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THE COCO-NUT LEAF-MINER

Promecotheca papuana, *Csiki* (*antiqua*, Wse.)*

(*John L. Froggatt, B.Sc., Entomologist.*)

Marked infestation by *P. papuana* sporadically occurs in various parts of the Territory, but it is usually worst in those parts where no definite dry period occurs throughout the year. Its attacks are not confined to palms of any particular age, occurring from the young plant with one or more expanded leaves to a palm 80 feet or more in height.

Infestation usually begins along the sea frontage, and, if not checked, later spreads inwards. In the early stages, the attack is confined to a limited number of palms, and may be localized in one or more groups of palms. Under normal conditions, the pest is held in control by *Microhymenopterous* parasites of the eggs and larvae.

At the end of 1937, this pest appeared along that portion of the North Coast-road from Rabaul, where coco-nut palms and all other vegetation had suffered severely from the effects of the deposition of pumice dust resulting from the eruptions in Blanche Bay in May of that year. In the early stages of infestation the attack was limited to a comparatively narrow strip along the foreshore, but measures recommended were not adopted by the owners of plantations and groves within the area, and the infestation rapidly developed into severe plague form within the limits of a strip for the most part not more than a quarter of a mile wide from the sea. Small localized infestations occurred later at several sites along the roads leading from the North Coast towards Kokopo, and investigation showed that these were places where natives, carrying produce to and from native markets within this area, were accustomed to stop either to rest or for making a centre for sale. The produce was carried in baskets made from plaited coco-nut foliage, and examination of these baskets proved that many of them carried either *Promecotheca* egg masses or larvae; baskets on being emptied were thrown away into the undergrowth, and, in many cases, the adult beetles had bred out and attacked coco-nut palms in the immediate vicinity. Outside the main infested area a slight attack of the pest was seen, but natural parasites quickly stopped any serious development; within the severely infested area parasites gradually bred up naturally, and were assisted by liberation of adults bred in the laboratory, Rabaul, and, finally, by May, 1938, had the plague under control.

A short account of the life history of the pest and of the *Microhymenopterous* parasite indigenous to New Britain are here given, with directions for control.

The Adult Beetle.

The adult beetles are slightly less than 1 cm. in length (.8–.9 cm.), and about .4–.5 cm. in width; the antennae are dark, the head and thorax iridescent dark blue; slightly more than half of the anterior portion of the elytra (wing covers) is yellow to orange in colour and the remainder dark metallic blue. Colour variations occur in some parts of the Territory, the metallic blue markings being much reduced in extent and intensity, and the orange to almost a yellow-brown.

* *Vide Entomological Bulletin* No. 1, T.N.G., —*New Guinea Agricultural Gazette*, Vol. 2, No. 1., 1936.

At first, the beetles feed only on the younger foliage, and on the under-surface of the leaflets in lines running parallel with the veins in the leaf. The edges of these feeding areas shrivel and tend to contract the surrounding tissues, causing the leaflets to curl. Where the number of beetles is small, the amount of damage so caused is relatively slight, but as the numbers increase with the development of succeeding generations, the damage caused by the adults alone is considerable. As the female beetles become gravid and are ready to deposit eggs, a migration gradually takes place onto the older foliage, where feeding will then also take place.

Normally, the adults cling firmly to the under-surface of the foliage, but may be disturbed by high winds, or by persons approaching close to young palms. The beetles will then drop downwards from the leaf and then fly upwards, but they are not strong fliers and do not travel far on the wing.

Adults kept under observation in the insectaries on growing palms have lived for more than six weeks, but it is possible that this period may be longer under field conditions. Deposition of eggs under insectary conditions in Rabaul continued for nearly the whole life of the female and occurred in from four to six days after emergence from the mine.

After emerging from the pupae, the adults remain in the mine until the body has hardened up and then cut their way through the upper surface of the leaf, generally not eating a hole but cutting sufficient to form a flap.

The Eggs.

The eggs are laid flat on the under-surface of the leaflets, and covered with fine portions of undigested leaf tissue set together by a mucous secretion from the female. From one to four eggs may occur in mass, but two or three are the more common. The egg mass on the leaf presents a dome-shaped structure with the long axis of the mass slightly more than 3 mm. in length and the shorter width of about 2.5 mm.

The eggs are laid side by side, and measure slightly over 1.5 mm. (average 1.7 mm.) in length. The period from deposition of eggs to emergence of larvae has been from 11 to 17 days (average 12 days) in Rabaul, and 13 to 16 days in Manus.

The Larva.

On emergence, the larva breaks the surface of the leaf and commences to feed on the green tissue in between the two surfaces, which are thus caused to separate and form a " blister ". The leaf tissue so affected dies and turns brown. A single mine may extend the whole length of a leaflet, but is often very much shorter, depending largely on the number of larvae present. They feed straight ahead, the excreta being cast behind, but on such occasions as may arise where the mine comes against another older one, the larvae may turn and continue in another direction in fresh tissue; also, when they come to the tip of a leaflet, they may return through the mine and start out afresh from the other end or from some place on the side; such cases mostly occur when the infestation has developed into plague proportions.

The adult larvae are dull, creamy white in colour with a brown head-capsule, and measure slightly more than 1 cm. in length (average 1.2 cm.). There are three larval instars, which may be readily distinguished by the size of the head capsule, the average of a series of measurements being—

1st instar	.5421 mm.
2nd ,, ...	.7276 mm.
3rd ,, ...	1.0519 mm.

The larvae prior to moulting on the completion of each instar (stage of growth when the old skin is shed), and also before pupation, retreat from the head of the mine into the old channelling for two to three days. This habit often causes the death of many of the first instar larvae in particular, due to the drying of the tissues at the head of the mine forming a barrier that the newly-moulted larva cannot penetrate.

This dry band persits in the mines, even after the next stage larva passes on, as a faint dark line, and forms one means of determining what stage of development the larvae have reached in any mine. An examination of the cast head capsules in a mine also determines the stage of development of the larva.

The number of larvae present in a mine varies from one to four, a series of counts giving the following percentages:—

1 larva per mine	14.7
2 larvae ,, ...	45.9
3 ,, ,, ...	33.9
4 ,, ,, ...	5.5

Under insectary conditions in Rabaul, the larval stage varied from 17 to 23 days (average 18 days). In Manus this period has varied from 17 to 29 days.

The Pupa.

The pupa is light brown in colour, and measures slightly less than 1 cm. in length (.8 cm. average), and externally exhibits the structure of the adult, tightly compacted together. It is capable of a certain amount of movement within the mine, which is especially noticed if the walls of the mine are touched in the immediate vicinity of the pupa.

Under insectary conditions in Rabaul, the pupal period varied from 12 to 24 days (average 21 days). In Manus, this has varied from 15 to 16½ days.

Life Cycle.

From the figures obtained by breeding the beetles in insectaries in Rabaul, it has been found that the life cycle (the period from deposition of egg to emergence of adult) varies from 44 to 52 days, with an average of 48 days. In Manus, the life cycle has varied from 48 days to 60 days (average 55 days).

Control.

In order to control the pest before material damage is caused, it is essential that measures be undertaken as soon as the pest is first noticed. The pest population is then small and limited in spread, so that the extent of the work that has to be done is so much less than is the case once the pest has started to spread from the original centre of infestation.

There are three lines of attack that may be adopted, either singly or in conjunction with one another—mechanical measures, the use of insecticides as either spray or dust, and biological measures.

Mechanical Measures.

Wherever *Promecotheca* appears in numbers beyond normal for the locality, and while natural enemies, wasp parasites, are in insufficient numbers to hold the pest in check, cutting off and burning infested fronds, combined with collecting and destroying all the adult beetles possible, will check an infestation satisfactorily. This work must, however, be carried out thoroughly and extensively over the affected area. Such measures were carried out with success over a very large extent of coco-nut lands in the Philippines in 1930-31, and have also proved successful on more than one occasion in this Territory in the initial stages of an outbreak. If the fronds are cut carefully, the greater majority of the beetles will come to the ground on the fronds and can there be readily collected and destroyed.

In such cases as those in which flares on poles can be handled with reasonable ease, scorching of the undersurface of the fronds will kill large numbers of the beetles, and destroy larvae in the mines. Comparatively tall palms have been treated in this way by fastening half a dry coco-nut husk to the end of a long bamboo to the top end of which two long ropes were tied; one native held the base of the pole, and two others held the ropes at different points out from the base of the pole and drew the flare along the fronds and around the palm.

In areas where palms are sufficiently small to be reached from the ground or from low stages, the egg masses can be rubbed off the leaves, the adults collected, and the larvae crushed by drawing the mines through between the thumb and fingers; this would obviate the removal of the foliage.

In all cases where the parasites are found to be multiplying, any measures that lead to the destruction of the mines will kill large numbers of the wasps, and hinder the rate of natural control of the pest.

Any source from which the pest may travel into cultivated areas should be searched for and, when found, should be thoroughly treated.

A method that can be used with advantage to destroy numbers of the adult beetles where plentiful, is to cut fresh young fronds of any palms that may be attractive to the adults (e.g., "sak-sak," *Metroxylon saga*, or "nipa" palms, *Nipa fruticans*), and standing these upright in the ground in rows between the palms; the beetles come to rest on the fronds, on which they can be destroyed by spraying with strong soap solution, or other contact insecticide, or by hand collection.

Use of Insecticides.

Stomach poisons (such as lead or calcium arsenate), or contact insecticides (such as soap solution, lime sulphur fluid, or nicotine sulphate), can be applied as sprays or dusts, where power spraying or dusting machinery is available and, with the former, where sufficient supplies of soft water are readily obtainable. Nicotine sulphate (i.e., "Blackleaf 40") can be mixed with the arsenicals to make a combined stomach poison and contact mixture. It must be remembered that the action of a contact insecticide is relatively transitory, although the action may be fairly rapid, but the arsenicals remain on the foliage for an appreciable time after application.

For spraying, arsenate of lead is mixed at the rate of 1 lb. of the powder, or 1½ lb. of the paste form, to 50 gallons of water. Unless a "sticker" is already mixed with the powder, it is advisable to add some preparation that will assist in making the poison spread out on and adhere to the foliage; calcium caseinate is a general-purpose preparation that can be used for this purpose with safety.

Nicotine sulphate is obtainable as a standard preparation under the name of "Blackleaf 40", and is generally used at a rate of 1 part to 800 parts of water.

Using dry dusts, derris preparations can be used in addition to arsenicals, and, in tests carried out, it has been found that 10 per cent. arsenate of lead, using fine ground lime as a filler, and a preparation containing 1 per cent. "cube" content, killed 90 per cent. of the beetles treated within two days, and calcium arsenate killed 60 per cent. in the same time. Arsenate of lead and the derris preparation, combined in one dust, killed the same percentage as either alone.

Arsenate of lead sprayed on to foliage killed over 95 per cent., and the foliage so treated remained toxic for at least a week, even after being exposed to rain. Both nicotine sulphate and lime sulphur fluid killed the adult beetles quickly, but the foliage did not remain toxic for more than a few hours after application.

Biological Control.

The value of parasitic insects in the control of scale insects has been known for many years, but their use for the control of beetle pests is only of recent date.

During the course of observations on coco-nut pests in 1930, a small *Hymenopterous* parasite of the larvae of *Promecotheca* was found at two centres on the south coast of New Britain, and, later, the same parasite was collected at other centres on New Britain. At none of these places was there more than a trace of the pest, and the number collected was very small. Specimens sent to the Imperial Institute of Entomology, London, were determined as belonging to the family *Eurytomidae*, genus *Eurytoma*. The number of specimens available were insufficient to enable a specific identification to be made, but a larger series has since been despatched for this purpose. From information on hand, it is evident that this is the natural control of *Promecotheca papuana* in New Britain.

In the early stages of the *Promecotheca* outbreak on the North Coast-road, Rabaul, in 1937, this parasite was found in small numbers over the greater part of the infested area, but was definitely numerous outside that area. On the northern side of the infestation nearer to Rabaul, these wasps were more numerous than elsewhere within the affected sector. In those parts where the parasites were plentiful, the number of mines was so small that the possibilities of distribution of the wasps from these centres were strictly limited. In March, 1938, it was evident that the parasite had increased very considerably, and the effect of its work became marked over a large section of the area by early April.

