struggle for existence then commences. Thus, in the second year of the growth of the seedling the whole area of the plantation should be manured and this should be continued each year till the younger trees commence to form a stem. It will be found that the yield of the older trees will fall off rapidly as the younger generation of trees gain size and strength, and when the latter have formed a stem the old trees should be cut out. The young trees will not commence to fruit as long as they are in the shade of the old trees. Thus, the owner of the plantation must be prepared to forego the crop from the plantation during the interval between the felling of the old trees and the time when the younger trees come into bearing. It is easy enough to make this recommendation on paper, but it is not so easy to carry it out in practice. Some of the more vigorous of the old trees will continue to give good crops and it is not so easy to deliberately cut out such while they still are profitable trees, but it must be remembered that the young trees have much more vigor than the old trees, and when once these are allowed to come into bearing by the removal of the top shade they will very soon make good any apparent loss.

When the old trees are felled the stumps of these should at once be cut out and burnt. The centre of the stem of these stumps is quite soft and full of sap and they will only form breeding places for the much-dreaded coco-nut red weevil and the rhinoceros beetle. After this clearance the planter must decide whether or not to continue the manuring which has had to be given. If the soil is at all fertile further manuring will not be necessary. The removal of the old trees removes at the same time a heavy drain on the resources of the soil and the roots of the old crop still left in the soil will all furnish plant food for the young crop and will tend to make the latter form a deeper root system. The removal of the old crop also will render the operations of cultivation and weeding much easier and more thorough, and this in itself will tend to develop the root system of the young plantation.

By Authority: L. F. JOHNSTON, Commonwealth Government Printer, Canberra.

SUPPLEMENT TO THE NEW GUINEA AGRICULTURAL GAZETTE, VOL. 4, NO. 4, DECEMBER, 1938.

List of Plants in Cultivation in the Botanic Gardens, Rabaul.

(Including a Catalogue of the Material Available for Distribution.)

Amended nomenclature has been used except in cases where the old name is long established and well known.

Plants have been divided, as far as possible, into classes according to their uses and habits of growth, e.g., "Trees, flowering" include such trees as are particularly notable for their floral display, while other trees (which have no major economic use) are grouped under "Trees, general".

Flowering and seeding periods are given but are approximate only and vary in accordance with the yearly variations of season and rainfall.

Every effort is made to fulfil orders, but the Department cannot guarantee the supply of all material listed.

Advice is always available as to the suitability for, and the cultivation of plants in the various districts of the Territory.

Abbreviations used—

B = Bulbs.
C = Cuttings.
M = Marcotts.
P = Plants.
R = Roots, or Rhizomes.
S = Suckers.
T = Tubers.
Y = Too young, material may be available at a later date

——		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available —Price.	
						Seed.	Plants, &c.
OILS.							
Aleurites fordii Hemsl. ..	Tung oil ..	Irregular ..	Does not seed low elevations New Guinea				
Aleurites moluccana Willd. = (*Atriloba* Forst.)	Wood oil ..	March–April ..	October–January ..	60 feet	30 feet	6d. packet	
Cocos nucifera Linn.	Coco-nut ..	Continuous ..	Continuous ..	70 feet	30 feet		
Elaeis guineensis Jacq. ..	Oil palm ..	Continuous ..	Continuous ..	35 feet	30 feet	6d. packet	Large quantities special rates
RUBBERS.							
Castilloa elastica Cerv. ..	Panama rubber ..	Continuous ..	Continuous ..	60 feet	35 feet	6d. packet	
Ficus elastica Roxb.	Assam rubber ..	Irregular ..	.. ..	100 feet	40 feet	..	C. 5s. per 100
Funtumia elastica Stapf ..	Lagos rubber ..	Continuous ..	Continuous ..	50 feet	30 feet	6d. packet	
Hevea brasiliensis Muell.-Arg. ..	Para rubber ..	November–December	February–April ..	60 feet	30 feet	6d. packet	
FIBRES.							
Agave sisalana Perrine = (*Arigida* Mill.)	Sisal hemp ..	Irregular ..	.. ..	6 feet	6 feet	..	S. 6s.
Carludovica palmata Ruiz & Pavon	"Panama hat palm"	Continuous ..	Continuous ..	8 feet	10 feet	6d. packet	S. 6s.
Ceiba pentandra Gaertn ..	Kapok	July–August ..	October–November	50 feet	15 feet.	6d. packet	
Furcraea gigantea Vent. ..	Mauritius hemp ..	Irregular ..	.. ..	6 feet	6 feet	..	S. 6s.
Musa textilis Née	Manila hemp ..	Continuous ..	.. ..	10 feet	8 feet	..	S. 6s.
Sansevieria guineensis Willd. ..	Bow string hemp	Irregular ..	Irregular ..	4 feet	5 feet	..	S. 6s.
Sansevieria zeylanica Willd. ..	Bow string hemp	Irregular ..	Irregular ..	4 feet	5 feet	..	S. 6s.
Sida rhombifolia Linn. ..	.. ..	Continuous ..	Continuous ..	5 feet	Broadcast	6d. packet	
Urena lobata Linn.	.. ..	Continuous ..	Continuous ..	5 feet	Broadcast	6d packet	
MISCELLANEOUS.							
Coffea arabica Linn.	Coffee	Irregular ..	Irregular ..	8 feet	10 feet	2s. lb.	
Coffea robusta Linden ..	Coffee	Irregular ..	Irregular ..	8 feet	10 feet	2s. lb.	
Nicotiana tabacum Linn. ..	Tobacco ..	Continuous ..	Continuous ..	4 feet	3 feet	6d. packet	

ECONOMIC CROPS—*continued.*

——		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
						Seed.	Plants, &c.
MISCELLANEOUS—*continued.*							
Saccharum officinarum Linn. ..	Sugar cane ..	Irregular ..	Irregular ..	10 feet	5 feet x 4 feet	..	C. 5s. per 100
Theobroma cacao Linn. var., *criollo*	Cocoa	Continuous ..	Continuous ..	20 feet	16 feet	2d. pod	
Theobroma cacao, var. *criollo-forastero* hybrid	Cocoa	Continuous ..	Continuous ..	20 feet	16 feet	2d. pod	
SHADE TREES.							
Adenanthera pavonina Linn. ..	.. ..	November–January	March–April ..	40 feet	..	6d. packet	
Albizzia Lebbek Benth. ..	.. ..	Irregular ..	Irregular ..	50 feet	..	6d. packet	
Albizzia procera Benth. ..	.. ..	Continuous ..	Continuous ..	50 feet	..	6d. packet	
Cajanus Cajan Druce ..	Pigeon pea ..	Continuous ..	Continuous ..	15 feet	..	6d. packet	
Enterolobium Saman Prain ..	Rain tree ..	Irregular ..	Irregular ..	80 feet	..	6d. packet	
Erythrina crassifolia Koorders & Valeton	Dadap	August–September	December–January	60 feet	..	..	C. 5s. per 100
Erythrina lithosperma Blume ..	Dadap	August–September	December–January	60 feet	..	..	C. 5s. per 100
Gliricidia maculata H. B. & K.	Madero	May, June ..	September–October	45 feet	..	..	C. 5s. per 100
Leucaena glauca Benth. ..	.. ..	Continuous ..	Continuous ..	30 feet	..	9d. lb.	C. 5s. per 100
COVER CROPS.							
Calopogonium mucunoides Desv. ..	..	March–April ..	July–October ..	Creeper	Rows 5 feet	1s. 6d. lb.	
Centrosema pubescens Benth. ..	.. ..	Continuous ..	Continuous ..	Creeper	Rows 3 feet	2s. 6d. lb.	
Mimosa invisa Mart. ..	.. ..	Continuous ..	Continuous ..	Creeper	Rows 5 feet	2s. 6d. lb.	
Pueraria javanica Benth. = (*P. phaseoloides* Benth.)	.. ..	.. ..	.. ..	Creeper	Rows 5 feet	..	C. 2s. 6d. per 100
ERECT COVER CROPS.							
Aeschynomene americana Linn. ..	..	Continuous ..	Continuous ..	10 feet	Rows 5 feet	2s. 6d. lb.	..
Cassia laevigata Willd. ..	.. ..	Continuous ..	Continuous ..	6 feet	Rows 5 feet	2s. 6d. lb.	

ECONOMIC CROPS—*continued.*

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
						Seed.	Plants, &c.
ERECT COVER CROPS—*continued.*							
Cassia occidentalis Linn.		Continuous	Continuous	3 feet	Rows 4 feet	2s. 6d. lb.	
Crotalaria anagyroides		Continuous	Continuous	12 feet	Rows 5 feet	1s. 6d. lb.	
Indigofera arrecta Hochst.		Continuous	Continuous	4 feet	Rows 4 feet	2s. 6d. lb.	
Tephrosia candida DC.		Continuous	Continuous	8 feet	Rows 5 feet	2s. 6d. lb.	
Tephrosia pumila Pers. (*T. purpurea* Pers.)		Continuous	Continuous	5 feet	Rows 3 feet	2s. 6d. lb.	
GRASSES.							
Chrysopogon aciculatus Trin.	Love grass	Continuous	Continuous	1 foot	3 feet	6d. packet	R. 2s. 6d. per 100
Coelorrhachis glandulosa Stapf.		Continuous	Continuous	3 feet	1 foot	6d. packet	R. 5s. per 100
Cymbopogon nardus Rendle	Citronella grass	..	..	4 feet	3 feet	6d. packet	
Cynodon dactylon Pers.	Couch grass	Continuous	Continuous	1 foot	3 feet	..	C. 5s. per 100
Melinis minutiflora Beauv.		..	..	3 feet	3 feet	6d. packet	
Pennisetum clandestinum Hochst.	Kikuyu grass	..	..	3 feet	3 feet	..	R. 5s. per 100
Pennisetum purpureum Schum.	Merkur grass	Continuous	Continuous	10 feet	6 feet	6d. packet	
Vetiveria zizaniodes Nash	Vetiver grass	..	..	3 feet	3 feet	..	R. 5s. per 100
VEGETABLES AND NATIVE FOODS.							
Abelmoschus manihot Linn (*Hibiscus Manihot* Linn.)	Aibika						
Amaranthus gangeticus Linn	Native spinach ("Aupa")	Continuous	Continuous	3 feet	2 feet x 2 feet	6d packet	
Benincasa hispida Cogn. (*Cerifera Savi*)	White gourd	Continuous	Continuous	Climber	Trellis	6d. packet	T. 3s. doz.
Canna edulis Ker.-Gawl.	Queensland arrow-root	Continuous	Continuous	4 feet	3 feet x 2 feet	6d. packet	T. 3s. doz.
Dioscorea spp.	Yams	..	..	Climber	4 feet x 3 feet	..	Setts 1s. doz.