With the supply of material available, breeding of the parasites was taken up in the laboratory in Rabaul, partly to study the life history and habits, and partly to breed up for liberation in the field. The wasp bred readily in captivity, especially in 2nd and 3rd instar larvae. The mines carrying the larvae were placed in glass tubes with parasites, which were fed on slightly-diluted honey, or sugar syrup; exposure of the mines to the parasites was maintained for three to four days, when the mines were placed in new tubes, and the parasites transferred on to new mines.

The adults of *Eurytoma* sp. are small metallic black wasps with an iridescent green sheen on the body: the joints and tarsi of the legs are whitish. The female measures up to 3.7 mm. (.15 of an inch) in length, with the male rather smaller (2.8 mm. = .1 of an inch). The antennae of the two sexes are quite distinct, and form a ready means of identification for separating the sexes in arranging the proportions in the breeding tubes.

The female wasp punctures the upper surface of the *Promecotheca* mine with the lancet-like ovipositor and deposits the eggs on the outside of the host larva. The parasite grubs, on emerging, attach themselves to the body of the *Promecotheca* grub and suck the body substance until only the mere skin remains. When the host larva is attacked, it retreats from the head of the mine, and becomes dormant, and exhibits little, if any, movement when disturbed.

The wasp larvae are elongated whitish bodies about 3 mm. in length when full grown; there are usually 4 to 5 per host larva, but there are often more. Pupation usually takes place on the site of feeding, each pupa being attached separately to the wall of the mine by the anal end of the body. The pupae are jet black in colour and are about the same size as the adults.

On emergence from the pupa, the adults remain for a short time within the mine, and then eat a small circular (emergence) hole through the leaf tissue, usually on the upper surface, although some emerge through the lower surface, immediately over the site of pupation. There may be any number of emergence holes from one to seven, but usually there are two to four per mine. As many as 25 adults have been bred from a single mine, but the number will obviously vary according to the number of *Promecotheca* larvae present.

The life-cycle has varied from 15 to 19 days (average 17 days) in the laboratory in Rabaul; the adults have lived for six to seven weeks, males usually dying before the females. Strong colonies have been bred, using female wasps six weeks old.

Eurytoma sp. is apparently only a larval parasite, more readily developing in the second and third instar larvae. Pupae placed in the tubes with the live parasites matured into adult beetles, although in a few mines dead pupae of *Promecotheca* have been found which appeared normal, but may have been attacked by wasp larvae which, although unable to penetrate the pupal integument, yet caused the death of the pupa.

Other Parasites Recorded from the Territory.

In the Rabaul-Kokopo and Gasmata areas other species of small wasp has been bred from *Promecotheca* larvae; the species has been identified as belonging to the family *Eulophidae, Closterocerus splendens,* Kovv.; this species has also been bred from *Promecotheca* larvae in Manus.

In the Manus district, two other larval, and one egg, *Hymenopterous* parasites have been bred from *Promecotheca* mines and egg-masses collected in the field. Both the larval parasites belong to the family *Eulophidae*, one a *Derostenus* sp., and the other *Entedon* sp.; the egg parasite has been identified as *Anastatus* sp.) (family *Eupelmidae*); *C. splendens* has also been bred from *Promecotheca* eggs collected on New Britain.

Small ants have been found destroying *Promecotheca* egg masses.

The "Kurukum" ant, *Oecophylla smaragdina virescens*, F., has often been stated to destroy *Promecotheca,* but our observations do not support this statement. Plantations and groves badly attacked by *Promecotheca* have been examined in which this ant was in swarms, not only in the heads of the palms, but on other vegetation amongst the palms. An experiment was carried out in the Talasea district, where an island on which *Promecotheca* infestation was present was selected, and these ants introduced from other parts, and left untouched for several weeks; the infestation at the end of the period had increased to severe proportions in the interim.

The Pentatomid *Amyotea reciprocus* Walk has been found attacking *Promecotheca* adults; this predator is, however, relatively scarce.

Promecotheca Parasites in Other Countries.

Taylor records two parasites of *Promecotheca reichei* Baly in Fiji—*Oligosita utilis* Kaw. of the eggs, and *Elasmus hispidarum* Ferr. of the larvae—and also a mite, *Pediculoides ventricosus* Newp. All the parasites referred to, except the mite *P. ventricosus*, are minute wasps.

The mite attacks the parasites as well as the *Promecotheca* larvae, and negatives the value of the wasp parasite to such an extent that Taylor was sent to Java to study any *Promecotheca* parasites in that country. Three primary parasites of *Promecotheca nuciferae* Maulik. were found,* of which *Pleurotropis*

* *Biological Control of an Insect Pest*, T. H. C. Taylor, 1937.

parvulus Ferr., a larval and pupal parasite, was successfully introduced into Fiji in 1933. This species was also introduced into the New Hebrides at the end of 1937 from Java by Dupertuis.

Larval parasites of *Promecotheca cumingi* Baly have been recorded from the Philippine Islands.

Introduction of P. parvulus into the Territory of New Guinea.

In 1936, the possibilities of introducing this parasite into this Territory from Fiji were investigated, but a combination of circumstances then prevented it being carried out.

Early in 1938, a colony of *Promecotheca* larvae, parasitized by *P. parvulus*, was sent from the New Hebrides through the courtesy of M. Dupertuis, but owing to extended delays in transit they were all dead on arrival. Later in the same year, through the assistance of W. R. Carpenter & Co. Ltd., and of the Department of Agriculture, Suva, another colony of adult *P. parvulus* was introduced from Fiji, by steamer to Sydney and thence by aeroplane to Rabaul, but these died *en route*. Finally, another colony from Fiji arrived alive on 6th September, 1938, partly as adults and partly as pupae in parasitized adult larvae of *Promecotheca*. This package was despatched in ship's cooler from Fiji to Sydney, where, on the ship's arrival, W. R. Carpenter & Co. Ltd. kept the parasites packed in ice, and, without delay, freighted them by mail 'plane to Rabaul.

The introduction of these parasites over so great a distance without personal and daily attention was due to a set of exceptionally favorable circumstances, that are rarely to be met with, owing to the synchronizing of steamer arrival and 'plane departure from Sydney. Any further period of cold storage in transit would almost certainly have been fatal to the parasites.

The adult parasites received were set on larvae of *Promecotheca papuana* the same day as received, and breeding work continued until all the parasites died. The first generation was not as large as was hoped for, possibly due to the effect of the long transit in cold storage. The second generation was, however, highly satisfactory, and liberations in the field were commenced within eight weeks of the receipt of the original colony.

A few notes are given on the life history, habits, &c., of this parasite, ascertained during the breeding work in developing the colony for acclimatization and distribution.

The adult females are about one-twentieth to one-twenty-fifth of an inch in length, with the males smaller; the former lived for a period up to 21 days, and the latter a few days less.

The adults are very active, the females being strongly attracted to light; they have fed freely on slightly diluted honey.

The life cycle occupied from 17 to 23 days, with an average of 19½ days.

The highest number of parasites from a mine containing three *Promecotheca* larvae was 39 in the first generation, and from a four-larvae mine 79 in the second generation.

FUMIGATION AND FUMIGANTS.

(*John L. Froggatt, B.Sc., Entomologist.*)

Insect pests infesting many forms of agricultural products, as well as orchard trees and nursery stocks, can be most effectively treated by the process of fumigation.

This is essentially a combined chemical and entomological matter; the chemical side comprising the study of gases for the dilution or saturation of the atmosphere surrounding the objects to be treated, which will be poisonous to the pests and non-poisonous to the materials on which the pests may be feeding. The entomological side of the work is to study the reaction of insects and plants to the different vapours and gases used, and determine the limits of susceptibility to each poison used of both pests and hosts.

As the chemical used, known as the fumigant, is a poisonous vapour or gas, it is essential that the greatest care be taken to render the enclosure inside which fumigation is to be carried out perfectly gastight. All cracks, holes and other openings must be closely sealed as the first step in the proceedings; pasting strips of brown paper over all such is generally sufficient, unless they are large. Lack of attention to such matters will easily lead to failure in results, and may even lead to the death of animals, or humans, in the vicinity of any leaks.

Provision for efficient ventilation after the process is completed is also essential before starting operations, in the case where buildings are to be treated. Furthermore, the work must be arranged to allow a margin of safety to enable the operator to leave the enclosure before the fumes become sufficient to catch him.

As the quantity of the fumigant, called the "dosage", depends on the cubic capacity of the enclosed space in which the operations are to be carried out, this must first be accurately determined.

Where live plants are not to be treated, the exposure to the gas should be from eight to twelve hours; with plants, the exposure is somewhat shorter.

Fumigation of orchard trees is carried out under specially prepared tents, and, where limited quantities of grain are to be treated, proofed tarpaulins can often be used. In all such cases, the bottom of the canvas must be covered over in such a way as to prevent escape of the fumigant.

Fumigation chambers for general purposes are made of concrete faced with bitumen, and provided with air-inlet valves at the bottom, and an air-exhausting plant at the top. Doors must be made so as to be gas-tight, as also must all air inlet and outlet openings.

When rice, wheat and other cereals and seeds are fumigated, they should be stored after treatment in insect-proof containers, otherwise re-infestation may result. Combining fumigation and storage of maize, &c., large galvanized iron tanks, with a pipe at the bottom which can be closed, are in common use in many countries. The fumigant can be introduced at the top and, after the required period for exposure, the pipe at the bottom is opened, and the fumigant vapours allowed to drain off, after which the openings at top and bottom are closed. Grain can be readily removed as required, and the remainder remains safe from re-infection.

Bulk storage is best maintained in concrete silos, arrangements for fumigation being made outside, and the grain, after treatment, being conveyed direct into the silo.

The choice of chemicals for commercial fumigation is rather limited, the main ones comprising—

Hydrocyanic acid (prussic acid).
Carbon disulphide.
Paradichlorbenzene.
Ethylene oxide.
Sulphur.
Nicotine.
Carbon tetrachloride.
Chloropocrin.

Hydrocyanic Acid Gas.

This is by far the most commonly-used fumigant, and is applicable to practically all fumigation purposes.

The gas is colourless and very slightly lighter than air; it has an odour resembling that of bitter almonds. It diffuses rapidly and, being lighter than air, this is mostly upwards. Under normal conditions, it will not penetrate readily through tightly packed materials, such as sacks of grain and flour. By partially exhausting the air from the chamber, this difficulty is largely eliminated.

The gas is one of the most deadly known poisons, very rapidly killing animals, and also plants when the dosage is too great or the exposure too prolonged.

Hydrocyanic acid gas can be generated in several ways.

1. *From Calcium Cyanide.*—This chemical is obtainable as a powder, in granules and in flakes, and in varying strengths; no acid is required for the generation of the gas, this taking place on exposure to the air, the rate of evolution being dependent on the humidity.

It is eminently suitable for the fumigation of buildings, plants, rodent burrows, and for the treatment of certain types of sap-sucking insects.

In the treatment of orchard trees, the trees are covered with tents and the powder blown in under force, thus eliminating all the trouble with containers, acid, &c., required by the "pot method", referred to later.

For buildings, &c., 1 lb. per 1,000 cubic feet of air space (where the strong grade is used) is sufficient for all ordinary purposes; about double this dosage is required with the weaker grade.

In the United States of America, for the treatment of grain in bulk storage, the chemical is run in with the grain in the chutes.

For the destruction of soil-frequenting pests, and rodents, the chemical is blown into the channels and burrows, and the openings plugged. Ant nests can be cleared out in a similar manner.

2. *From Liquified Hydrocyanic Acid.*—This is supplied in steel cylinders, and is freed by opening a valve at the top of the cylinder, the gas being led into the enclosure by pipes from the valve.

One pound of the liquid is sufficient to fumigate 3,000 cubic feet of air space in buildings, &c.

3. *By the Pot Method.*—In this, the gas is generated by mixing sodium or potassium cyanide in earthenware containers with sulphuric acid and water; specially enamelled iron basins can also be used as containers.

The proportions per 1,000 cubic feet of air space of the chemicals are—

Water	30 fluid ounces
Sulphuric acid (commercial)	15 fluid ounces
Sodium cyanide (pure)	10 ounces

The acid and water are *slowly* mixed togeher, otherwise splashing may occur, and the sodium cyanide dropped in. It is often advisable to place the weighed quantity of the cyanide in a thin paper bag, as the action of the acid on the cyanide is thereby delayed slightly, thus giving a greater margin of safety to the operator.

4. A special chamber or machine is in use in some parts in which the above chemicals are mixed, and the gas led into the fumigation chamber by pipes connected with the generator.

The use of calcium cyanide and liquified hydrocyanic acid are gradually replacing the older methods with the use of acid and potassium or sodium cyanide.

Another form in which this fumigant is available is felted-paper discs impregnated with the fumigant, and which on exposure to the air yield the poison gas. The dosage is varied according to the number of discs used.

Carbon Disulphide, CS_2.

In its commercial form, carbon disulphide is an almost colourless liquid with a strong and disagreeable smell. It rapidly volatilizes into a gas on exposure which, mixed with air, forms an explosively inflammable mixture. Great care has, therefore, to be exercised in using it, the glowing end of a cigarette or the glowing bowl of a pipe, or even a spark from two metal pieces striking together, being sufficient to ignite the vapours.

The gas is two and a half times heavier than air, and, therefore, sinks to the bottom of any container in which it is used; it has great penetrating power through tightly-packed materials. Any container in which it is used, therefore, must be thoroughly gas-tight.

This chemical cannot be used for the fumigation of living plants, owing to its high toxicity towards all forms of plant life and, even in small quantities, it will cause giddiness and nausea in humans.

It is well suited for the treatment of grain, and can also be used for the destruction of ant-nests; for the latter, a small quantity is poured into one or more holes in the nest, which is then covered with wet sacks; after five minutes, one of the bags can be lifted and a flare thrown on to the nest, which is shattered by the ensuing explosion.

The usual dosage for the treatment of grain is 4 to 5 pounds per 1,000 cubic feet of air space in the chamber, allowing 24 hours exposure. The temperature plays an important part in successful fumigation with this chemical, and should not be below 70 degrees Fahrenheit.

Owing to the vapours being so much heavier than air, the liquid should be placed in the top of the container either in a shallow basin, or poured on to sacks; by the latter method, a more rapid diffusion takes place.

Paradichlorbenzene $C_6H_4Cl_2$.

This chemical is available in a white crystalline form, and volatilizes readily on exposure to air; the vapours are about one and a quarter times heavier than air, and are non-inflammable.

It is used against certain root-boring and soil-frequenting insects, and for keeping seeds free from insect pests in storage; it cannot be used with grain that is for consumption by either humans or animals, as it leaves a very strong taint. Cases are on record where grain so treated, and fed to fowls, brought about a taint in the eggs, and, when such grain was fed to dairy cows, a taint came out in the milk.

It is excellent for the destruction of "white ants" (termites) in houses or timber when introduced into the channelling. It will penetrate further when dissolved in kerosene at the rate of 1 lb. to 4 gallons, and the solution poured in. It can also be used for the protection of furs and woollens in tightly closed containers.

The writer has used this chemical with very successful results against the "tobacco beetle", *Lasioderma serricorne* Fabr., infesting bindings of large ledgers, &c., treatment being carried out in a tightly-closed concrete chamber.

Ethylene Oxide $(CH_2)_2O$.

This chemical is a liquid with a boiling point of 14 degrees Centigrade (57 degrees Fahrenheit), and is used extensively at the Port of London for the fumigation of dried fruits, &c., steel barges with gas-proof covers being used for the purpose.

In application, about 10 per cent. of carbon dioxide is added to the fumigant in steel cylinders to provide a greater pressure for expulsion of the ethylene oxide.

Supplementary to this treatment, the warehouses where the cases are stored are sprayed with a solution of pyrethrins in a highly-refined non-volatile oil of the nature of medical paraffin.

Sulphur Dioxide SO_2

This gas is used to a certain extent in insect fumigation, but it is generally not as effective as those referred to previously.

The gas is generated by burning sulphur at the rate of from 2 to 6 lb. per 1,000 cubic feet of air space, the amount depending on the insects to be killed and the material to be treated. In the presence of moisture, sulphur dioxide is a strong bleaching agent.

It is slightly heavier than air, and is not applicable in many cases, as it destroys the viability of the seed of most grain crops, and, also, has a deleterious effect on the baking quality of flour.

The action of burning sulphur in an air-tight container is partly due to suffocation, owing to the removal of the oxygen to form sulphur dioxide, and, also, in part due to the formation of a poisonous gas.

Nicotine.

This alkaloid is used extensively in the fumigation of greenhouses, but has little, if any, application in this Territory.

Carbon Tetrachloride.

This chemical is a heavy liquid, yielding a gas about one and a half times heavier than air, but it is not nearly as toxic to most insects as carbon disulphide, requiring four to five times the dosage for an equivalent result. It has the advantage of being non-inflammable.

Chloropicrin.

The vapour of this chemical is very heavy, but has a low volatility, and is non-inflammable. It corrodes metals, and has an irritating effect on the person using it, causing the eyes to water freely.

The power of penetration of the gas is particularly good, but is markedly affected by temperature.

It is more toxic to insects than carbon disulphide, but the susceptibility of insects to the vapour shows marked variation. It is less toxic to humans than to insects and rodents, but cannot be used for the fumigation of plants.

Owing to the heavy nature of the vapour, this chemical is very suitable for the fumigation of rodent burrows, and it has been used for the destruction of insects (moths, &c.) in upholstered furniture.

Chloropicrin has been used in grain stores and flour mills for killing moths, &c., but some experiments have shown that it has a definite effect on the gluten content, which, however, disappears when the material treated is exposed for several days to the open air.

"White Ant" Fumigation.

A special technique has been developed in Malaya for the fumigation of "white ants" (termites) in living trees. This consists of burning arsenic and sulphur together in a special combustion chamber and blowing the fumes into the channels of the termites through a pipe leading from the combustion chamber.

The highly-poisonous fumes are thus deposited in the interior of the nest inside the trunk of the tree, and results in killing out the pest, without in any way damaging the tree.

RAINFALL MEMORANDA.

Inches of rainfall × 2,323,200 = cubic feet per square mile.

" " " × 14½ = millions of gallons per square mile.

" " " × 3,630 = cube feet per acre.

NEW CEYLON INDUSTRY.*

Ceylon is to try to develop an export trade in brown paper made from coco-nut husks. Good white paper, it has been found, can also be made out of husks, but its manufacture is not economical. The bleaching of the husk fibres for this purpose raises the production cost excessively. But brown paper can be made at an economical cost.

* From Supplement to the *British Trade Journal and Export World*, October, 1938, p. 28, Vol. LXXVI., No. 909.

INSECT PESTS OF RICE.*

(*John L. Froggatt, B.Sc., Entomologist.*)

Although the cultivation of rice has not so far developed into an important agricultural industry in this Territory, small areas have been planted in several parts, and areas in the Rabaul-Kokopo and Talasea districts have been kept under observation by the Entomologist and other officers of the Department of Agriculture, and the following found to be the principal insects associated with this crop:—

LEPIDOPTERA—

Pyralidae —*Marasmia* sp.
Hesperidae —*Panara cinnara* Wall.
Noctuidae —*Cirphis unipuncta* Haw.

HEMIPTERA—

Coreidae —*Leptocorisa* sp.
Pentatomidae —*Nezara viridula, L. smaragdula* F.
Colobathristidae—*Phaenacantha* sp.

COLEOPTERA—

Halticidae —*Apthona bicolorata* Jac.
Curculionidae —*Exopthalmida rustica* Fst.
—*Coptorrhynchus* sp.
Coccinellidae —*Coccinella 8-maculata* F.

Insects causing material damage to the polished grain in store are—

LEPIDOPTERA—

Pyralidae —*Ephestia cautella* Wlk.
—*Corcyra cephalonica* Staint.

LEPIDOPTERA (Moths and Butterflies).

Marasmia sp.

This is a small moth measuring about half an inch across the outspread wings; the general colour is light brown, with a darker brown margin around the wings, which have rather a semi-transparent appearance.

The eggs are laid on the foliage, and the grub, on emerging, rolls the leaf around on itself, forming a tube in which it shelters, and feeds on the surface tissue of the leaf. Pupation takes place within the tube. Where the pest is plentiful, an appreciable greying of the flag of the rice is noticeable, due to the dead areas of foliage resulting from the feeding of the grubs.

The larvae of this moth are heavily parasitized by a small *Braconid* wasp, as yet unidentified.

Panara cinnara Wall.

This "skipper" butterfly varies from dark brown to almost black in colour with two white spots in the middle of each forewing, and measures about 1¼ inches over the outspread wings. The caterpillar fastens two or more leaves together with "silken" threads, and feeds at night. Pupation takes place inside the shelter thus formed.

This species was bred on several occasions from larvae collected in the Rabaul-Kokopo areas.

* Identifications were obtained through the courtesy of the Imperial Institute of Entomology, London.

Cirphis unipuncta Haw.

This "cutworm" moth was bred from material collected in the Talasea area. The grubs live in the soil near the base of the plants, and come out to feed on the foliage at night; they are brownish-black in colour. Where plentiful, a poison bait will kill the grubs readily. (*See* later.)

The adult moths are a biscuit-brown colour, and about 2 inches across the outspread wings.

Hemiptera (Plant Bugs).

Leptocorisa sp.

This is a long slender bug, measuring about $\frac{5}{8}$ inch in length and about $\frac{1}{8}$ inch in width; in colour the adults are a light greenish brown.

Both adults and nymphs suck the sap of the head of grain when very young in the "milk" stage, with the result that no grain forms in those parts attacked—where the pest is numerous, whole heads may be affected—and such parts go white, giving rise to the name of "whitehead" to the damage done by these pests.

Nezara viridula, L. smaragdula F.

In the adult stage, this bug is green in colour, and measures about $\frac{1}{2}$ inch long and slightly less in width; all stages of the life cycle, from small nymphs to adults, are sap-suckers, and are mostly found on the rice heads. At times they are extremely numerous.

This species is also prevalent on beans.

Phaenacantha sp.

This is another slender bug as compared with its width, measuring about $\frac{3}{8}$ inch long and about $^1/_{16}$ inch wide; in colour, it is reddish with a black patch on the top of the thorax.

This species is very active in movement, and is generally found on the seed heads; it is also a sap-sucker.

Coleoptera (Beetles).

Apthona bicolorata Jac.

This is one of the "flea beetles", so named from the habit of jumping when disturbed. It is a small brown beetle with a black mark along the middle of the back. It feeds on the flag (foliage), and blossoming heads of rice.

Exopthalmida rustica Fst.

This grey weevil is very variable in size, being usually about $\frac{1}{2}$ inch long. It feeds on the foliage of a number of plants, and has the habit of shamming dead and falling when disturbed.

Coptorrhynchus sp.

This is a small weevil less than $\frac{1}{2}$ inch in length, and a dark grey in colour. It feeds on a variety of crops.

Coccinella 8-maculata F.

This is one of the "ladybird" beetles. It is usually reddish in colour with eight black spots on its back, and it feeds on foliage.

Control Measures.

In most cases the areas under rice were small, and, where necessary, hand-picking could be resorted to. In cases where this is too slow a few notes are given below for general guidance.

With bugs and other sap-sucking insects, any spraying measures undertaken should be carried out in the early morning, when the insects are more or less comatose. Spraying with any strong contact spray, such as kerosene emulsion, or miscible oil sprays, should suffice, especially if this is done while the bugs are in the immature (or nymphal) stages, when they are much more susceptible to treatment than after they reach maturity.

With the adult bugs, it is possible with many types to wait until the insects have become active, and send a line of boys through the crop armed with cardboard or leather "swatters" coated with "tanglefoot", and as the bugs fly on being disturbed, strike them with the "swatter", and catch them on the sticky surface. Numbers can be killed in this way in a short while.

Beetles that have the dropping habit when disturbed can be readily collected in a tin or other suitable receptacle held under the heads or flag, and then shake the stalks; the beetles drop into the tin and are then easily destroyed, especially if a little water and kerosene are placed in it before starting out.