ECONOMIC CROPS—*continued.*

	Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
					Seed.	Plants, &c.
VEGETABLES AND NATIVE FOODS—*continued.*						
Hibiscus esculentus Linn. .. Okra	Continuous ..	Continuous ..	4 feet	5 feet x 1 ft. 6 in.	6d. packet	
Ipomoea Batatas Lam. .. Sweet potato ..	.. ..	.. ..	Creeper	2 feet	..	C. 2s. 6d. per 100
Manihot utilissima Pohl. .. Cassava ..	Irregular ..	.. ..	6 feet	4 feet x 3 feet	..	C. 2s. 6d. per 100
Maranta arundinacea Linn. .. Bermuda arrowroot	Continuous ..	.. ..	2 feet	2 ft. 6 in. x 1 ft. 6 in.	..	T. 3s. doz.
Phaseolus vulgaris Linn. .. Long bean ..	Continuous ..	Continuous ..	Climber	3 feet x 1 foot	6d. packet	
Psophocarpus tetragonobulus DC. Wing bean ..	Continuous ..	Continuous ..	Climber	4 feet x 1 foot	6d. packet	
Solanum Melongena Linn. .. Egg plant ..	Continuous ..	Continuous ..	3 feet	3 feet x 2 feet	6d. packet	
SPICES.						
Capsicum annuum Linn. .. Chillies ..	Continuous ..	Continuous ..	3 feet	3 feet x 2 feet	6d. packet	
Cinnamomum zeylanicum Nees. (or Breyn ?) Cinnamon ..	Irregular ..	March–April ..	6 feet (40 feet)	10 feet	6d. packet	P. 12s. doz.
Curcuma domestica Valeton .. Turmeric ..	Continuous ..	.. ..	2 feet	3 feet x 2 feet	..	R. 6s. doz.
Myristica fragrans Houtt (or Linn ?) Nutmeg mace ..	Irregular ..	Irregular ..	60 feet	25 feet	1s. doz.	
Piper nigrum Linn. .. .. Pepper ..	Continuous ..					
Vanilla planifolia Andr. .. Vanilla ..	Irregular ..	Irregular ..	Climber	8 feet	..	C. 5s. per 100
EDIBLE FRUITS AND NUTS.						
Achras zapota Linn. .. .. Sapodilla ..	June–August ..	October–December	20 feet	20 feet	6d. packet	
Aegle Marmelos Correa .. Bael fruit						
Anacardium occidentale Linn. .. Cashew nut						
Ananas comosus Merr. .. Pineapple ..	.. ..	.. ..	2 feet	3 feet x 2 feet	..	S. 6s. doz.

——		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
						Seed.	Plants, &c.
EDIBLE FRUITS AND NUTS—*continued.*							
Annona Cherimolia Mill.	Cherimoyer	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Annona glabra Linn.		Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Annona muricata Linn.	Soursop	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Annona reticulata Linn.	"Bullock's heart"	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Annona squamosa Linn.	Custard apple	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Antidesma Bunius Spreng		Y	Y				
Artocarpus communis Forst.	Breadfruit, seeded	July–September	December–March	60 feet	35 feet	6d. packet	P. 12s. doz.
Artocarpus communis Forst.	Breadfruit, seedless variety	July–September		60 feet	35 feet		P. 24s. doz.
Artocarpus integra Merr.	Jak fruit	Continuous	Continuous	60 feet	35 feet	6d. packet	
Averrhoa bilimbi Linn.	Five corners	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Averrhoa Carambola Linn.	Sweet and sour varieties	Continuous	Continuous	20 feet	20 feet	6d. packet	P. 12s. doz.
Barringtonia edulis Seem.		Continuous	Continuous	40 feet	30 feet	6d. packet	
Bertholletia excelsa Humb. & Bonpl.	Brazil nut	Y	Y				
Canarium commune Linn.	Java almond	Y	Y				
Canarium polyphyllum Schum.	"Galip"	March–September	September–March	60 feet	35 feet	6d. packet	
Carica Papaya Linn.	Pawpaw	Continuous	Continuous	20 feet	15 feet	6d. packet	P. 6s. doz.
Carrissa Carandas Linn.	"Natal plum"	Y	Y				
Chrysobalanus Icaco Linn.	"Coco plum"	Continuous	Continuous	20 feet	20 feet	6d. packet	
Chrysophyllum cainito Linn.	Star apple						
Cicca accida Merr.		Continuous	Continuous	20 feet	20 feet	6d. packet	
Citrus spp.	Lime	Continuous	Continuous	20 feet	20 feet		P. 12s. doz.
	Kumquat	Continuous	Continuous	20 feet	20 feet		P. 12s. doz.
	Orange	Continuous	Continuous	20 feet	20 feet		P. 12s. doz.
	Lemon	Continuous	Continuous	20 feet	20 feet		P. 12s. doz.
	Mandarin	Continuous	Continuous	20 feet	20 feet		P. 12s. doz.
	Pomelo	Continuous	Continuous	20 feet	20 feet		P. 12s. doz.
Clausena Wampi Oliver	Wampee						
Cynometra cauliflora Linn.	Nam-nam	Continuous	Continuous	25 feet	20 feet	6d. packet	
Dillenia indica Linn.		Irregular	Irregular	40 feet	30 feet	6d. packet	
Diospyros discolor Willd.	Velvet apple	September–December	March–May	40 feet	30 feet	6d. packet	
Durio zibethinus Murr.	Durian	Y	Y				

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart	Material available—Price.	
						Seed.	Plants, &c.
EDIBLE FRUITS AND NUTS—*continued.*							
Eriobotrya japonica Lindl.	Loquat	Y	Y				
Eugenia brasiliensis Lam.	Brazilian cherry	Continuous	Continuous	15 feet	15 feet	6d. packet	P. 12s. doz.
Eugenia Jambos Linn.	Rose apple	Irregular	Irregular	45 feet	30 feet		
Eugenia jambolana Lam.	Java plum	Irregular	Irregular	60 feet	35 feet		
Eugenia javanica Lam.	Wax jambu	Y	Y				
Eugenia malaccensis Linn.	Malay apple	April–May	August–September	45 feet	35 feet	6d. packet	
Flacourtia indica Merr.	Governor plum	Continuous	Continuous	25 feet	25 feet	6d. packet	
Garcinia Mangostana Linn.	Mangosteen	Y	Y				
Hibiscus Sabdariffa Linn.	Rozelle, red and white varieties	Continuous	Continuous	8 feet	4 feet x 3 feet	6d. packet	
Inocarpus edulis Forst.		December, February	April–June	40 feet	30 feet	6d. packet	
Lansium domesticum Jack	Lansat	Y	Y				
Lucuma nervosa A.D.C. = (*L. Rivicoa* Gaertn. f.)		March–April	July–September	20 feet	20 feet	6d. packet	
Macadamia ternifolia F. Muell.	Queensland nut	Y	Y				
Mangifera indica Linn.	Mango	Irregular	Irregular	60 feet	35 feet	6d. packet	P. 12s. doz.
Mimusops bojeri A.D.C.		Y	Y				
Monstera deliciosa Liebm.		Irregular	Irregular	Epiphyte			P. 12s. doz.
Morus nigra Linn.	Mulberry	Irregular	Irregular	15 feet	15 feet		C. 3s. doz.
Muntingia Calabura Linn.	Japanese cherry	Continuous	Continuous	30 feet	25 feet	6d. packet	
Musa paradisica Linn.	Plantain	Continuous	Continuous	15 feet	10 feet		S. 6s. doz.
Musa sapientum Linn.	Banana	Continuous	Continuous	15 feet	10 feet		S. 6s. doz.
Nephelium Lappaceum Linn.	Rambutan	Irregular	Irregular	70 feet	40 feet	6d. packet	P. 12s. doz.
Nephelium Lit-chi Cambess	Litchee	Y	Y	35 feet	30 feet		M. 30s. doz.
Nephelium Longana Cambess	Longan	Irregular	Irregular	70 feet	40 feet		M. 30s. doz.
Passiflora edulis Sims	Passion fruit	Continuous	Continuous	Climber	10 feet	6d. packet	P. 12s. doz.
Passiflora quadrangularis Linn.	Granadilla	Continuous	Continuous	Climber	10 feet	6d. packet	P. 12s. doz.
Persea americana Mill = (P. *gratissima* Gaertn. f.)	Avocado pear	July–September	October–February	40 feet	30 feet	6d. packet	P. 12s. doz.
Psidium cattleianum Sabine	Cherry guava	Continuous	Continuous	15 feet	15 feet	6d. packet	
Psidium Guajava Linn.	Guava	Continuous	Continuous	15 feet	15 feet	6d. packet	
Punica Granatum Linn.	Pomegranate	Continuous	Continuous	15 feet	15 feet	6d. packet	
Spondias pinnata Kuntz = (S. *Mangifera* Will.)	Hog plum	June-September	January-March	30 feet	20 feet	6d. packet	
Tamarindus indica Linn.	Tamarind	March—May	June–September	50 feet	35 feet	6d. packet	
Zalacca edulis Blume				20 feet	20 feet		S. 12s. doz.

—	Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
					Seed.	Plants, &c.
ROCKERY, BEDDING AND POT PLANTS, FERNS.						
Achimenes grandiflora D.C.	Continuous ..	.. ..	6 inches	..	..	6s. doz.
Adiantum concinnum H.B.K. .. }	.. ..	.. ..	1 foot	..	..	R. 24s. doz.
Adiantum farleyense T. Moore .. }	.. ..	.. ..	1 foot	..	..	R. 24s. doz.
Adiantum gracillimum T. Moore } Maidenhair ferns	.. ..	.. ..	1 foot	..	..	R. 24s. doz.
Adiantum peruvianum Klotzsch }	.. ..	.. ..	1 foot	..	..	R. 24s. doz.
Adiantum trapeziforme Linn. .. }	.. ..	.. ..	1 foot	..	..	R. 24s. doz.
Agave vera-cruz Mill. = (*Alurida Ait.*) Century plant ..	.. ..	.. ..	3 feet	..	..	B. 12s. doz.
Aglaonema commutatum Schott = (*Scindapsus Cuscuaria* Presl.)	.. ..	.. ..	2 feet			
Aglaonema costatum N.E.Br.	.. ..	.. ..	6 inches			
Alocasia indica Schott						
Alsophila atrovirens Presl. .. } Tree ferns ..	.. ..	.. ..	10 feet			
Alsophila crenata Papl. .. }	.. ..	.. ..	10 feet			
Alternanthera amoena Voss.	Continuous ..	.. ..	6 inches	..	..	P. 1s. doz. C. 6d. doz.
Amorphophallus campanulatus Blume	Irregular ..	Irregular ..	3 feet	..	6d. packet	
Anthurium cristallinum Linden and André						
Anthurium macrolobium Hybrid						
Asplenium nidus (*-avis*) Linn.						
Begonia Bismarcki Hybrid	Continuous ..	.. ..	2 feet	..	..	C. 3s. doz.
Begonia semperflorens Link and Otto	Continuous ..	.. ..	2 feet	..	..	C. 3s. doz.
Begonia rex Putz.	Continuous ..	.. ..	2 feet	..	..	P. 12s. doz. C. 3s. doz.
Begonia socatrana Hook. f.	Continuous ..	.. ..	2 feet			
Billbergia pyramidalis Lindl.						
Billbergia saundersii Hort.						
Bryophyllum pinnatum Kurz = (*B. Calycinum* Salisb.)	.. ..	.. ..	1 foot	..	..	P. 3s. doz. C. 1s. dz.
Caladium spp.	.. ..	.. ..	3 inches–1 foot	..	..	B. 6s. doz.
Calathea zebrina Lindl.						

ECONOMIC CROPS—*continued.*

—	Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
					Seed.	Plants, &c.
ROCKERY, BEDDING AND POT PLANTS, FERNS—*continued.*						
Canna indica Linn.	Continuous	Continuous	3 feet			T. R. 6s. doz.
Cleome speciosissima Deppe	Continuous	Continuous	1 foot		6d. packet	
Coleus sp.			2 feet			
Crinum asiaticum Linn.	Continuous		2 feet			B. 6s. doz.
Crinum giganteum Andr.	Continuous		3 feet			B. 6s. doz.
Crinum Moorei Hook. F.	Continuous		2 feet			B. 6s. doz.
Crinum pedunculatum R.Br.	Continuous		2 feet			B. 6s. doz.
Datura metel Linn.	Continuous	Continuous	4 feet		6d. packet	
Dieffenbachia Bowmannii Carr			3 feet			C. 3s. doz.
Dieffenbachia magnifica Linden & Rodigas			3 feet			C. 3s. doz.
Dracaena sanderiana Hart.			3 feet			C. 3s. doz.
Dracaena Victoria Hort.			3 feet			C. 3s. doz.
Haemanthus multiflorus Martyn	Continuous	Continuous	1 foot			B. 6s. doz.
Hedychium coronarium Koenig.	Continuous	Continuous	4 feet			B. 6s. doz.
Hippeastrum reticulatum Herb.	Continuous	Continuous	2 feet			B. 6s. doz.
Hippeastrum vittatum Herb.	Continuous	Continuous	2 feet			B. 6s. doz.
Karatas Morreniana Antoine						
Karatas spectabilis Antoine						
Nelumbium speciosum Willd. = *Nymphaea lotus* Linn.	Continuous	Continuous	1 foot		6d. packet	
Opuntia spp.			Varies			C. 3s. doz.
Ruellia tuberosa Linn.	Irregular		2 feet			P. 6s. doz.
Selaginella flabelluta Spring			6 inches			R. 6s. doz.
Selaginella umbrosa			6 inches			R. 6s. doz.
Serissa foetida Comm. = (S. *fetidaham*)	Continuous		2 feet			C. 3s. doz.
Sinningia speciosa Hiern	Continuous		1 foot			P. 6s. doz.
Spathiphyllum commutatum Schott	Continuous		2 feet			P. 6s. doz.
Strelitzia reginae Hort [Banks in] *Ait Hortkew*						
Torenia Fournieri Linden	Continuous	Continuous	1 foot		6d. packet	P. 3s. doz.
Vinca rosea Linn.	Continuous	Continuous	1 foot		6d. packet	
Zephyranthes rosea Lindl.	Continuous		6 inches			P. 3s. doz.

——		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
						Seed.	Plants, &c.
CREEPERS AND SCANDENT SHRUBS.							
Abrus precatorius Linn. ..	Prayer-seed ..	Continuous ..	Continuous ..	..	..	6d. packet	
Allamanda hendersoni Bull. ..	.. ..	Continuous ..	.. ..	..	..	..	P. 6s. doz. C. 3s. doz.
Antigonon leptopus Hook and Arn.	Coralita, pink and white	Continuous ..	Continuous ..	..	..	6d. packet	P. 6s. doz.
Aristolochia floribunda Lem. ..	Dutchman's pipe	Continuous ..	Continuous ..	..	..	6d. packet	
Aristolochia grandiflora Arruda	Dutchman's pipe	Continuous ..	Continuous ..	..	..	6d. packet	
Aristolochia hians Willd. ..	Dutchman's pipe	Continuous	Continuous ..	..	..	6d. packet	
Arrabidaea magnifica Sprague ..	.. ..	Continuous ..	.. ..	..	..	..	P. 12s. doz. C. 3s. doz.
Beaumontia grandiflora Wall ..	.. ..	.. ..	.. ..	..	..	..	C. 3s. doz.
Begonia unguis-cati Linn. ..	.. ..	.. ..	.. ..	..	..	..	C. 3s. doz.
Begonia venusta Ker-Gawl. ..	.. ..	.. ..	.. ..	..	..	..	C. 3s. doz.
Bougainvillaea spectabilis Willd.	Mauve ..	Continuous ..	.. ..	..	..	..	P. 6s. doz. C. 3s. doz.
Bougainvillaea spectabilis var. Mrs. Butt	Crimson ..	Continuous ..	.. ..	..	..	..	P. 12s. doz. C. 6s. doz.
Bougainvillaea spectabilis var. *laterita* as *sp.* Hort	Brick red ..	Continuous ..	.. ..	..	..	..	C. 6s. doz.
Clematis paniculata Thunb. ..	.. ..	Irregular ..	.. ..	..	..	..	C. 3s. doz.
Clematis triloba Henye ..	.. ..	Irregular ..	.. ..	..	..	..	C. 3s. doz.
Clerodendron thomsonae Balf. ..	.. ..	Continuous ..	.. ..	..	..	..	C. 3s. doz.
Clerodendron thomsonae var. *Balfourii* Hort.	.. ..	Continuous ..	.. ..	..	..	..	C. 3s. doz.
Clitoria Ternatea Linn.	.. ..	Continuous ..	Continuous ..	..	..	6d. packet	P. 6s. doz. C. 3s. doz.
Congea tomentosa Roxb. ..	.. ..	December–February	.. ..	..	..	..	
Gloriosa Rothschildiana O'Brien	.. ..	Continuous ..	Continuous ..	..	..	6d. packet	B. 6s. doz.
Gloriosa superba Linn. ..	.. ..	Continuous ..	Continuous ..	..	..	6d. packet	B. 6s. doz.
Ipomoea arborescens Sweet ..	.. ..	Continuous ..	Continuous ..	..	..	6d. packet	
Landolphia Heudelotii A.D.C. ..	.. ..	Continuous					
Lantana trifolia Linn. ..	.. ..	Continuous ..	.. ..	..	..	..	C. 3s. doz.
Loincera Caprifolium Linn. ..	.. ..	Continuous ..	.. ..	..	..	..	C. 3s. doz.
Macrozanonia macrocarpa Cogn.	.. ..	April–June ..	July–December ..	..	..	6d. packet	
Mucuna Kraetkei Warb. ..	.. ..	Y	Y				

—		Flowering period.	Seeding period.	Approximate average height.	Suggested planting distance feet apart.	Material available—Price.	
						Seed.	Plants, &c.
CREEPERS AND SCANDENT SHRUBS—*continued.*							
Odontadenia speciosa Benth.		Y	Y				
Passiflora foetida Linn.		Continuous	Continuous			6d. packet	
Petrea volubilis Linn.		Irregular	Irregular				C. 3s. doz.
Piper Betle Linn.	Betel leaf	Continuous	Continuous				C. 3s. doz.
Piper minimum scandens							C. 3s. doz.
Pogostemon patchouly Pellet = (*P. Heyneanus* Benth.)	Patchouli						C. 3s. doz.
Porana paniculata Roxb.		Continuous					C. 3s. doz.
Quisqualis indica Linn.		Continuous					P. 6s. doz. C. 3s. doz.
Solanum jasminoides Paxt.		Continuous	Continuous			6d. packet	
Strophanthus gratus Baill.		Irregular					C. 3s. doz.
Strophanthus hispidus D.C.		Irregular					C. 3s. doz.
Tecomanthe dendrophila K. Schumm		Irregular					C. 3s. doz.
Thunbergia fragrans Roxb.		Continuous					C. 3s. doz.
Thunbergia grandiflora Roxb.		Continuous					C. 3s. doz.

—		Flowering period.	Seeding period.	Approximate average height.	Material and Price.		
					Seeds.	Cuttings.	Plants, &c.
FLOWERING AND ORNAMENTAL SHRUBS.							
Abutilon indicum Sweet	Pink and white varieties	Continuous		12 feet		3s. doz.	P. 6s. doz.
Acalypha godseffiana Masters		Continuous	Continuous	4 feet		3s. doz.	
Acalypha marginata Spreng.		Continuous	Continuous	6 feet		3s. doz.	
Acalypha Sanderiana Hort.		Continuous	Continuous	4 feet		3s. doz.	
Acalypha wilkesiana Muell. Arg. var. *macrophylla*		Continuous	Continuous	8 feet		3s. doz.	
Aglaia odorata Lour.		Continuous	Continuous	6 feet			M. 30s. doz.
Allamanda schottii Pohl.		Continuous	Continuous	4 feet	6d. packet		P. 6s. doz.