Cutworm caterpillars are readily killed by preparing a bait of the following composition:—

Bran		25 lb.
Paris green		1 lb.
Molasses (or treacle)		1 quart
Lemons (or moolies)		2 fruits
Water	about	2 gallons

The bran and paris green are thoroughly mixed in the dry state, and the molasses and chopped-up lemons mixed with portion of the water.

The liquid is worked into the poisoned bran, and, if necessary, more water added, so as to give the final consistency as just crumbly.

This is best prepared in the morning, and scattered around the base of the plants in the late afternoon.

Moth Pests of Stored Rice.

Two small moths, *Corcyra cephalonica* Staint. and *Ephestia cautella* Wlk. (family *Pyralidae*), cause considerable loss to rice in storage in sheds in the Territory, the grubs feeding on, and matting together, the grains, forming tubes; a thick mass of these tubes is often found on the inside of the bags when opened. Both species have also been bred from cocoa beans which have been bagged and stacked in sheds with rice and copra.

The adults of both species are grey to brownish grey, and measure from ½ to 1 inch across the outspread wings.

Fumigation with subsequent storage in insect-free sheds will control the pests, but with the conditions existing at the ports of concentration of rice this is a practical impossibility. Treatment of sheds as soon as a shipment has been cleared out will help to minimize the trouble, but this must be done thoroughly to be effective.

FALL OF MATURE COCO-NUT PALMS IN NEW GUINEA, DUE TO SOIL CONDITIONS.

(*R. E. P. Dwyer, B.Sc.Agr., Economic Botanist.*)

Falling of mature coco-nut palms due to soil conditions, bad drainage, and so on, is not an uncommon occurrence in some plantations in New Guinea. The bending over of palms on water-logged, low-lying situations, or in peaty soils, so that they almost touch the ground, is a common indication that palms are growing on such soils. Often, though not invariably, such palms fall completely to the ground. They usually remain stunted or low in height, chlorotic and poorly bearing, until drainage is improved.

On one plantation in Buka Island (Small Buka),* coco-nuts are grown under very wet conditions, where extensive drainage has been found necessary. The low-lying nature of the ground, as seen where the water is always slowly running in the shallow drains and around the roots of the palms, has caused many of them to fall over, due to their restricted rooting system. Some of these palms still continued to grow upwards from the tip. The roots at the base are not wholly severed, and such palms may grow on for years, and even produce moderate crops of coco-nuts. Similar areas to those mentioned are known in New Britain and other parts of the Territory, but the example quoted in Buka is an extreme case, where a large area of coco-nuts was planted under wet conditions.

On another plantation in Bougainville Island, a different set of soil conditions is found which has also led to the fall of mature palms over a fairly extensive area. In this case, the surface soil is light and relatively sandy over a large flat area of country. The plantation is a very good, heavy-yielding place, and the coco-nuts generally look strong and healthy, although the planting is closer than usual (probably about 27 feet spacing).

The light soil at the surface does not, on first appearance, appear rich, but under the sandy layer a distinct retentive, clay layer exists at a little distance below the surface. Water is continually moving from the high foothills behind. Through and above the clayey layer there is a continuous slow movement of water, probably carrying dissolved nutrients in it. In the plantation, the water comes almost to the surface during the wet season, and thus drainage under such conditions was found necessary. It is not in the frontage areas, however, that the fall of palms occurs. It is at the back of the plantation, where the soil is lighter on the surface with more pumice mixed in with it, that a proportion of the mature palms fall, though, of course, the silt or clay layer still persists underneath. In the worst areas there is some evidence of swampy conditions in the near past. In such areas the soil is stiffer at the surface, and clay bands have reduced the natural drainage, which in turn has restricted the root area of the palms, and thus, in heavy winds, there is a decided tendency for the palms to fall.

The palms which have fallen on this plantation show a distinct ball of roots and earth at the base. The broken roots appear to have died and decayed owing to lack of aeration, and, in some cases, the fungus *Fomes* spp. was seen to be present. This was not the cause of the trouble, however, as the fungus was not always present. It appeared that the light upper soil could not hold the roots firmly, where the shallow-rooting tall palms had not penetrated far into the

* Buka Island or Small Buka is north of Bougainville Island, one of the Solomon Islands Group, and is only separated from it by the narrow Buka Passage.

sub-soil, or else the roots had rotted off due to excess water and bad aeration. In several localities, shallow planting on heavy, clayey soils appeared to be the main cause of the mature palms falling over.

SHOWING AREA OF FALLEN PALMS, WITU ISLAND.

N.B.—Growth continues vertically at their extremities.

In the Witu group, it was noticed, in some areas, that tall palms planted in 1912, and now aged about 26 years, fell down after heavy winds. These palms were fully bearing and appeared quite healthy, prior to falling. The fronds were dark green in colour and there was no sign of chlorosis, tapering stem, or other deficiency diseases. The palms fell over, particularly in a high wind, and though no detailed counts were made at least a couple of hundred of palms had fallen, particularly in one belt on a large, low-lying area.

FALLEN COCO-NUT PALM.

Showing growing point vertically and at right angles to the fallen trunk.

The fallen palms have a peculiar and distinctive appearance, as they do not die altogether, but continue growing from the head, which turns at right angles from the ground and the main trunk as it lies. The size of the fronds becomes noticeably smaller than on mature palms or compared with fronds which would be seen on palms of comparable age and size (*see* photographs). The diameter of the upright portion of the trunk is decidedly smaller than the main trunk. These growth habits indicate that less nutrients are taken in, which is accounted for in the reduced rooting surface and feeding area, after the palms

ROOT SYSTEM OF FALLEN COCO-NUT PALM.
Close view showing Root Plate of Matted Roots, taken at Witu.

ROOT SYSTEM OF FALLEN COCO-NUT PALM.
Same subject as above, taken at a greater distance away.

have fallen down. The fallen palms do continue to flower and fruit, but never thrive satisfactorily, as could be expected, when the reduced leaf area and nutrient intake, and the shading from the surrounding palms, are taken into account. The nuts produced are smaller and fewer when they do commence bearing. It should be noted that the palms do not fall until fully grown, and some of those which had fallen were probably 40 to 50 feet long.

An examination of the root system of a fallen palm is most illuminating (*see* photographs). The roots do not break off as would be the case where a normal palm falls, due to other causes, such as washaways, &c. Except at the outside periphery of the palm roots, more than two-thirds of the base is entirely flat and compressed, though there were some exceptions which are described. In these exceptional cases, the centre of the palms has roots protruding as an ovate or round ball, at the base of which the roots are severed. The explanation of why this ball of roots occurs in the central basal portion of some palms appears to be associated with the size of the original planting holes. Where the holes were made larger than usual, the roots were able to penetrate deeper in an area corresponding with the size of the hole. A great proportion of the palms showed no evidence of this secondary bole whatsoever.

The flattened roots which had not been broken at all, except at the periphery, showed every evidence of a "soil-bound" condition, or an effect similar to that which is brought about where large plants are grown in small earthenware pots in the garden or nursery, and the roots are compressed into a small space. The great mass of compressed roots at the base were curled and twisted into a labyrinth of matted roots, which were almost as flat as a plate where they had been in contact with the ground surface. This interwoven mass of twisted roots could be termed a "root plate" caused by enforced restriction of the rooting and feeding area. It was apparent that a detailed examination of the soil profile was necessary to solve the reasons for the flattened appearance at the base of the palms.

Soil sections which were exposed in gullies, exposed foreshores, cuttings for small railway trucks, &c., were examined. The appearance of the actual soil conditions at the base of the palms was most instructive. The first 12 to 15 inches of soil was a reddish-brown chocolate and very friable, volcanic loam which, on appearance, seemed to be chemically and physically a rich soil. The chemical richness of the soil is easily confirmed, as the plantations there yield well over a half a ton per acre per annum (in the vicinity of 14 cwt.), which must be classed as good, high-yielding property. It appeared that so far there was practically no evidence of soil deficiency, and the only weak palms present were hereditarily or genetically so, and such palms can be seen on almost any plantation. The next underlying layer extends for more than 8 inches in thickness, and is definite hard-pan, which is found under a fairly wide area of ground. This layer is very hard and proved difficult to pierce, even with a crowbar. When dug out the hardened material breaks into a fine palpable mass, when pounded, or else comes off in definite flakes or layers in much the same way as shale does. The next underlying layer to the above, when reached, proved not quite so compacted as the above, being composed of a matrix of greyish ash comparable with the hardened layer, but mixed with volcanic scoria. The scoria and rocks found in this matrix appear to be very variable in colour and composition. This last layer is very deep but variable, being composed of several layers apparently as the result of many upheavals. Curiously, in many sections, a second hardened layer, comparable with that described previously, is met at about 4 feet depth. This appears very similar in appearance to the top hardened layer, but may not be the same in composition. It is the first hardened layer met with which is responsible for the plating and compaction of the roots at the base of the coco-nuts, as it was practically impenetrable to root growth, even by roots so hardened as those of coco-nuts. A native boy had considerable difficulty in digging through this layer when soil samples were being taken, as it was extremely fine-grained and very hard. Semi-weathered, flat pieces of this hardened ground (mud-stone) up to about ½ inch in thickness were seen, in numerous instances, to be attached to the flattened basal roots, and sometimes very fine roots had penetrated partially through this material. The compacting of the roots against this hardened layer explains the origin of the basal plate of roots.

When one walked along the roads and paths where the washing away had exposed this hardened layer at the surface, it was found to be very slippery and very hard. As far as could be gathered it was almost impervious to water, especially when flowing quickly and in quantity, and the loose surface soil was easily eroded away from it, indicating that cover cropping would be valuable. Wherever any low-lying areas are present, the water tends to collect in wet seasons and thus the root system becomes even more restricted in such places from this cause. The topography is, however, usually undulating, with a moderate grade towards the beach which provides a ready get-away for the water through the pervious, rich top-soil. Owing to the presence of this hardened layer, no deep gullies or creeks are present, which limits the available water supply. The ability of such a relatively shallow depth of soil to support such good coco-nut palms is testimony of its richness. It is also plain that coco-nuts can flower and give good production with a very limited root-system, providing the soil is really good.

The palms under the conditions where the hard-pan exists are entirely lateral rooters. This habit offers an interesting comparison with deep-rooting palms seen in washaways or sections exposed by the heavy rains after the volcanic eruption in the soft, deep pumice soils close to Rabaul. Here it was seen that the roots of a young palm (about eight years old) reached a depth of at least 30 feet.

The explanation as to why the palms fall only when they are fully grown and have reached a good height appears to be a question of increased leverage, which is assisted by strong winds, where the root-hold is weak. The soil, as said before, is sufficiently good as to maintain a heavy leaf growth, plus a heavy yield of nuts. It is probable that the tops of the palms reach a maximum weight at a particular height and curve backwards and forwards through a greater number of degrees in heavy winds, when they are tall, than when they are short and carrying even the same or may be a heavier crop. The root anchorage is not deep because of the hard-pan mentioned, so that in heavy winds there is a tremendous strain placed on the roots. It becomes heavier and heavier until eventually a breaking point is reached and the palms fall down. The roots at the edge of the hole on the side closest to the ground are not even severed, and they continue to supply a certain amount of nutriment to the fallen palm, leading to its eventual re-growth at the growing point. Soil and rubbish are sometimes heaped around the unsevered roots to assist the continued growth.

It is evident that, although such palms continue to grow, the roots can never supply enough nutriment for the fallen palms to enable them to become heavy bearers again, though they might conceivably assist in shading the soil.

The reason for certain low-lying areas being more liable to the fall of palms is associated with less aeration and weaker root development where the water is close to the surface, and not moving quickly. The soil is also softer when wet, which leads to an earlier fall of the palms.