—		Flowering period.	Seeding period.	Approximate average height.	Material and Price.		
					Seeds.	Cuttings.	Plants, &c.
FLOWERING AND ORNAMENTAL SHRUBS—*continued.*							
Allamanda violacea Gardn. = (*A. Blanchettii* A.D.C.)	.. ..	Continuous ..	.. ..	4 feet	..	3s. doz.	P. 6s. doz.
Aralia Balfouriana Hort. ..	.. ..	Continuous ..	.. ..	6 feet	..	3s. doz.	
Aralia filicifolia Chr. Moore ..	.. ..	Continuous ..	.. ..	6 feet	..	3s. doz.	
Aralia Veitchii Hort.	.. ..	Continuous ..	.. ..	6 feet	..	3s. doz.	
Barleria cristata Linn... ..	.. ..	Continuous ..	Continuous ..	4 feet	6d. packet	..	P. 6s. doz.
Barleria lupulina Lindl. ..	.. ..	Continuous ..	Continuous ..	3 feet	6d. packet	..	P. 6s. doz.
Bauhinia candida Roxb. ..	} Synonyms ? {	Continuous ..	Continuous ..	10 feet	6d. packet	..	P. 6s. doz.
Bauhinia variegata Linn ..	} Synonyms ? {	Irregular ..	Irregular ..	15 feet	6d. packet	..	P. 6s. doz.
Bauhinia megalandra Griseb. ..	.. ..	Y	Y				
Bauhinia tomentosa Linn ..	.. ..	Irregular ..	Irregular ..	15 feet	6d. packet		
Brunfelsia americana Linn. ..	.. ..	Continuous ..	Continuous ..	5 feet	6d. packet	3s. doz.	
Caesalpinia pulcherrima Swartz	Bird of paradise red and yellow varieties	Continuous ..	Continuous ..	8 feet	6d. packet	..	P. 6s. doz.
Calliandra haematocephala Hassk	.. ..	Continuous ..	Continuous ..	6 feet	6d. packet		
Cassia alata Linn.	.. ..	Continuous ..	Continuous ..	8 feet	6d. packet	..	P. 6s. doz.
Cassia bacillaris Linn. f. ..	.. ..	Continuous ..	Continuous ..	8 feet			
Cassia corymbosa Lam. ..	.. ..	Y	Y				
Cassia glauca Lam.	.. ..	Y	Y				
Clerodendron fallax Lindl. ..	.. ..	Continuous ..	Continuous ..	4 feet	..	3s. doz.	P. 6s. doz.
Clerodendron fragrans R.Br. ..	.. ..	Continuous ..	Continuous ..	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Clerodendron Minahhassae Teijsm & Binn	.. ..	Continuous ..	Continuous ..	6 feet	..	3s. doz.	P. 6s. doz.
Clerodendron paniculatum Linn.	.. ..	Continuous ..	Continuous ..	6 feet	..	..	P. 6d. doz.
Codiaeum variegatum Blume ..	Croton ..	Continuous ..	.. ..	6 feet	..	3s. doz.	P. 6s. doz.
Cycas Rumphii Miq.	.. ..	Continuous ..	Continuous ..	6 feet	6d. packet		
Duranta repens Linn. = (*D. Plumieri* Jacq.)	.. ..	Continuous ..	Continuous ..	12 feet	6d. packet	..	P. 6s. doz.
Eranthemum atropurpureum Hort.	.. ..	Irregular ..	.. ..	6 feet	..	3s. doz.	
Ervatamia coronaria Stapf. ..	.. ..	Continuous ..	.. ..	5 feet	..	..	P. 6s. doz.
Euphorbia heterophylla Linn ..	.. ..	Continuous ..	Continuous ..	3 feet	6d. packet		
Euphorbia pulcherrima Willd. ..	Poinsettia ..	Continuous ..	.. ..	10 feet	..	3s. doz.	P. 6s. doz.
Flemingia strobilifera R.Br. ..	.. ..	Continuous ..	Continuous ..	5 feet	6d. packet		
Galphimia gracilis Bartl. ..	.. ..	Continuous ..	Continuous ..	4 feet	6d. packet	..	P. 6s. doz.
Gardenia florida Linn. = (*G. jasminoides* Ellis')	.. ..	Continuous ..	.. ..	4 feet	..	3s. doz.	

—		Flowering period.	Seeding period.	Approximate average height.	Material and Price.		
					Seeds.	Cuttings.	Plants, &c.
FLOWERING AND ORNAMENTAL SHRUBS—*continued.*							
Hibiscus Rosa-sinensis Linn. ..	Several colours and varieties	Continuous ..	.. ..	6 feet–10 feet	..	3s. doz..	P. 6s. doz.
Hibiscus schizopetalus Hook f. ..	.. ..	Continuous ..	.. ..	8 feet	..	3s. doz.	P. 6s. doz.
Hydrangea Hortensia Siebold ..	.. ..	Continuous ..	.. ..	3 feet	..	3s. doz.	
Ixora coccinea Linn.	Red.	Continuous ..	Continuous ..	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora congesta Roxb.	Red	Continuous ..	Continuous ..	3 feet	6d packet .	3s. doz.	P. 6s. doz.
Ixora Dixiana Hort.	Red	Continuous ..	Continuous ..	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora javanica DC.	Apricot ..	Continuous ..	Continuous ..	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora lutea Hutch.	Yellow.. ..	Continuous ..	Continuous ..	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora macrothyrsa Teijsm and Binn.	Red	Continuous ..	Continuous ..	6 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora multibracteata Pearson ..	White	Continuous ..	Continuous ..	6 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora occulata	Red	Continuous ..	Continuous ..	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora rosea K. Schum. ..	Pink	Continuous ..	Continuous ..	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Ixora stricta Roxb.	Red	Continuous ..	Continuous ..	3 feet	6d. packet	3s. doz.	P. 6s. doz.
Jasminum sambac Soland ..	Jasmine ..	Continuous ..	.. ..	4 feet	..	3s. doz.	
Jatropha podaggrica Hook ..	.. ..	Continuous ..	.. ..	5 feet	..	3s. doz.	
Lagerstroemia indica Linn. ..	Indian lilac ..	Irregular ..	.. ..	8 feet	..	3s. doz.	P. 6s. doz.
Lagerstroemia tomentosa Presl. ..	.. ..	.. ..	.. ..	6 feet	..	3s. doz.	
Lantana aculeatea Linn. = (*L. Camara* Linn)	Red, yellow, white	Continuous ..	Continuous ..	4 feet	..	3s. doz.	P. 6s. doz.
Macrosphyra longistyla Hook f.	.. ..	Continuous ..	Continuous ..	8 feet	6d. packet		
Malpighia coccigera Linn. ..	.. ..	Irregular ..	Irregular ..	3 feet	6d. packet		
Manihot variegata	.. ..	Continuous ..	Continuous ..	6 feet	6d. packet	3s. doz.	
Murraya exotica Linn. ..	.. ..	Continuous ..	Continuous ..	15 feet	6d. packet		P. 6s. doz.
Mussaenda frondosa Linn. ..	.. ..	Continuous ..	.. ..	8 feet	..	3s. doz.	
Nerium Oleander Linn. ..	Pink, white ..	Continuous ..	.. ..	10 feet	..	3s. doz.	
Oncoba spinosa Forsk. ..	.. ..	Continuous ..	Continuous ..	15 feet	6d. packet		
Panax fruiticosum Linn. ..	.. ..	Continuous ..	.. ..	6 feet	..	3s. doz.	
Plumbago capensis Thunb. ..	Blue	Continuous ..	.. ..	2 feet	..	..	P. 6s. doz.
Plumbago indica Linn. ..	Scarlet.. ..	Continuous ..	.. ..	2 feet	..	..	P. 6s. doz.
Plumbago zeylanica Linn. ..	White	Continuous ..	.. ..	2 feet	..	..	P. 6s. doz.
Plumeria acutifolia Poir ..	Frangipani	Continuous ..	Continuous ..	15 feet	..	3s. doz.	P. 6s. doz.
Plumeria alba Linn.	Frangipani	Continuous ..	Continuous ..	15 feet	..	6s. doz.	P. 6s. doz.
Plumeria rubra Linn.	Frangipani	..	..	..	..	..	
Quassia amara Linn.	.. ..	Continuous ..	Continuous ..	6 feet	6d. packet	3s. doz.	

		Flowering period.	Seeding period.	Approximate average height.	Material and Price.		
					Seeds.	Cuttings.	Plants, &c.
FLOWERING AND ORNAMENTAL SHRUBS—*continued.*							
Randia maculata DC.		Y	Y				
Rosa sp.	Rose	Irregular					
Rhodomyrtus tomentosa Wight		Y	Y		..	6s. doz.	
Russelia juncea Zucc.		Continuous	.. ..	5 feet	..	3s. doz.	
Sambucus canadensis Linn.		Continuous	Continuous	10 feet	6d. packet		
Solanum mammosum Linn.		Continuous	Continuous	2 feet	6d. packet		
Tecoma capensis Lindl.	Scarlet	Continuous	.. ..	4 feet	..	3s. doz.	
Tecoma mollis H. B. & K.		Continuous					
Tecoma smithii Hybrid	Orange-red	Continuous	.. ..	6 feet	..	3s. doz.	
Tecoma stans Juss.	Yellow	Continuous	.. ..	15 feet	..	3s. doz.	
Tecoma velutina Lindl.		Continuous	.. ..	12 feet	..	3s. doz.	
Thevetia neriifolia Juss.		Continuous	.. ..	4 feet	..	3s. doz.	P. 6s. doz.
Thunbergia erecta T. Anders.		Continuous	.. ..	4 feet	..	3s. doz.	P. 6s. doz.
Tithonia diversifolia A. Gray		Continuous	Continuous	6 feet	6d. packet		
Uroskinnera spectabilis Lindl.		Continuous	.. ..	4 feet	..	3s. doz.	
Yucca gloriosa Linn.	Adam's needle	Irregular	.. ..	10 feet	..	..	P. 6s. doz.
SHRUBS—GENERAL.							
Abroma augusta Linn.	"Devil's cotton"	Continuous	Continuous	10 feet	6d. packet		
Acacia catechu Willd.	Cutch	Continuous	Continuous	15 feet	6d. packet		
Acacia confusa Merr.		Y	Y				
Acacia arabica Willd.		.. ..	.. ..	10 feet			
Acacia sphaerocephala Cham. & Schlecht.				10 feet			
Bixa Orellana Linn.	Anatto	Continuous	Continuous	15 feet	6d. packet	..	P. 3s. doz.
Bocconia frutescens Linn.		.. ..	.. ..	10 feet			
Brucea amarissima Merr. (Desv.?)							
Erythroxylon nova-granatense Hieron	Cocaine	Continuous	Continuous	8 feet			
Jatropha Curcas Linn.	Physic nut	Continuous	Continuous	10 feet	..	3s. doz.	
Languas rafflesiana Burkill = (*Alpinia Rafflesiana* Wall)		Continuous	Continuous	10 feet	6d. packet	..	P. 6s. doz.
Languas regia Val. = (*Alpinia regia* Val.)		Continuous	Continuous	10 feet	6d. packet	..	P. 6s doz.
Languas variegata		Continuous	Continuous	10 feet	6d. packet	..	P. 6s. doz.