It appears likely that the area, where this fall of mature palms occurs, may extend somewhat as the palms become older and higher. This may not reduce the value of the places to any great extent as the fall of palms is due to weak root anchorage and not soil deficiency, hence, replanting should prove practical, if any considerable areas are affected in the future. The re-plant palms would

FALLEN COCO-NUT PALM, WITU ISLAND.
Trunk, showing growing point, with length and development otherwise normal.

need to be planted away from the original holes, and then they should continue to grow and yield again for many years. The experiences of re-planting lightning-struck areas, where the soil is rich, would confirm this opinion, as they were seen to come away well indeed in similar areas to those under consideration. It would be almost a waste of time to re-plant such misses if the soil were poor.

Dynamiting or Explosives.

This is, apparently, a case where the use of explosives in the original planting holes was indicated and, in fact, it was said that dynamite was used on a small scale in some of the original plantings. After these operations, plenty of top soil shou'd then be drawn into the enlarged holes. There is no danger of compacting the surrounding soil by explosives where such a hard-pan exists, and the hardened formation should give good results from such treatment.

Origin of the Hard Pan Layers.

This is really a question for the geologist and soil chemist and soil samples were taken for submission to Institutes dealing with such problems. It might be pointed out that the areas, where this fall of palms has occurred, are composed of geologically new soil, comparable with the whole of Witu Island. These islands are certainly volcanic in origin and, according to observers, John Albert (Johann Albrecht) and Peterhaven are practically breached craters filled by the sea. The predominant rock is stated by Stanley* to be "Augite Andesite," covered with a thick deposit of scoriaceous material, tuff and pumice, which, apparently, makes a fine soil for the growth of cacao, coco-nuts and rubber. The fact of its recent origin is also shown by no large virgin forest trees being present. There is a large proportion of *Albizzias*, Breadfruits (*Artocarpus* spp.), *Eugenias*, Galips (*Canarium* spp.) and other fruits present, a large proportion of which were, apparently, planted by natives in the first instance.

The John Albert Harbour still has hot springs near the entrance and this is one of the best examples of a submarine crater one could find. The areas where the falling palms are found are situated on what appears to be the slope of the raised lips of this crater. When this large rim was built up further volcanic activity occurred on the raised land and thus a newer land crater is found, facing these slopes. The chances are very probable that the top layer of good soil was derived from weathered rock of lava flows from this land crater, as the country rock here appeared to be a fine grained basic basalt. There are hard lava belts present, which are so young that they have not weathered sufficiently to support other than short vegetation, and coco-nuts, not at all. The rich, red, chocolate soil at the surface is derived from weathered basalts or Andesites. The hard pan layers appear to be derived from submarine volcanic disturbances. They are greyish in colour, and very fine grained and compacted, sometimes with contained small fragments of rock. In texture and appearance, it is very like the fine grained compacted mud thrown out of Matupi Crater during the recent volcanic eruptions in Rabaul.

The incidence of the mud-stone layer appears to be confined to comparatively limited areas of the island, and lies approximately in one direction. This again is comparable with what occurred at Matupi, where only an isolated, locular-shaped area was covered with mud. Saturated fine volcanic ash does not appear to be thrown very far out from the original focus, which is apparently due to its relative weight or high specific gravity. The lower layer of similar type apparently represents the results of earlier submarine eruptions. The central layers of scoria appear to be derived from a more explosive volcanic activity acting over a fairly wide range of time. It is also feasible to believe that the gradual sifting action of rainfall would assist in compacting such layers. A chemical and physical examination of these soils is intended and should provide interesting data concerning the profile described and its origin.

Fall of Mature Palms at Manus, Admiralty Islands.

During a recent visit to Manus, it was noticed that some patches of mature palms, growing on the coralline fringes of certain plantations, had fallen over, although the palms were otherwise healthy. These fallen palms were situated on

* Stanley, Evan Rd. "Report on the Salient Geological Features and Natural Resources of the New Guinea Territory." Reprinted from Report on the Territory of New Guinea, 1921-22 (Commonwealth Parliamentary Paper, No. 18 of 1923).

areas possessing a very loose soil at the surface, but with hard coral coming in at a shallow depth. This led to restriction of root growth at the base of the palms, while the loose root-hold in the surface layers led to their eventually falling over, particularly after heavy rains accompanied by strong winds.

On one plantation at Namatanai, New Ireland, it was noted recently by Mr. F. O. Moody, Departmental Inspector and Instructor, that a number of palms had fallen down in some areas. He ascribed this fall of palms, aged about thirteen years, to shallow planting where a loose top-soil was present overlying coralline rock, which in some areas came near to the surface. Furthermore, in these areas the secondary growth had been left to grow almost as high as the palms, or in some cases higher, and this undergrowth acted as an effective wind-break before being cut down. Once this tall undergrowth was removed any winds occurring gained increased velocity, and blew the shallow planted, shallow rooted palms over.

Ninigo Group of Coral Atolls, Western Islands.

The centres of the majority of these coral islands are low and swampy, and here the palms flourish best on the higher ground between these central lagoons and the sea. The proportion of dry ground present in a particular island greatly influences its value for growing strong coco-nut palms. Although a great deal of low-lying land is planted, the palms do not flourish so well, and they tend to become stunted, poor yielders with a tendency to fall over.

It was seen that most of these small islands taper towards their longest extremities and because the soil is newer and shallower there, the palms do not grow so well as in the deeper soil, found in the raised dry areas, present on the more central margins.

Underneath the whole of the Ninigo Islands, free, underground water is present at a relatively constant depth. The differences in depth from the ground surface to the water in the various places is more dependent on the slight irregularities of ground elevation present on these low-lying islands. On the higher ground in the central margins of the island, it may be 5 ft. 6 in. to the water surface, while it rises to ground level in the lagoons.

Owing to the existence of a very porous, gritty, sand layer at almost the sea-level, the underground water here is influenced by the tidal rise and fall with a time lag, dependent on the size of the island and the distance from the shore. Owing to the various salts being absorbed and filtered in the sand layers, the water is only slightly brackish and, hence, is used by the natives for drinking purposes, without any ill effects.

In between this underground water and the surface, there is, in all of these islands, a semi-hard pan of lime-impregnated sand, which, in most areas, restricts the access of the coco-nuts to the free water.

The holding up of the surface water by the lime-impregnated layer would tend to cause waterlogging in very wet seasons, as is periodically experienced. It is also a curious fact that despite the presence of free, underground water, the palms on these islands do feel the effects of prolonged drought, when the surface layers above the hardened lime layer are dried out.

In the low-lying lagoons or swampy depressions, it is the excess of free, brackish, rather stagnant water which restricts the root-growth and makes these areas unfavorable for the growth of the coco-nut palms.

The distance from the ground surface to the free water (practically at sea-level) determines the depth of rooting in such cases. In the swamps and semi-waterlogged areas, where the palms become dwarfed, lean over, and either partially or completely fall out of the ground, root-restriction due to waterlogging, is indicated.

Where the roots of such fallen palms are not entirely severed, the crowns commence to grow again, vertically at their growing point, but in such cases, they usually flower sparsely and give poor production.

The fall of mature palms on some areas in the Ninigo Group was definitely associated with the compacted layer already mentioned, especially where it was underlying the loose, sandy soil at a shallow depth.

In an examination of different soil profiles here, it was seen that at varying distances below the surface (never much greater than a couple of feet), this stiff, puggy layer of compacted sand was to be found and its consistency was comparable with mortar.

The origin and formation of this layer is explained by the fact that the calcareous or limey sand has great facility to become agglutinated into a clay-like layer of calcareous mud. The deposition of the layer is due to the leaching action of water taking the lime into solution, and depositing it into distinct layers at limited depth. Here it has a mortarizing effect and firmly cements the fragments of sand together, making the whole mass difficult to dig out. This layer is not altogether impervious to the coco-nut roots, but it badly restricts their spread and growth into the deeper layers. It also causes the roots to become thin, spindly and weak, thus providing a distinct break in the root system at the zone, where the restriction occurs. It is in patches where this layer is found close to the surface, such as where surface irregularities are present and the palms are growing in the low-lying patches, or where surface erosion has occurred, that the palms are most liable to fall over.

In all of the profiles examined in these islands, the depth of rooting, though variable, ranged from shallow to moderate depths only. The depth of rooting, apparently, was influenced by several main factors, such as, depth and age of the soil, presence of hardened sub-soil layers, distance to water table, and whether the palms were growing on the rim of islands, in, or near, the central lagoons, or at the extremities of the islands.

An attempt is made to describe, from a typical dry land profile on which the palms are growing well, what may be taken as approximating the prevailing coco-nut-root distribution in the Ninigo Islands. This description does not fit those areas where the palms are so shallow rooting as to have fallen over, as there the compacted layers are nearer the surface.

In the first 4 inches to 9 inches of soil, comprising the humus layers, the fibrous coco-nut roots are densely scattered as feeder roots.

At about 4 inches to 6 inches depth, it is usual to find that a compacted layer of larger main roots comes in which are mixed with the fibrous roots for a depth of a few inches.

These main lateral roots extend throughout the soil and sub-soil until the plaster-like layer is met, usually at about 2 feet to 2 ft. 6 in. After passing through this compacted layer, the larger, main water-feeding roots come to a looser layer of semi-saturated, gritty sand, and extend right to the free water surface. As mentioned before, the lime infiltrated zone has a constricting effect on the root system. The roots in the looser, sandy layers, below the lime layer, are generally evenly distributed, but are often constricted, gnarled and discoloured, and do not appear so healthy, or well developed as in the upper layers. This is not always the case, because in several instances, what appeared to be perfectly healthy roots were seen in the water saturated zone.

Most of the native trees present in the Ninigo Islands are not deep-rooted, especially in the shallow lagoons where shallow, prop-rooted trees, such as Mangroves and species of Ficus are usually present.

Decided evidence of the influence of the underground compacted layer, mentioned, on the rooting system of the original bush trees was seen as Pelleluhn.

At the end of one small island, some large Casuarina trees, several feet in circumference, were observed growing on a comparatively shallow sand-spit. Two of these Casuarina trees had fallen over, and it was noted that despite the size of these trees, their roots had not extended much more than one foot into the ground.

The whole root system was completely flattened at the base, showing that the roots were living on the surface humic layer only. Owing to the shallow root-hold, the trees had fallen over when undermining and heavy winds had taken effect. The dense flattened mass of interlaced roots present, was closely comparable with what had previously been seen on certain coco-nut palms, which had fallen down.

Some of the roots present in this mass were as large as the limbs of a man, and these were intertwined with thousands of smaller roots, mainly feeding, fibrous roots.

Specific Instances of Fall of Mature Palms, Ninigo Group.

On the main areas of Ahettin and Paleotola Islands (Pelleluhn Plantation), also at Mal Island, shallow rooting was so apparent that many of the palms had actually fallen over on the relatively dry land. Restricted and shallow rooting was also observed on palms growing on the poorer areas of the islands, comprising Longan Plantation.

On one fairly extensive area on Mal Island, a little distance away from some areas of unfallen bush, it was seen that about 50 per centum of the palms growing under semi-swampy conditions had fallen over. In most instances, large rounded-shaped plates or balls of soil were left firmly attached to their bases. A large percentage of the palms, however, still continued to grow vertically from their crowns. In this instance, the surface soil was loose and sandy, while the palms, being shallow rooted with a weak hold, were liable to fall over in heavy winds.

In Ahettin and Paleotola Islands, it was observed, in some areas, that coco-nut palms had fallen completely over, and that many of these fallen palms had flat plates of hardened mortar-like ground attached to their bases. The depth of the rooting system was often only 18 inches in such instances. It was seen that, although some of the palms may have struck outliers of original coral, the hardened plates were usually derived from the hardened lime layer mentioned.

On the north end of Paleotola Island at 80 yards from the beach, the water-table was only 1 ft. 9 in. to 2 feet below the surface and here, in most cases, the palms were short and shallow rooted.

After heavy rains these areas become boggy and the water lies on the surface, though in the dry season, the same ground is relatively dry.

In such places, exposed masses of broken off prop-roots are seen to be covering the trunk for upwards of 3 feet above ground level. This is either due to the trunks being pushed upwards as the basal roots press against the hardened sub-soil layers or due to the ground sinking and leading to the same effect. One such palm examined was at least 50 feet high with a large, well-developed trunk, and a very heavy bunch of exposed and broken off prop-roots at the base. This palm which had recently fallen, showed very healthy fronds and had been forced over because of the restricted root-growth not being able to anchor the palm, when it had grown sufficiently tall and heavy.

At Sakalin Island, palms undermined by sea-shore erosion appeared very shallow-rooted, being flattened at the base, with the fibrous roots curled, matted and pressed closely to the lime-infiltrated, hardened, sand layer.

It might be pointed out that, at times (e.g., in 1932), some heavy gales are experienced accompanying sudden squalls in the Western Islands, and such occurrences in the areas described, assisted in blowing the palms over.

Relation of Restricted Root Development to Nutrient Intake.

It comes within another province to discuss the effects of root restriction, such as is described, on the nutrient intake and the yield of coco-nuts, nevertheless, a brief mention of the problem is thought desirable.

It the Witu Island Group, as already indicated, palms are found to be flourishing despite the fact that their roots could not penetrate more than 18 inches at the most, owing to the presence of hardened rock-layer underneath. In these islands, it was indicated that the surface soil was of volcanic origin, and chemically rich and friable. It is thus evident that shallow and restricted rooting of coco-nuts may not be detrimental to their healthy growth and heavy bearing propensities, providing that the soils are rich and that there are plenty of nutrients available in the soils to which the roots have access.

Where nutrients are not so plentiful, any restriction of the rooting system will most certainly have a more adverse effect on the life of the palms. This is most likely the case on those particular Western Islands, where it is believed that the soils, being sandy and shallow, are relatively poor in total nutrients, though these were readily available.

In this regard, chemical analyses are to be made.

The experiences in these islands, however, tend to bear this contention out, as, usually, the palms, though coming into bearing and producing excellently for some years have a relatively short period of maximum production.

It is found also that there is a very close relationship between the times of planting and the times at which the production tends to retrogress. There are other factors involved, such as original derivation of the soil, its nature, i.e. physical and chemical qualities, type of ground cover, original planting methods &c., which cannot be discussed here.

This physical adaptability of the root system of a coco-nut palm to its environment, as for instance, where the palms can flourish, although the roots do not penetrate deeper than 1 foot, providing the soil is good and sufficient water is present, provides a very good explanation why they do so well under such a wide diversity of conditions.

Erosion of Foreshore Areas.

Erosion of foreshore areas, accompanied by loss of coco-nut palms, is of common and regular occurrence in many parts of New Guinea, but more particularly on the island properties. Small islands have a large proportion of foreshore in proportion to total area, and are thus particularly susceptible to foreshore erosion, and loss of palms. Such loss of palms is very difficult to check on the foreshore fringes of the larger plantations situated so that the presence of bays and swirling currents, assisted by storms and heavy breakers, lead to the undermining and loss of old palms.

In some places, planting of *Ficus elastica*, *Casuarina* spp., &c., has been tried to lessen the effect, while in other areas, the original beach-loving trees, such as *Calophyllum inophyllum* and "Kwila", *Afzelia* (*Intsia*) *bijuga*, have been left in an attempt to remedy the position.

Erosion of foreshore areas is usually difficult to avert and attempts at prevention must depend upon the circumstances under which the erosion is occurring.

Heavy Floods and Shifting River Mouths.

In many parts of New Guinea, many hundreds of coco-nuts have been washed away. One plantation on the mainland has been greatly reduced in value, owing to a shifting river cutting right through the plantation.

Where short and rapid rivers are present, as in many of the islands here, losses from this cause are always likely to occur.

Washaways and Fall of Mature Palms following on the Recent Eruption—Rabaul.

Serious washaways consequent on the heavy storms following the eruption, caused widespread loss of palms and permanent damage in five plantations on the north coast of the Gazelle Peninsula. The compacting and sealing of the volcanic dust did not allow of the heavy rains penetrating to the porous soils underneath and, hence, surface run off became serious. The effects were particularly serious, where many ravines and low-lying gullies were present, such as at Kurakakaul Plantation, where several thousands of palms (estimated at 5,000 palms) were carried away. In some of the larger ravines, the coco-nuts were washed out by the roots and carried out to sea. The extent of these washaways can be judged by the immense deposition of new land which occurred at the sea shore.

Very serious damage was also caused, particularly in the native groves, by the breaking over of the palms due to the extremely heavy winds following the eruption. Palms which were suffering badly from soil deficiency and tapering stem, were most affected. In the zones of greatest deposition, the heads of the palms were full of pumice dust and mud, and the heavy winds caused the heads to fall over under great pressure and, in almost every case, left a large split or gash on that side facing away from the wind. In some instances, the palms were so affected by the heavy winds as to have their fronds turn inside out, like an inverted umbrella.

As this damage due to the volcanic eruption is caused by unusual circumstances, it is not proposed to discuss it in detail in this article.

Summary.

Some occurrences of the falling of healthy, mature coco-nut palms in New Guinea plantations associated with particular physical soil and sub-soil conditions, are described. The appearances of such fallen palms and their compacted root system are also given.

In some areas of Buka Island, swampy conditions are associated with the fall of mature coco-nut palms.

In Bougainville Island, the presence of loose, sandy soil with an underlying retentive, stiff, clay sub-soil, which led to water-logging and root restriction, was the apparent cause.

At Witu Island, the fall of palms is found where the underlying country rock is geologically recent and only weathered to a shallow depth. Here the loose, friable, volcanic loam, which is rarely much more than 15 inches in depth, leads to shallow rooting.

At Manus, palms fall over where loose, sandy soil overlies the original raised coralline rock. A similar occurrence is recorded from New Ireland.

In the islands of the Ninigo Group of coral atolls, there are at least two causes, which may be inter-related, leading to the fall of mature palms. In some places, the presence of a raised water-table in the central swamps and lagoons leads to root restriction and fall of palms. Elsewhere, the fall of palms was often associated with the presence of a compacted lime layer formed by deposition and underlying a loose, sandy soil.

This compacted, mortarised layer is found in most coral atolls, and leads to root restriction, where water-logging occurs.

The explanation as to why palms fall only when they are fully grown and have reached a particular height, appears to be related to increased leverage, due to greater weight and height, causing the palms to fall during heavy winds.

Coco-nuts can flourish and produce normally with a very restricted rooting system, providing the surface soil is physically and chemically rich. Where the soils are poor or compacted, root restriction and water-logging will finally lead to deficiency symptoms and soil exhaustion becoming apparent.

It is clear from these observations that from a practical stand point, the study of soil profiles, yields much information concerning suitability of particular areas to coco-nut cultivation, even where chemical data is not available.

The planter or intending planter should be cognisant of the presence of hard-pans in his coco-nut areas, whether due to the natural country rock coming to the surface, or to deposition of lime, iron or other minerals.

Acknowledgment.

The photographs accompanying this article were taken by Mr. E. Hann, Plantation Manager, Witu Group.

THE COCO-NUT OIL INDUSTRY.

(By A. E. Williams, F.C.S.)

Although coco-nut oil has been used extensively by the natives in the tropical lands of its origin for many centuries, it was not exported to European countries in any appreciable quantity until the middle of the Nineteenth Century. At that time the industry was entirely in the hands of the natives, who expressed the oil by very primitive and unhygienic methods, so that the resulting product was vastly inferior to the oil produced in recent years. As the demand for coco-nut oil increased, due chiefly to its adoption in soap manufacture, the crude methods of producing it were improved, and the systematic cultivation of the coco-nut palm was commenced.

In 1907, nearly 3,000,000 acres were under cultivation, and, at the present time, there are approximately 7,000,000 acres devoted to the cultivation of the tree, of which area more than one-half is in the British Empire. India possesses the largest area under cultivation, but this is no indication of the amount of oil or copra exported from that country, as owing to religious scruples forbidding the use of animal fat as a food a large proportion of the natives rely entirely on the locally-produced vegetable oils. The bulk of the copra and coco-nut oil exported to European countries is from the Dutch East Indies, Philippine Islands, South Sea Islands and Ceylon. In addition to the cultivated areas, there are vast tracts of land containing uncultivated coco-nut palms, the extent of which has not yet been estimated. The chief botanical species cultivated is *Cocos nucifera,* which is essentially a coastal plant, being rarely grown successfully at considerable distances inland. From the time of planting about seven or eight years elapse before the tree begins to bear fruit; the bearing period is from 60 to 70 years, each tree yielding annually from 80 to 90 nuts. Many of the larger plantations are equipped with testing stations in which work on the production of seedlings for future use is carried out. In some districts it is the custom to gather the nuts from the trees before fully ripe; by so doing it is said that the copra will keep longer and possess a higher oil-content than would be the case if the nuts were allowed to fully mature before harvesting.

Copra Production.

Copra, or the dried broken kernels of the whole fruit, represents about 30 per cent. by weight of the nuts as taken from the trees. The splitting of the coco-nuts is generally done by hand; although in some districts machinery is in use for this purpose, it is found to be not much quicker than native labour. Much of the copra exported is produced by sun-drying the broken nuts, the latter being spread out in thin layers in the open and left for a period of from five to eight days.

During this process the kernel separates from the hard shell, and the moisture content is reduced to about 8 per cent.; this is further reduced by gradual evaporation of water during transport and storage. The result is that copra arriving in European ports seldom contains more than 5 per cent. of water, the oil content being from 65 per cent. to 70 per cent. In many districts the nuts are not sun-dried, but recourse is had to artificial means, and there are a number of efficient dryers available for the purpose. Generally, artificially-dried copra has a more uniform moisture content, and frequently yields a better quality oil than the sun-dried product. In the sun-drying of coco-nuts, which occupies about one week, putrefaction often takes place, and the oil expressed therefrom will have a higher percentage of free fatty acids, and also a darker colour.

The native method of drying copra by artificial means is somewhat crude, consisting, in general, of arranging the broken nuts on bamboo racks, under which a fire of coco-nut shells is lit, the hot gases and smoke from the fire being

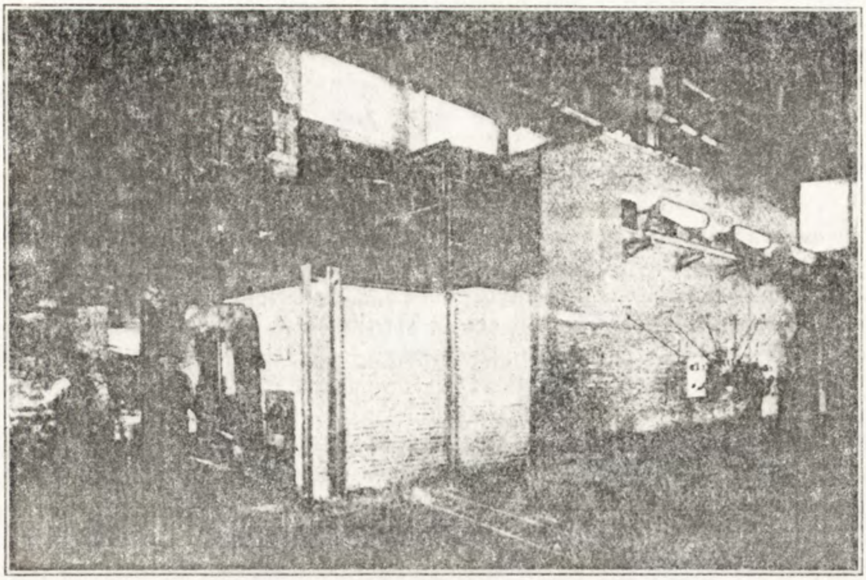


Fig. 1.—Furnace End of Copra Drying Plant.