	Flowering period.	Seeding period.	Approximate average height.	Material and Price.		
				Seeds.	Cuttings.	Plants, &c.
SHRUBS—GENERAL—*continued.*						
Ocimum viride Willd.	Continuous	Continuous	9 feet	6d. packet		
Pachira insignis Savign.	..	..	15 feet	..	3s. doz.	
Phyllanthus myrtifolius Moon	Continuous	Continuous	15 feet	6d. packet	..	P. 6s. doz.
Stachytarpheta jamaicensis Vahl. = (*S. indica* Vahl.)	Continuous	Continuous	15 feet			
Vitex trifolia Linn.	Continuous	Continuous	6 feet	..	3s. doz.	
BAMBOOS.						
Bambusa arundinacea Willd.	Irregular	Irregular	20 feet	..	..	R. 6s. doz.
Bambusa aurea Siebold	Irregular	Irregular	20 feet	..	..	R. 6s. doz.
Bambusa multiplex Racusch	Irregular	Irregular	10 feet	..	..	R. 6s. doz.
Bambusa siamensis Kurz. = (*B. regia* Thoms)	Irregular	Irregular	25 feet	..	..	R. 6s. doz.
Bambusa vulgaris Schrad.	Irregular	Irregular	30 feet	..	..	R. 6s. doz.
Dendrocalamus giganteus Munro	Irregular	Irregular	80 feet	..	..	R. 6s. doz.
Dendrocalamus strictus Nees	Irregular	Irregular	30 feet	..	..	R. 6s. doz.
Gigantochloa verticillata Munro	Irregular	Irregular	80 feet	..	..	R. 6s. doz.

		Flowering period.	Seeding period.	Approximate average height.	Material available.	
					Seeds.	Plants, &c.
TREES—FLOWERING.						
Canangium odoratum King	"Ylang-ylang"	Continuous	Continuous	40 feet	6d. packet	P. 12s. doz.
Cassia Fistula Linn.	Indian laburnum	November–February	July–September	35 feet	6d. packet	P. 12s. doz.
Cassia grandis Linn.		November–February	July–September	50 feet	6d. packet	P. 12s. doz.
Cassia javanica Linn.		Continuous	Continuous	45 feet	6d. packet	
Cassia multijuga Rich.		Continuous	Continuous	45 feet	6d. packet	P. 12s. doz.
Cassia nodosa Buch.-Ham.		November–February	July–September	35 feet	6d. packet	
Cassia siamea Lam.		Continuous	Continuous	45 feet	6d. packet	P. 12s. doz.
Cassia sieberiana DC.		November–February	July–September	20 feet	6d. packet	
Couroupita guianensis Aubl.	Cannonball tree	Continuous	Continuous	70 feet	6d. packet	P. 12s. doz.

——		Flowering period.	Seeding period.	Approximate average height.	Material available.	
					Seeds.	Plants, &c.
TREES, FLOWERING—*continued.*						
Jacaranda mimosaefolia D. Don. = (*J. ovalifolia* R.Br.)		Y	Y			
Kleinhovia Hospita Linn.		Continuous	Continuous	50 feet	6d. packet	
Lagerstroemia Flos-reginae Retz.	Queen flower	Y	Y			
Lysidice rhodostegia Hance		Y	Y			
Melia Azedarach Linn.	Persian lilac	Irregular	Irregular	30 feet	6d. packet	
Michelia alba DC.		Y	Y	35 feet		M. 30s. doz.
Michelia Champaca Linn.	Champak	Continuous	Continuous	35 feet	6d. packet	
Monodora tenuifolia Benth.	Orchid flower	December–January		20 feet		
Peltophorum pterocarpum Backer		Irregular	Continuous	80 feet	6d. packet	P. 12s. doz.
Poinciana regia Boj.	Flamboyante	Irregular	Continuous	45 feet	6d. packet	
Schizolobium excelsum Vog.		Irregular	Irregular	80 feet	6d. packet	
Sesbania coccinea Poir.= (*S. grandiflora* Poir.)		Continuous	June–September	20 feet	6d. packet	
Solanum macranthum Dun.	Potato tree	Continuous	Continuous	30 feet	6d. packet	
Spathodea campanulata Beauv.	W. African tulip tree	Continuous	Continuous	100 feet	6d. packet	P. 12s. doz.
TREES, GENERAL.						
Albizzia falcata Backer		Y	Y			
Albizzia fastigiata Oliver		Y	Y			
Albizzia sumatrana (Temporary species name ? Java)		Y	Y			
Alstonia scholaris R.Br.		April–May	September–October	100 feet	6d. packet	
Araucaria Bidwilli Hook	Bunya pine	Y	Y			
Araucaria Cunninghamii Sweet		Y	Y			
Araucaria excelsa R.Br.	Norfolk Island pine					
Barringtonia racemosa Roxb.		Continuous	Continuous	50 feet	6d. packet	
Berria cordifolia Burret		February	May	40 feet	6d. packet	
Bombax ellipticum H.B. & K.		Y	Y			
Brassaia actinophylla F. Muell.		Y	Y			
Caesalpinia coriaria Willd.	"Divi-divi"	March–April	July–August	45 feet	6d. packet	
Caesalpinia Sappan Linn.		Continuous	Continuous	25 feet	6d. packet	
Calophyllum Inophyllum Linn.		May–June	October–December	40 feet	6d. packet	
Carapa guianensis Aubl.	Crabwood	Y	Y			

		Flowering period.	Seeding period.	Approximate average height.	Material available.	
					Seeds.	Plants, &c.
TREES, GENERAL—*continued.*						
Casuarina equisetifolia Linn.		Continuous	Continuous	120 feet	6d. packet	P. 12s. doz.
Cedrela odorata Linn.		April–May	November–December	60 feet	6d. packet	
Cola acuminata Schott & Endl.		Continuous	Continuous	40 feet	6d. packet	
Crescentia Cujete Linn.		Continuous		20 feet		
Cupressus funebris Endl.		Y	Y			
Dipteryx odorata Willd.	Tongka bean	Y	Y			
Elaeocarpus serratus Linn.		October–November	January–February	40 feet	6d. packet	
Enterolobium cyclocarpum Griseb.		Y	Y			
Erythrina variegata Linn. = (*E. indica* Lam.)				25 feet		C. 3s. doz.
Erythrophleum guineense G. Don.		September–October	December–January	60 feet	6d. packet	
Eucalyptus deglupta Blume	"Kamerere"	Irregular	Irregular	80 feet	6d. packet	
Eugenia grandis Wight		Y	Y			
Ficus gibbosa Blume		Continuous	Continuous	70 feet	6d. packet	
Filicium decipiens Thw.		Y	Y			
Firmiana colorata R.Br. = (*Sterculia colorata* Roxb.)		Y	Y			
Glochidion nova-guineense K. Schum.		Continuous	Continuous	45 feet	6d. packet	
Grevillea robusta A. Cunn.	Silky oak					
Haematoxylon campechianum Linn.	Logwood					
Heritiera littoralis Dryand		Continuous	Continuous	30 feet		
Hibiscus tiliaceus Linn.		Continuous	Continuous	30 feet	6d. packet	
Intsia bijuga Kuntze = (*Afzelia bijuga* A. Gray)	"Kwila"	October–December	January-March	70 feet	6d. packet	
Kigelia pinnata D.C.		September–October	November–December	50 feet	6d. packet	
Laportea Gigas Wedd.	Stinging tree					
Mangifera foetida Lour.		Irregular	Irregular	60 feet	6d. packet	
Melaleuca Leucadendron Linn.		August				
Moringa oleifera Lam. = (M. *pterygosperma* Gaertn.)	Horse radish tree	Continuous		50 feet		C. 3s. doz.
Myroxylon balsamum Druce	Balsam of Tolu		April–May	50 feet	6d. packet	
Ochroma Lagopus Swartz	Cork wood	June–September	October–December	50 feet	6d. packet	
Octomeles sumatrana Merr. = (Octomiles *Sumatranus* Miq.)	"Erima"	Continuous	Continuous	80 feet	6d. packet	
Oroxylum indicum Vent.		April–May	August–October	45 feet	6d. packet	
Pandanus Leram Jones		Continuous	Continuous	40 feet	6d. packet	

—		Flowering period.	Seeding period.	Approximate average height.	Material available.	
					Seeds.	Plants, &c.
TREES, GENERAL—*continued.*						
Pandanus dubius Spreng.		Continuous	Continuous	30 feet	6d. packet	
Pandanus labyrinthicus Kurz.		Continuous	Continuous	30 feet	6d. packet	
Pandanus tectorius Soland.		Continuous	Continuous	30 feet	6d. packet	
Parkia intermedia Hassk.		May	July–August	100 feet	6d. packet	
Parkia Roxburghii G. Don.		Y	Y			
Parmentiera cereifera Seem.	Candle tree	November–January	March–April	25 feet	6d. packet	
Pericopsis Mooniana Thw.		Y	Y			
Pometia pinnata Forst.	"Towan"	December–February	April–June	70 feet		
Pongamia pinnata Merr.	Indian beech	Continuous	Continuous	40 feet	6d. packet	
Prosopis juliflora DC.	Mesquite					
Pterocarpus indicus Willd.	Padouk	Y	Y			
Ravenala madagascariensis J. F. Gmel.	Traveller's tree			30 feet		S. 6s. doz.
Sapindus Saponaria Linn.	Soap-berry tree	Y	Y			
Saraca indica Linn.	Asoka	September				
Sterculia Balanghas Linn.		May	August–September	40 feet	6d. packet	
Swietenia macrophylla King.	Mahogany	Y	Y			
Swietenia Mahogani Jacq.	Mahogany	Y	Y			
Tabebuia Guayacan Hemsl.		Y	Y			
Tectona grandis Linn.	Teak	Continuous	Continuous	60 feet	6d. packet	
Terminalia Catappa Linn.	"Talis"	Irregular	Irregular	50 feet	6d. packet	
Tetrapleura Thonningii Benth.		Y	Y			
Tripetalum cymosum K. Schum.		Irregular	Irregular	25 feet	6d. packet	P. 6s. doz.
Tripetalum cymosum, forma pendula	"Tambun"	Irregular	Irregular	25 feet	6d. packet	P. 12s. doz.
PALMS.						
Acoelorraphe Wrightii H. Wendl.		Y	Y			S. 30s. doz.
Areca Catechu Linn.	Betel-nut	Continuous	Continuous	40 feet	6d. packet	P. 6s. doz.
Arenga pinnata Merr.	Sugar palm	Y	Y			
Bentinckiopsis ponapensis Becc.		Y	Y			
Borassus flabellifer Linn.	Palmyra palm	Y	Y			
Calamus spp.	Rattan palms	Irregular	Irregular	Climbers	6d. packet	P. 6s. doz.
Caryota Rumphiana Mart.		Continuous	Continuous	50 feet	6d. packet	P. 6s. doz.
Chrysalidocarpus lutescens H. Wendl.		Continuous	Continuous	20 feet	6d. packet	P. 18s. doz.
Cocos plumosa Hook.		Y	Y			
Copernicia cerifera Mart.	Carnauba wax palm	Continuous		30 feet		