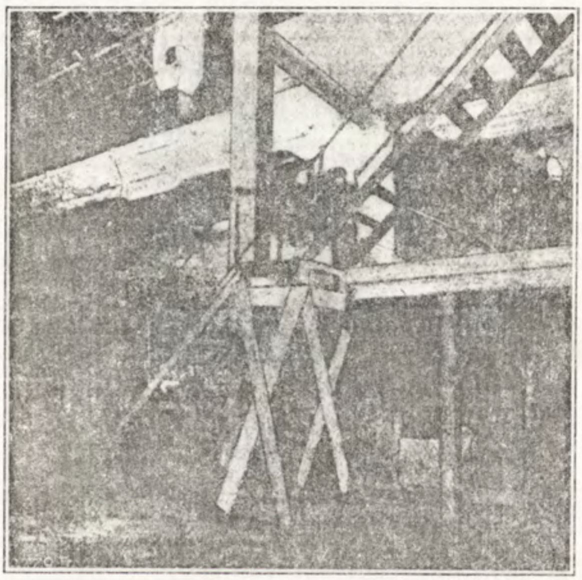


Fig. 2.—Charging End of Copra Drying Plant.

relied upon to dry the nuts. This method is rapidly being replaced by modern drying apparatus, of which an example is furnished by the copra-drying plant illustrated in Figures 1 and 2, which show one of several recently installed abroad for this purpose by Messrs. George Scott and Son (London) Limited, Silvertown, London. A feature of this plant is that the coco-nut shells, available on the spot, may be used as fuel, and by a special arrangement of the furnaces the fuel consumption is very low.

The broken nuts are dried by a current of clean, maintained hot air in constant circulation, its temperature and volume being regulated as the drying of the copra proceeds. This plant has a capacity of 150 tons of coco-nuts per day, and produces a very light coloured copra, yielding a first-class quality edible oil.

Utilization of Husk and Shell.

The outer husk of the nut is frequently removed in as sound a condition as possible, as it forms the raw material of an important tropical industry. The fibrous husk is allowed to soak for several days in a week alkaline solution, whereby the material is considerably softened. It is then thoroughly washed free from alkali and dried. The product can be readily spun into a coarse yarn, from which a large number of native requisites may be manufactured. The coco-nut shells may be advantageously used as fuel for the artificial drying of the copra, or may be ground up, mixed with a suitable binding material and pressed into briquettes for domestic fuel. Both in Europe and America, the manufacture of activated charcoal from coco-nut shells is carried out on a fairly extensive scale.

Reduction of the Copra to Meal.

It is necessary to reduce the dried copra to a fine meal in order to facilitate the extraction of the oil in the presses. The reduction, or grinding, process, is usually carried out in two stages—the machine used in the first stage grinds the

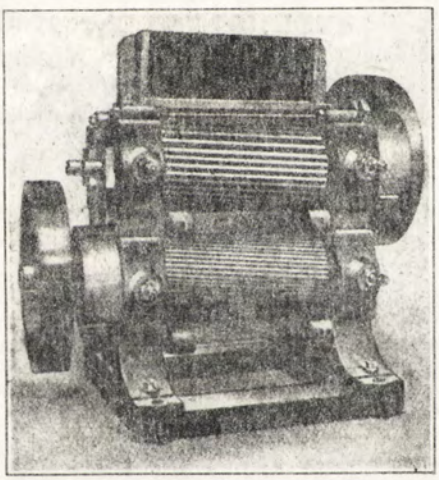


Fig. 3.—Copra Reducing Mill.

copra to a coarse meal, which is then further reduced by special rolls. The preliminary grinding may be carried out in an ordinary disintegrator, or, more speedily, by a machine made specially for the purpose, such as that illustrated in Figure 3. This apparatus comprises two pairs of adjustable gear-driven rollers, all 17 inches diameter by 4 feet long; the roll bodies are of chilled cast-iron. They are forced on to the steel shafts under hydraulic pressure, and secured by sunk keys.

A feed-hopper with shaker feed, roll-scrapers, and cover plates are included. The upper rolls are fluted, or grooved, to a coarse pitch to take the copra as received, and the lower rolls to a finer pitch to reduce the product further. The output of this machine, which is constructed by Messrs. Rose, Downs, and Thompson Limited, of Hull, is 3 tons of copra per hour. In large mills these machines are arranged in batteries of six or more, alongside of which a conveyor and elevator are installed to carry the coarse meal to the rolls for the final reduction.

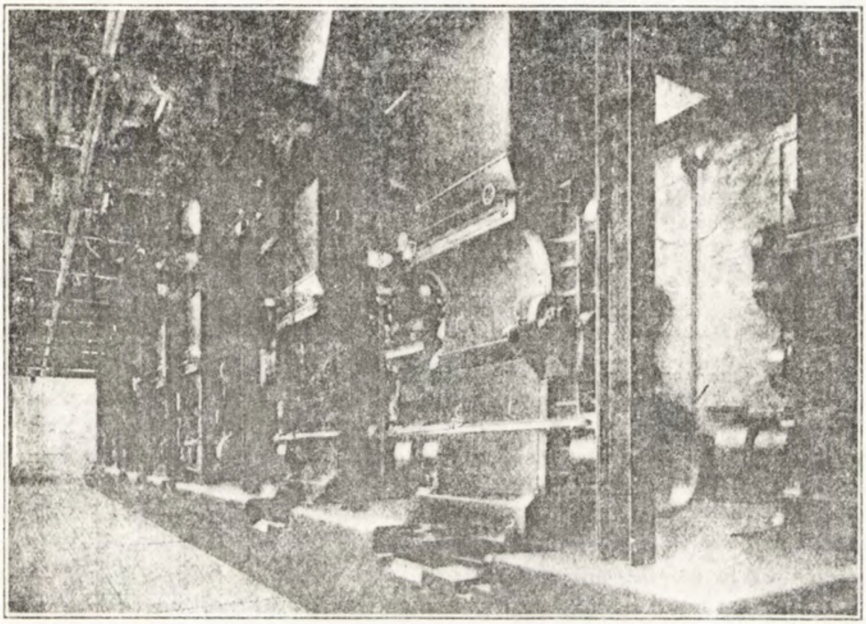


Fig. 4.—Copra Grinding Mills.

A grinding-room of a large mill, equipped with fifteen sets of Anglo-American five-high rolls, made by Messrs Rose, Downs and Thompson, is illustrated in Figure 4. Each machine comprises five rolls made of chilled cast-iron, and has an output of about 1 ton per hour. The coarsely-ground copra passes into the feed-hopper at the top of each machine, a regulator being fitted to control the rate of feed to the rolls beneath. A grooved feed-roll in the base of the hopper ensures even distribution of the meal along the full length of the rolls. From the feed-roll the meal falls on an inclined guide-plate, off which it slides between the first and second rolls. Emerging from these, a guide plate on the opposite side catches it, to pass it between the second and third rolls, and so on, until the meal in one passage through the five-high rolls is crushed four times. The rolls are compact and entirely self-contained machines. The roll shafts are of forged steel, the shafts of the top and bottom rolls having extra large bosses towards each end, where they are fixed in the rolls; the bottom roll shaft is also fitted with a barring collar. The roll bodies may be either in cast-iron or in specially hard chilled cast-iron; the latter type give generally the greatest satisfaction. All roll bodies are accurately turned and finished; the shafts are forced into the rolls under hydraulic pressure, and fitted with sunk keys. After the shafts have been fixed in the rolls, the roll bodies and shafts are ground together The rolls are driven by fast and loose pulleys on the bottom roll shaft. Plain bearings, roller, or ball-bearings may be fitted.

The pressure on the meal, and thus its particle size, may be regulated by means of a combination of compression screws and springs fitted on each machine. In general, the finer the particle size of the meal delivered from the rolls, the greater will be the oil yield in the subsequent pressing operation, for any given pressure and meal temperature. On the other hand, a finely-ground meal will increase the proportion of "foots" (an emulsion of water, dissolved lauric acid and coco-nut oil with fine meal in suspension) contained in the expressed oil, the removal of which is a frequent source of trouble and loss to the oil-miller.

Expression of Coco-nut Oil.

In the tropics, where coco-nut oil is the chief vegetable fat used, it is often expressed from the fresh nuts, or sometimes copra, by simple crushing in a pestle and mortar worked by a bullock team. Naturally, the percentage of yield of oil by this method is much less than when modern machinery is employed. However, in many important commercial centres in these countries, modern crushing mills, equipped with hydraulic presses, are now installed, and these mills supply the bulk of the oil for export and home consumption in the larger towns. In European crushing mills, most of the coco-nut oil is produced by means of hydraulic presses. The type usually adopted for materials of high oil content, such as copra, is known to the trade as the "cage" press.

An example of modern plant for the expression of coco-nut oil is represented by the Rose, Downs and Thompson "Premier" presses illustrated in Figure 5. In these presses several important labour-saving devices have been introduced, resulting in an increased capacity and very efficient operation. Each press is surmounted by a cooking kettle with an additional kettle, for the preliminary heating of the meal, on top. The kettles are steam-jacketed, 5 feet in diameter by 26 inches deep internally, and are made of cast-iron, lagged, and fitted with belt-driven stirrers and steam-damping apparatus. The presses each have an extracting box or pressing cage, 19 inches diameter by 9 feet long internally. The press head and base are of cast iron, the columns of forged steel; the hydraulic cylinder of cast steel with a ram of 18½ inches diameter, working up to a pressure of 3 tons per square inch. The presses are also fitted with preliminary compressor apparatus, automatic strickle, and hydraulic jacking cylinders. The latter comprise four small hydraulic cylinders in the press base, by means of which the press box can be lifted a distance of about 9 inches, the box being free to rise and fall in the press to this extent. In all Premier presses, the press box is free to rise and fall to a limited extent to facilitate the removal of the loose head block; in the earlier types of press, the box was lifted by skin friction between the box and the charge of meal, but with the jacking cylinders a positive lift is given to the box. When the hydraulic pressure is put on the press, the jacking cylinders are put in operation, and lift the box so that the loose head block enters the press-box to a depth of about 9 inches. When the main hydraulic pressure is released, the jacking cylinders are also allowed to exhaust, and they allow the box to drop gradually to its original position, acting meantime as shock absorbers. By this procedure, the risk of the loose head block being jammed by the expanding meal in the box is done away with.

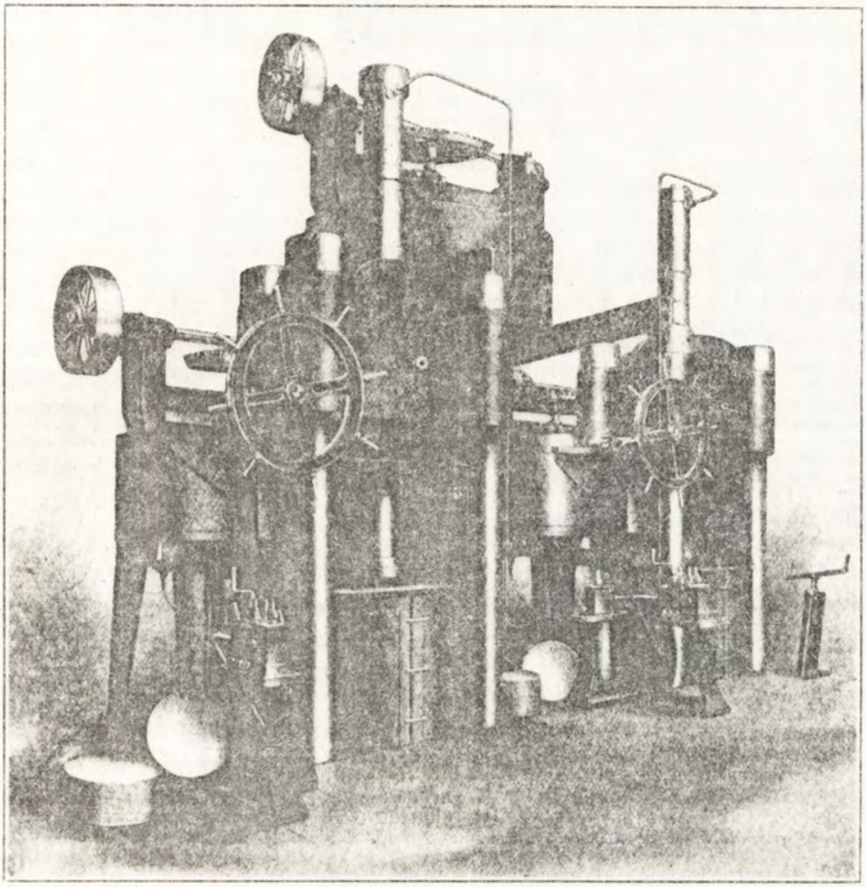


Fig. 5.—Copra Press.