		Flowering period.	Seeding period.	Approximate average height.	Material available.	
					Seeds.	Plants, &c.
PALMS—*continued.*						
Corypha umbraculifera Linn. ..	Talipot palm ..	Y	Y			
Cyrtostachys lakka Becc.	"Sealing wax" palm	Y	Y			
Jubaea spectabilis H. B. & K. ..	.. ..	Y	Y			
Latania Commersonii J. F. Gmel. ..	.. ..	Continuous ..	Continuous ..	30 feet	6d. packet	P. 18s. doz.
Latania Loddigesii Mart.	.. ..	Continuous ..	Continuous ..	30 feet	6d. packet	P. 18s. doz.
Licuala paludosa Griff.	.. ..	Continuous ..	Continuous ..	6 feet	6d. packet	
Livistona altissima Zoll.	.. ..	Continuous ..	Continuous ..	70 feet	6d. packet	P. 18s. doz.
Livistona australis Mart.	.. ..	Continuous ..	Continuous ..	40 feet	6d. packet	P. 18s. doz.
Livistona chinensis R.Br.	.. ..	Y	Y			
Livistona Hoogendorpii Hort. ..	.. ..	Y	Y			
Livistona mariae F. Muell.	.. ..	Y	Y			
Martinezia caryotaefolia H. B. & K. ..	.. ..	Y	Y			
Metroxylon Sagu Rottb.	Sago palm ..	Y	Y			
Metroxylon Rumphii Mart.	Sago palm ..	Y	Y			
Oreodoxa oleracea Mart.	Cabbage palm	Continuous ..	Continuous ..	80 feet	6d. packet	
Oreodoxa regia H. B. & K.	Royal palm ..	Continuous ..	Continuous ..	70 feet	6d. packet	P. 18s. doz.
Phoenix canariensis Chabaud. Hort.	.. ..	Y ..	Y			
Phoenix pusilla Gaertn.	.. ..	Y	Y			
Phoenix reclinata Jacq.	.. ..	Y	Y			
Phoenix zeylanica Trimen = *P. pusilla* Gaertn.						
Pinanga micronesica Kan.	.. ..	Y	Y			
Ponapea hoshinoi Kan.	.. ..	Y	Y			
Ponapea Leddermanniana Becc. ..	.. ..	Y	Y			
Ptychosperma Macarthurii H. Wendl.	.. ..	Continuous ..	Continuous ..	20 feet	6d. packet	P. 18s. doz.
Raphia Hookeri Mann & H. Wendl. ..	.. ..	Dies after seeding ..	.. ..	50 feet	6d. packet	
Sabal Blackburnianum Glazebrook ..	.. ..	Continuous ..	Continuous ..	40 feet	6d. packet	
Sabal mauritiiforme Griseb. & H. Wendl.	.. ..	Continuous ..	Continuous ..	40 feet	6d. packet	
Sabal Palmetto Lodd.	.. ..	Continuous				
Thrinax barbadensis Lodd.	.. ..	Y	Y			
Thrinax parviflora Swartz	.. ..	Continuous ..	Continuous ..	20 feet	6d. packet	
Veitchia Joannis H. Wendl. ..	.. ..	Continuous ..	Continuous ..	30 feet	6d. packet	
Verschaffeltia splendida H. Wendl. ..	.. ..	Y	Y			
Washingtonia filifera H. Wendl. ..	.. ..	Y	Y			

List of Plants in Cultivation in the Botanic Gardens, Rabaul.

Arranged according to their Natural Orders.

Including particulars of the material available for distribution.

The second column indicates the nature of the material which can be distributed; the third column the time at which such material is available.

Abbreviations used:—

r.	..	roots.
s.	..	seed.
su.	..	suckers.
b.	..	bulbs.
c.	..	cuttings.
p.	..	plants.
Con.	..	Continuous.
Irr.	..	Irregular.

PTERIDOPHYTA.

Filicinae.

Adiantum concinnum H.B.K.	r.	Con.
Adiantum farleyense T. Moore	r.	Con.
Adiantum gracillimum T. Moore	r.	Con.
Adiantum peruvianum Klotzsch	r.	Con.
Adiantum trapeziforme Linn.	r.	Con.
Alsophila atrovirens Presl. ..	..	..
Alsophila crenata Pahl. ..	..	..
Asplenium nidus(-avis) Linn.	..	..
Selaginella flabellata Spring	r.	Con.
Selaginella umbrosa ..	r.	Con.

GYMNOSPERMAE.

Coniferae.

Araucaria Bidwilli Hook ..	..	..
Araucaria Cunninghamii Ait.	..	..
Araucaria excelsa R.Br. ..	..	..
Cupressus funebris Endl. ..	..	..

Cycadaceae.

Cycas Rumphii Miq. ..	s.	Con.

MONOCOTYLEDONES.

Amaryllideae.

Agave sisalana Perrine ..	su.	Con.
Agave vera-cruz Mill. ..	su.	Con.
Crinum asiaticum Linn. ..	b.	Con.
Crinum giganteum Andr. ..	b.	Con.
Crinum Moorei Hook f. ..	b.	Con.
Crinum pedunculatum R.Br.	b.	Con.
Furcraea gigantea Vent. ..	su.	Con.
Haemanthus multiflorus Martyn	b.	Con.
Hippeastrum reticulatum Herb.	b.	Con.
Hippeastrum vittatum Herb.	b.	Con.
Zephyranthes rosea Lindl. ..	b.	Con.

MONOCOTYLEDONES—*continued.*

AROIDEAE.

Aglaonema commutatum Schott		
Aglaonema costatum N.E.Br.		
Alocasia indica Schott		
Amorphophallus campanulatus Blume	s.	Irr.
Anthurium cristallinum Linden and André		
Anthurium macrolobium Hyb.		
Dieffenbachia Bowmanni Carr.	c.	Con.
Dieffenbachia magnifica Linden and Rodigas	c.	Con.
Monstera deliciosa Liebm.	p.	Con.
Spathiphyllum commutatum Schott	p.	Con.

Bromeliaceae.

Ananas comosus Merr.	su.	Con.
Billbergia pyramidalis Lindl.		
Billbergia saundersii Hort		
Karatas morreniana Antoine		
Karatas spectabilis Antoine		

Cyclanthaceae.

Carludovica palmata Ruiz & Pavon	s.su.	Con.

Gramineae.

Bambusa arundinacea Willd.	r.	Con.
Bambusa aurea Siebold	r.	Con.
Bambusa multiplex Raeusch	r.	Con.
Bambusa siamensis Kurz. = (*B. bregia* Thoms.)	r.	Con.
Bambusa vulgaris Schraed.	r.	Con.
Chrysopogon aciculatus Trin.	s.r.	Con.
Coelorrachis glandulosa Stapf.	s.r.	Con.
Cymbopogon nardus Rendle	s.	Con.
Cynodon dactylon Pers.	s.r.	Con.
Dendrocalamus giganteus Munro	r.	Con.
Dendrocalamus strictus Nees	r.	Con.
Gigantochloa verticillata Munro	r.	Con.
Imperata cylindrica Beauv.	s.	Con.
Melinis minutiflora Beauv.	s.	Con.
Pennisetum Clandestinum Hochst	r.	Con.
Pennisetum Purpureum Schum.	s.	Con.
Saccharum officinarum Linn.	c.	Con.
Vetiveria Zizanoides Nash	r.	Con.

Haemodoraceae.

Sansevieria guineensis Willd.	su.	Con.
Sansevieria zeylanica Willd.	su.	Con.

Liliaeceae.

Dracaena sanderiana Hart.	c.	Con.
Dracaena Victoriae Hort	c.	Con.
Gloriosa Rothschildiana O'Brien	s.b.	Con.
Gloriosa superba Linn.	s.b.	Con.
Yucca gloriosa Linn.	su.	Con.

Orchidaceae.

Vanilla planifolia Andr.	c.	Con.

MONOCOTYLEDONES—*continued*.

Palmae.

Acoelorraphe Wrightii H. Wendl.	su.	..
Areca Catechu Linn.	s.	Con.
Arenga pinnata Merr.	s.p.	..
Bentinckiopsis ponapensis Becc.	..	..
Borassus flabellifera Linn.	..	..
Calamus spp.	s.p.	Irr.
Caryota Rumphiana Mart.	s.p.	Con.
Chrysalidocarpus lutescens H. Wendl.	s.p.	Con.
Cocos nucifera Linn.	s.	Con.
Cocos plumosa Hook	..	..
Copernicia cerifera Mart.	..	Con.
Corypha umbraculifera Linn.	..	..
Cyrtostachys lakka Becc.	..	..
Elaeis guineensis Jacq.	s.	Con.
Jubaea spectabilis H.B. & K.	..	..
Latania Commersonii J. F. Gmel.	s.p.	Con.
Latania Loddigesii Mart.	s.p.	Con.
Licuala paludosa Griff.	s.	Con.
Livistona altissima Zoll.	s.p.	Con.
Livistona australis Mart.	s.p.	Con.
Livistona chinensis R.Br.	..	..
Livistona Hoogendorpii Hort	..	..
Livistona mariae F. Muell.	..	..
Martinezia caryotifolia H.B. & K.	..	..
Metroxylon sagu Rottb.	..	..
Metroxylon Rumphii Mart.	..	..
Oreodoxa oleracea Mart.	s.	Con.
Oreodoxa regia H.B. & K.	s.p.	Con.
Phoenix canariensis Chabaud Hort	..	..
Phoenix pusilla Gaertn.	..	..
Phoenix reclinata Jacq.	..	..
Phoenix zeylanica Trimen	..	..
Pinanga micronesica Kan.	..	..
Ponapea hoshinoi Kan.	..	..
Ponapea Leddermanniana Becc.	..	..
Ptychosperma Macarthurii H. Wendl.	s.p.	Con.
Raphia Hookeri Mann & H. Wendl.	s.	..
Sabal Blackburnianum Glazebrook	s.	Con.
Sabal Mauritiiforme Grisob and H. Wendl.	..	..
Thrinax barbadensis Lodd.	..	..
Thrinax parviflora Swartz	s.	Con.
Veitchia Joannis H. Wendl.	s.	Con.
Verschaffeltia splendida H. Wendl.	..	..
Washingtonia filifera H. Wendl.	..	..
Zalacca edulis Blume	su.	Con.

DICOTYLEDONES.

Acanthaceae.

Barleria cristata Linn.	s.	Con.
Barleria lupulina Lindl.	s.	Con.
Eranthemum atropurpureum Hort	c.	Con.
Ruellia tuberosa Linn.	p.	Con.

DICOTYLEDONES—*continued.*

Acanthaceae—continued.

Thunbergia erecta T. Anders	c.p.	Con.
Thunbergia fragrans Roxb.	c.	Con.
Thunbergia grandiflora Roxb.	c.	Con.

Amarantaceae.

Alternanthera amoena Voss.	c.	Con.
Amaranthus gangeticus Linn.	s.	Con.

Anacardiaceae.

Anarcardium occidentale Linn.	..	..
Mangifera foetida Lour.	s.	Irr.
Mangifera indica Linn.	s.p.	Con.
Spondias pinnata Kurtz = (*S. mangifera* Will.)	s.	Jan.–Mar.

Annonaceae.

Annona Cherimolia Mill.	s.p.	Con.
Annona glabra Linn.	s.p.	Con.
Annona muricata Linn.	s.p.	Con.
Annona reticulata Linn.	s.p.	Con.
Annona squamosa Linn.	s.p.	Con.
Canangium odoratum Baill.	s.p.	Con.
Monodora tenuifolia Benth.	..	..

Apocynaceae.

Allamanda hendersoni Bull	c.p.	Con.
Allamanda schottii Pohl.	s.c.	Con.
Allamanda violacea Gardn.	c.	Con.
Alstonia scholaris R.Br.	s.	Sept.–Oct.
Beaumontia grandiflora Wall	c.	Con.
Carissa Carandas Linn.	..	..
Ervatamia coronaria Stapf.	p.	Con.
Funtumia elastica Stapf.	s.	Con.
Landolphia Heudelotii A.D.C.	c.	Con.
Nerium Oleander Linn.	c.	Con.
Odontadenia speciosa Benth.	..	..
Plumeria acutifolia Poir.	s.c.p.	Con.
Plumeria alba Linn.	c.	Con.
Plumeria rubra Linn.	..	..
Strophanthus gratus Baill.	c.	Con.
Strophanthus hispidus DC.	c.	Con.
Thevetia neriifolia Juss.	s.p.	Con.
Vinca rosea Linn.	s.	Con.

Araliaceae.

Aralia Balfouriana Hort.	c.	Con.
Aralia filicifolia Chr. Moore	c.	Con.
Aralia Veitchii T. Moore-Hort.	c.	Con.
Brassaia actinophylla F. Muell.	..	..
Panax fruticosum Linn.	c.	Con.

Aristolochieae.

Aristolochia floribunda Lam.	s.	Con.
Aristolochia grandiflora Arrunda	s.	Con.
Aristolochia hians Willd.	s.	Con.

DICOTYLEDONES—*continued.*

	Begoniaceae.		
Begonia Bismarcki Hyb.			
Begonia rex Putz.			
Begonia semperflorens Link & Otto.			
Begonia socatrana Hook			
	Bignoniaceae.		
Arrabidaea magnifica Sprague	c.		Con.
Bignonia unguis-cati Linn.	c.		Con.
Bignonia venusta Ker-Gawl.	c.		Con.
Crescentia Cujete Linn.			
Jacaranda mimosaefolia D. Don.			
Kigelia pinnata D.C.	s.		Nov.-Dec.
Oroxylum indicum Vent.	s.		Aug.-Oct.
Parmentiera cerifera Seem.	s.		Mar.-April
Spathodea campanulata Beauv.	s.		Con.
Tabebuia Guayacan Hemsl.			
Tecoma capensis Lindl.	c.		Con.
Tecoma mollis H.B. & K.			
Tecoma smithii Hyb.	c.		Con.
Tecoma stans Juss.	c.		Con.
Tecoma velutina Lindl.	c.		Con.
Tecomanthe dendrophila K. Schumm.	c.		Con.
	Bixineae.		
Bixa orellana Linn.	s.p.		Con.
Flacourtia indica Merr.	s.		Con.
Oncoba spinosa Forsk.	s.		Con.
	Burseraceae.		
Canarium commune Linn.			
Canarium polyphyllum Schum.	s.		Sept.-Mar.
Filicium decipiens Thw.			
	Capparideae.		
Cleome speciosissima Deppe	s.		Con.
	Caprifoliaceae.		
Lonicera caprifolium Linn.	c.		Con.
Sambucus canadensis Linn.	s.		Con.
	Casuarineae.		
Casuarina equisetifolia Linn.	s.p.		Con.
	Combretaceae.		
Quisqualis indica Linn.	c.p.		Con.
Terminalia Catappa Linn.	s.		Irr.
	Compositae.		
Tithonia diversifolia A. Gray	s.		Con.
	Convolvulaceae.		
Ipomoea arborescens Sweet	c.		Con.
Ipomoea Batatas Lam.	c.		Con.
Porana paniculata Roxb.	c.		Con.
	Crassulaceae.		
Bryophyllum pinnatum Kurz	c.p.		Con.

DICOTYLEDONES—*continued.*

Cucurbitaceae.

Benincasa hispida Cogn.	s.	Con.
Macrozanonia macrocarpa Cogn.	s.	Irr.

Datisceae.

Octomeles sumatrana Merr. = (*Octomiles sumatranus* Miq.)	s.	Con.

Dilleniaceae.

Dillenia indica Linn.	s.	Irr.

Ebenaceae.

Diospyros discolor Willd.	s.	Mar.–May

Euphorbiaceae.

Acalypha godseffiana Masters	c.	Con.
Acalypha marginata Spreng	c.	Con.
Acalypha Sanderiana Hort	c.	Con.
Acalypha wilkesiana Muell. Arg. var. *macrophylla*	c.	Con.
Aleurites fordii Hemsl.		
Aleurites moluccana Willd.	s.	Oct.–Jan.
Antidesma Bunius Spreng		
Cicca acida Merr.	s.	Con.
Codiaeum variegatum Blume	c.p.	Con.
Euphorbia heterophylla Linn.	s.	Con.
Euphorbia pulcherrima Willd.	c.p.	Con.
Glochidion nova-guineense K. Schum.	s.	Con.
Hevea brasiliensis Muell.–Arg.	s.	Feb.–April
Jatropha Curcas Linn.	c.	Con.
Jatropha podagrica Hook	c.	Con.
Manihot utilissima Pohl.	c.	Con.
Manihot variegata	c.p.	Con.
Phyllanthus myrtifolius Moon	s.p.	Con.

Geraniaceae.

Averrhoa bilimbi Linn.	s.p.	Con.
Averrhoa Carambola Linn.	s.p.	Con.

Gesneraceae.

Achimenes grandiflora DC.	p.	Con.
Sinningia speciosa Hiern.	p.	Con.

Guttiferae.

Calophyllum Inophyllum Linn.	s.	Oct.–Dec.
Garcinia Mangostana Linn.		
Tripetalum cymosum K. Schum.	s.	Irr.

Labiateae.

Leonurus sibiricus Linn.	s.	Con.
Ocimum viride Willd.	s.	Con.
Pogostemon patchouly Pellet	c.	Con.

Lineae [*Erythroxylaceae ?*]

Erythroxylon nova-granatense Hieron.	s.	Con.

Laurineae.

Cinnamomum Zeylanicum Breyn	s.p.	Mar.–April.
Persea americana Mill.	s.p.	Oct.–Feb.

DICOTYLEDONES—*continued.*

Leguminosae.

Abrus precatorius Linn.	s.	Con.
Acacia catechu Willd.	s.	Con.
Acacia confusa Merr.		
Acacia sphaerocephala Cham. & Schlecht		
Adenanthera pavonina Linn.	s.	Mar.–April
Aeschynomene americana Linn.	s.	Con.
Albizzia falcata Backer		
Albizzia fastigiata Oliver		
Albizzia Lebbek Benth.	s.	Irr.
Albizzia procera Benth.	s.	Con.
Albizzia Sumatrana (Temp. sp. name Java)		
Bauhinia candida Roxb. (Synon. *B. variegata* ?)	s.	Con.
Bauhinia megalandra Griseb		
Bauhinia tomentosa Linn.	s.	Con.
Bauhinia variegata Linn.	s.	Con.
Caesalpinia coriaria Willd.	s.	July–Aug.
Caesalpinia pulcherrima Swartz	s.	Con.
Caesalpinia Sappan Linn.	s.	Con.
Cajanus cajan Druce	s.	Con.
Calliandra haematocephala Hassk.	s.	Con.
Calopogonium mucunoides Desv.	s.	Con.
Cassia alata Linn.	s.	Con.
Cassia bacillaris Linn., F.		
Cassia corymbosa Lam.		
Cassia Fistula Linn.	s.	July–Sept.
Cassia glauca Lam.		
Cassia grandis Linn.	s.	July–Sept.
Cassia javanica Linn.	s.	Con.
Cassia laevigata Willd.	s.	Con.
Cassia multijuga Rich	s.	July–Sept.
Cassia nodosa Buch.-Ham.	s.	July–Sept.
Cassia occidentalis Linn.	s.	Con.
Cassia siamea Lam.	s.	Con.
Cassia sieberiana DC.	s.	July–Sept.
Centrosema pubescens Benth.	s.	Con.
Clitorea Ternatea Linn.	s.	Con.
Crotalaria anagyroides H.B. & K.	s.	Con.
Cynometra cauliflora Linn.	s.	Con.
Dipteryx odorata Willd.		
Enterolobium cyclocarpum Griseb.		
Enterolobium Saman Prain...	s.	Irr.
Erythrina crassifolia Koonders and Valeton	c.	Con.
Erythrina lithosperma Blume ?	c.	Con.
Erythrina variegata Linn.	c.	Con.
Erythropleum guineense D. Don.	s.	Dec.–Jan.
Flemingia strobilifera R.Br.	s.	Con.
Gliricidia maculata H.B. & K.	s.	Con.
Haematoxylon campechianum Linn.		
Indigofera arrecta Hockst.	s.	Con.
Inocarpus edulis Forst.	s.	Con.
Intsia bijuga Kuntze	s.	Jan.–Mar.

DICOTYLEDONES—*continued.*

Leguminosae—continued.

Leucaena glauca Benth.	s.c.	Con.
Lysidice rhodostegia Hance		
Melia Azedarach Linn.	s.	irr.
Mimosa invisa Mart.	s.	Con.
Macuna Kraetkei Warb.		
Myroxylon balsamum Druce	s.	April–May.
Parkia intermedia Hassk.	s.	July–Aug.
Parkia Roxburghii G. Don.		
Pericopsis Mooniana Thw.		
Peltophorum pterocarpum Backer	s.	Irr.
Phaseolus vulgaris Linn.	s.	Con.
Poinciana regia Boj.	s.	Irr.
Pongamia pinnata Merr.	s.	Con.
Prosopis juliflora DC.		
Psophocarpus tetragonobulus DC.	s.	Con.
Pterocarpus indicus Willd.		
Pueraria javanica Benth.	c.	Con.
Saraca indica Linn.		
Schizolobium excelsum Vog.	s.	Irr.
Sesbania coccinea Poir.	s.	June–Sept.
Tamarindus indica Linn	s.	June–Sept.
Tephrosia candida DC.	s.	Con.
Tephrosia pumila Pers.	s.	Con.
Tetrapleura Thonningii Benth.		

Lythrarieae.

Lagerstroemia Flos-reginae Retz	s.p.	Con.
Lagerstroemia indica Linn	c.	Con.
Lagerstroemia tomentosa Presl.	c.	Con.
Punica Granatum Linn.	s.	Con.

Magnoliaceae.

Michelia alba DC.		
Michelia Champaca Linn.	s.	Con.

Malpighiaceae.

Galphimia gracilis Bartl.	s.	Con.
Malpighia coccigera Linn.	s.	Irr.

Malvaceae.

Abelmoschus manihot Linn.	c.	Con.
Abutilon indicum Sweet	c.	Con.
Bombax ellipticum H.B. & K.		
Ceiba pentandra Gaertn.	s.	Oct.–Nov.
Durio Zibethinus Murr.		
Hibiscus esculentus Linn.	s.	Con.
Hibiscus Rosa-sinensis Linn.	c.p.	Con.
Hibiscus sabdariffa Linn.	s.	Con.
Hibiscus schizopetalus Hook. f.	c.	Con.
Hibiscus tiliaceus Linn.	s.	Con.
Ochroma lagopus Swartz	s.	Oct.–Dec.
Pachira insignis Savign.	c.	Con.
Sida rhombifolia Linn.	s.	Con.
Urena lobata Linn.	s.	Con.

DICOTYLEDONES—*continued.*

Meliaceae.		
Aglaia odorata Lour.	p.	Con.
Carapa guianensis Aubl.		..
Cedrela odorata Linn.	s.	Nov.–Dec.
Lansium domesticum Jack		..
Swietenia macrophylla King		..
Swietenia Mahogani Jacq.		..
Moringeae.		
Moringa oleifera Lam.	c.	Con.
Myristiceae.		
Myristica Fragrans Linn.?—Houtt.	s.	Irr.
Myrtaceae.		
Barringtonia edulis Seem.	s.	Con.
Barringtonia racemosa Roxb.	s.	Con.
Bertholletia excelsa Humb. & Bonpl.		..
Couroupita guianensis Aubl.	s.p.	Con.
Eucalyptus deglupta Blume.	s.	Irr.
Eugenia brasiliensis Lam.	s.p.	Con.
Eugenia grandis Wight.		..
Eugenia jambolana Lam.		..
Eugenia Jambos Linn.		..
Eugenia javanica Lam.		..
Eugenia malaccensis Linn.	s.p.	Aug.–Sept.
Melaleuca Leucadendron Linn.		..
Psidium Cattleianum Sabine	s.	Con.
Psidium Guajava Linn.	s.	Con.
Rhodomyrtus tomentosa Wight	c.	Con.
Nyctagineae.		
Bougainvillaea spectabilis Willd.	c.p.	Con.
Bougainvillaea spectabilis var. *laterita* as sp. Hort	c.	Con.
Bougainvillaea spectabilis var. Mrs. Butt	c.p.	Con.
Nymphaeaceae.		
Nelumbium speciosum Willd. = (*Nymphaea lotus* Linn.)	s.	Con.
Oleaceae.		
Jasminum sambac Soland.	c.	Con.
Papaveraceae.		
Bocconia frutescens Linn.		..
Passifloreae.		
Carica Papaya Linn.	s.p.	Con.
Passiflora edulis Sims.	s.p.	Con.
Passiflora foetida Linn.	s.	Con.
Passiflora quadrangularis Linn.	s.p.	Con.
Piperaceae.		
Piper Betle Linn.		..
Piper nigrum Linn.	c.	Con.
Plumbagineae.		
Plumbago capensis Thunb.	p.	Con.
Plumbago indica Linn.	p.	Con.
Plumbago zeylanica Linn.	p.	Con.

DICOTYLEDONES—*continued.*

Polygonaceae.			
Antigonon leptopus Hook & Arn.	s.p.	..	Con.
Proteaceae.			
Grevillea robusta A. Cunn.	..	..	..
Macadamia ternifolia F. Muell.	..	..	..
Ranunculaceae.			
Clematis paniculata Thunb.	c.	..	Con.
Clematis triloba Heyne.	c.	..	Con.
Rosaceae.			
Chrysobalanus Icaco Linn.	s.	..	Con.
Eriobotrya japonica Lindl.	..	..	..
Rubiaceae.			
Coffea arabica Linn.	s.	..	Con.
Coffea robusta Linden	s.	..	Con.
Gardenia florida Linn.	c.	..	Con.
Ixora coccinea Linn.	s.c.	..	Con.
Ixora congesta Roxb.	s.c.	..	Con.
Ixora Dixiana Hort.	s.c.	..	Con.
Ixora javanica DC.	s.c.	..	Con.
Ixora lutea Hutch.	s.c.	..	Con.
Ixora macrothyrsa Teijsm & Binn.	s.c.	..	Con.
Ixora multibracteata Pearson	s.c.	..	Con.
Ixora occulata	s.c.	..	Con.
Ixora rosea K. Schum.	s.c.	..	Con.
Ixora stricta Roxb.	s.c.	..	Con.
Macrosphyra longistyla Hook f.	s.	..	Con.
Mussaenda frondosa Linn.	c.	..	Con.
Randia maculata DC.	..	..	..
Serrisa foetida Comm.	c.	..	Con.
Rutaceae.			
Aegle Marmelos Correa.	..	..	..
Clausena Wampi Oliver	..	..	..
Murraya exotica Linn.	s.p.	..	Con
Sapindaceae.			
Nephelium lappaceum Linn.	s.p.	..	Irr.
Nephelium Lit-chi Cambess	..	..	..
Nephelium Longana Cambess	..	..	..
Pometia pinnata Forst.	s.	..	April–June
Sapindus Saponaria Linn.	..	..	..
Sapotaceae.			
Achras zapota Linn.	s.	..	Oct.–Dec.
Chrysophyllum cainito Linn.	..	..	.
Lucuma nervosa A.D.C. = (*L. Rivicoa* Gaertn. f.)	s.	.	July–Sept.
Mimusops bojeri A.D.C.	..	.	.
Saxifrageae.			
Hydrangea Hortensia Siebold	c.		Con.
Scrophularineae.			
Russelia juncea Zucc.	c.		Con.
Torenia Fournieri Linden	s.p.		Con.
Uroskinnera spectabilis Lindl.	c.		Con.

DICOTYLEDONES—*continued.*

Simarubeae.

Brucea amarissima Desv. ? Merr.	..	s.	Con.
Quassia amara Linn.	..	s.	Con.

Solanaceae.

Brunfelsia americana Linn.	..	s.	Con.
Capsicum annum Linn.	..	s.	Con.
Datura metel Linn.	..	s.	Con.
Nicotiana Tabacum Linn.	..	s.	Con.
Solanum jasminoides Paxt.	..	s.	Con.
Solanum macranthum Dun.	..	s.	Con.
Solanum mammosum Linn.	..	s.	Con.
Solanum Melongena Linn.	..	s.	Con.

Sterculiaceae.

Abroma augusta Linn.	..	s.	Con.
Cola acuminata Schott & Endl.	..	s.	Con.
Firmiana colorata R.Br.	..	..	..
Heritiera littoralis Dryand.	..	s.	Con.
Kleinhovia Hospita Linn.	..	s.	Con.
Sterculia Balanghas Linn.	..	s.	Aug.–Sept.
Theobroma cacao Linn var *criollo*	..	s.	Con.
Theobroma cacao Linn. var *criollo forastero* hybrid		s.	Con.

Tiliaceae.

Berria cordifolia Burret.	..	s.	May
Elaeocarpus serratus Linn.	..	s.	Jan.–Feb.
Muntingia Calabura Linn.	..	s.	Con.

Urticaceae.

Artocarpus communis Forst.	..	s.p.	Dec.–Mar.
Artocarpus integra Merr.	..	s.	Con.
Castilloa elastica Cerv.	..	s.	Con.
Ficus elastica Roxb.	..	c.	Con.
Ficus gibbosa Blume.	..	s.	Con.
Laportea Gigas Wedd.	..	p.	Con.
Morus nigra Linn...	..	c.	Con.

Verbenaceae.

Clerodendron fallax Lindl.	..	c.	Con.
Clerodendron fragrans R.Br.	..	s.c.	Con.
Clerodendron Minahhassae Teijsm. & Binn.		c.	Con.
Clerodendron paniculatum Linn.	..	p.	Con.
Clerodendron Thomsonae Balf. f.	..	c.	Con.
Clerodendron Thomsonae var. *balfourii*		c.	Con.
Congea tomentosa Roxb.	..	c.	Con.
Duranta repens Linn. = (*D. plumieri* Jacq.)		s.	Con.
Lantana aculeata Linn.	..	c.p.	Con.
Lantana trifolia Linn.	..	c.	Con.
Petrea volubilis Linn.	..	c.	Con.
Stachytarpheta jamaicensis Vahl.	..	s.	Con.
Tectona grandis Linn.	..	s.	Con.
Vitex trifolia Linn.	..	c.	Con.

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