Three cooking kettles are supplied with each pair of presses, the upper one serving for the preliminary warming up of the meal, or for the mixing of different grades of meal before crushing. From the upper kettle the meal passes, as required, to either of the lower kettles situated immediately above the presses. The heating up of the copra meal in the kettles facilitates the extraction of the oil in the presses; by this treatment, copra meal containing 70 per cent. of oil may be reduced, in one treatment, to 6 per cent. oil content. The meal may be heated in the cooking kettles to a temperature of 45 degrees to 60 degrees Centigrade, depending on the particle size of the meal and moisture content. Occasionally, copra meal is pressed in the cold; this produces a superior quality oil, but in much less quantity, and a cold pressing must always be followed by a hot pressing to reduce the oil in the residual meal to the appropriate amount. The extracting boxes of the presses are built up of steel staves, so constructed that when united they provide innumerable minute perforations, through which the oil may escape. The strain due to the great pressure employed is taken by a series of solid, weldless, steel rings which surround the boxes. To ensure even pressure throughout the charge in the press, steel plates, with an outer covering of softer material, are introduced into the press at regular intervals in the column of meal, during the loading operation.

The charging of the press is carried out automatically, as is also the levelling of the meal, both these operations being controlled by a foot-valve, thus speeding up the loading of the press and lightening the task of the operator. A hydraulic ram, operating from a compressor appliance at the top of the press, comes into operation several times during the charging of the press, packing the meal tightly into the press-box, and so greatly increasing the quantity of meal treated at one extraction. The hydraulic pressure employed in oil presses is as high as 6,000 lb. per square inch, and is obtained from a series of pumps, which, in the case of the larger mills, work in conjunction with high-and-low pressure accumulators.

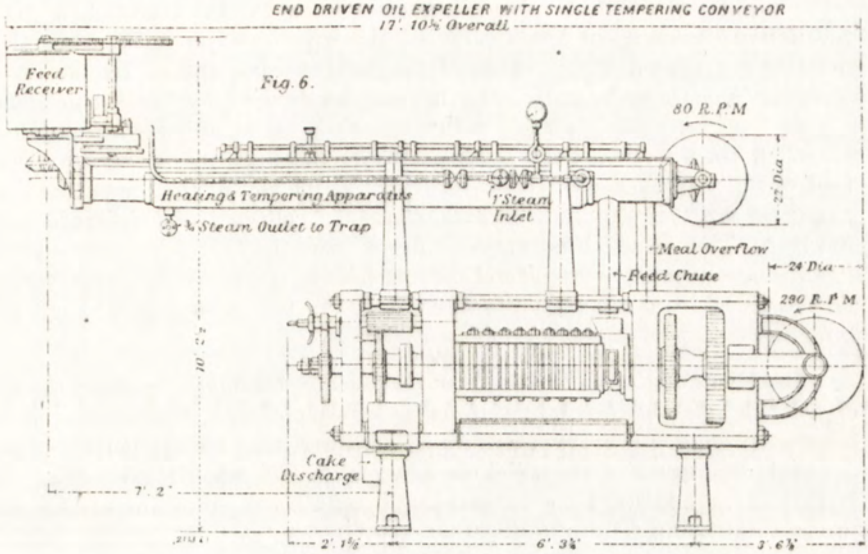
The residual meal from the presses may contain from 5 per cent. to 9 per cent. of oil, and is valued as a cattle foodstuff chiefly for the oil it contains. The oil-miller often disposes of it to "compound" feeding cake makers, who incorporate it with other materials. In most oil-producing centres, the manufacture of compound cakes is quite an important industry, frequently carried on in factories quite apart from the oil mills.

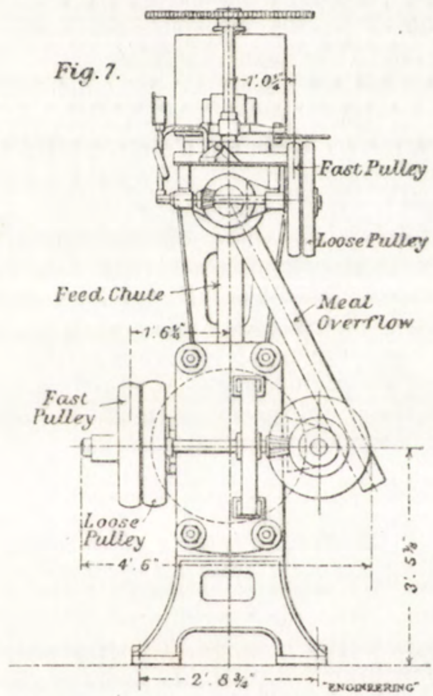
Oil Expellers.

The Rosedowns expeller, illustrated in Figures 6 and 7, is a type of apparatus much favoured by small oil mills, or in isolated mills abroad, as no expensive hydraulic equipment is necessary. Heavy foundations are not required, and the expellers may be erected on any level floor or in an upper storey. In many oil mills they are used in conjunction with hydraulic presses, particularly in the treatment of meals of high oil content. In the case of copra two expressions are usually necessary when using the expeller; both expressions may be made in the expeller or one may be made in a hydraulic press. The oil is expressed from the meal in a split horizontal extracting box, or cage, made up of machined steel bars. A shaft running through the barrel carries a series of steel pressure screws affixed to it, which convey the meal through the box and at the same time exert a gradually increasing pressure. The oil is thus pressed out of the meal and escapes between the staves of the box. The residue or cake is discharged at the end of the box, through an annular opening. The meal is passed to the pressure screws by means of a feed worm which rotates over the worm shaft. Pressure exerted in the barrel on the meal may be adjusted by means of a sliding cone which reduces or enlarges the opening through which the cake is discharged. By engaging a clutch, the cone is moved mechanically, the limit of movement being fixed by adjustable catches which operate automatically. On the size of the annular opening allowed depends the amount of oil removed from the copra meal and the thickness of the leaves of cake discharged.

The treatment of the meal as regards grinding before it goes to the expeller is essentially the same as in other methods of oil extraction. For the necessary preliminary cooking a steam-jacketed heating and tempering conveyor is mounted

END DRIVEN OIL EXPELLER WITH SINGLE TEMPERING CONVEYOR





over the standard machine. The meal is delivered to a feed receiver, which comprises a collecting and distributing pan, fitted with a stirrer driven by bevel gears from the worm shaft of the tempering trough. The purpose of this is to regulate the supply of meal to the tempering conveyor and thus ensure even feed to the expeller. Copra meal is passed along the trough by means of a screw conveyor, and is heated by the steam jacket. Live steam may also be admitted to the meal in cases where it is too dry.

The best yield of oil is only obtained when careful attention is given to the preliminary cooking of the meal. In the case of damp meal, surplus moisture must be evaporated off by means of the jacket steam, and no live steam admitted. Very dry meal may be sufficiently heated and damped by live steam alone. From the cooking conveyor the meal falls through a chute, fitted with a slide, into the barrel of the expeller, where it is passed to the pressure worms by means of the feed worm. An overflow chute is provided at the end of the tempering conveyor to pass over any surplus meal, which would be collected and returned to the feed receiver. The oil which is expressed drops from the barrel into a trough built into the machine just below the barrel. From here it can be led by a pipe into a ground tank from which it is pumped to store; or it can be run into an oil bogie or wheeled tank for transport to store.

In order to ensure freedom from trouble and automatic working, the Rosedowns expeller is well provided with self-acting safety devices. Mention has already been made of the clutch-operated pressure-regulating cone. This in itself acts as a safety device in the event of the machine being clogged. Should this occur, the clutch is thrown in and the cone automatically withdrawn, thus increasing the size of the annular orifice and allowing the cake freedom to pass. At the same time, by reason of the excess pressure in the barrel, the feed worm would cease to rotate, owing to the slipping of the friction clutch through which it is driven, independently of the pressure worm. Thus no more meal would be admitted to the box until the blockage is cleared and the excess pressure reduced. The surplus meal being passed along the tempering conveyor at such times passes out through the overflow chute. The barrel, which is built up of hardened steel bars, in a substantial cast-iron casing, heavily bolted, is readily opened for inspection or cleaning by the operation of a single lever. Owing to the extensive use of ball-bearings, the power required to work the expeller is low, and varies from 4½ horse-power to 9 horse-power, and the steam consumption generally does not exceed 70 lb. per hour. When the expressed coco-nut oil is intended for soap-making or other non-edible purposes, it is merely filter-pressed before being used; but if it is destined for edible use, it must pass through an elaborate purification process before it can be so employed. These purification plants or oil-refineries may be incorporated in the same mill in which the oil is expressed. In other cases they form entirely separate establishments, and may be situated at some considerable distance from the crushing mills.

Chief Applications of Coco-nut Oil.

In combination with other oils and fats, coco-nut oil is largely used in the manufacture of soap. The advantages of coco-nut oil to the soap industry are that it does not require bleaching before use; produces a hard soap which has, simultaneously, a fair degree of solubility in water; soap made from coco-nut oil will lather in salt water, an important consideration in the manufacture of marine soaps; the amount of glycerine produced in the making of soap from coco-nut oil is greater than can be obtained from any other oil available for the purpose. At the present time, coco-nut oil represents about 12 per cent. of the total oils and fats used in soap manufacture in Great Britain; and in America, about 20 per cent.

In the manufacture of margarine, coco-nut oil often plays an important part, comprising over 60 per cent. of the margarine in some instances. Its melting point, texture and consistency render it specially suitable for this purpose and result in a product closely simulating butter. Before the war, very little coco-nut oil was used in margarine making; the fats then employed were chiefly of animal origin. During the war and the subsequent inflation of prices for animal fats, coco-nut oil and other vegetable oils were employed in greatly increased amounts. Experience has proved them to be quite as satisfactory from every point of view, with the possible exception of their deficiency in vitamins. This deficiency is remedied in some cases during the manufacture of the margarine. During the last ten years or so, coco-nut oil has largely displaced cottonseed oil in the American margarine industry. It now represents nearly 50 per cent. of the total margarine made in that country, while in Great Britain the corresponding figure is about 35 per cent.

The "stearine" from coco-nut oil (obtained by pressing out the more liquid portion of the oil at a suitable temperature) is employed in chocolate manufacture to supplement the cocoa butter already present in the chocolate. Up to 5 per cent. of coco-nut oil is used in toffee manufacture. When the toffee is intended for export to tropical countries, hardened coco-nut oil is usually employed, as the higher melting point, about 41 degrees Centigrade, thus obtained prevents the softening of the toffee at the climatic temperature obtaining in such countries. Its keeping qualities render it specially suitable in the biscuit and similar foodstuffs industries.

(From *Engineering*, 16th October, 1931.)

STAINING WOODEN BENCHES BLACK.

Treatment renders benches so treated impervious to staining, and is acid proof. Used in chemical laboratories.

Solution 1—

105 grams anilin hydrochloride.
40 grams ammonium chloride.
720 grams water.

Solution 2—

105 grams copper sulphate, crystallized.
54 grams potassium chlorate.
720 grams water.

Directions.

Apply Solution 1 thoroughly to bare wood and allow it to dry. Then apply Solution 2 and dry. Repeat these applications several times. Wash with plenty of hot soap solution, let dry and rub well with vaseline.

When finish begins to wear, an application of hot soap solution or vaseline will bring back the deep black colour.

GROWING IMPORTANCE OF SISAL INDUSTRY*

A few years ago people might have asked, "What is sisal?"

To-day, the commodity is much better known on account of the importance it has assumed among hard fibres, as they are called, to distinguish them from soft fibres obtained from the real hemp.

The uses of sisal are extending from binder twine for the reaper and binder to ply twines for parcels, cordage and ropes, and further into new fields such as attractive carpets, matting of varied gay hues and patterns. Australia uses a large quantity for plaster board, while for plastics sisal has been found to produce an economical and durable article which can be applied to many purposes. The tow and so-called waste find a ready market for upholstery, mattress filling, &c. It is also used for ladies' hats and footgear and for high-class paper. It can readily be seen that sisal, far from being unknown, may soon become a household word.

Sisal is a hardy plant and grows under varying conditions of soil and climate. Formerly, it was thought that it would only flourish in limestone soil near the coast, but its introduction in 1903 to the highland plateau of Kenya disposes of this theory. In that area, right on the Equator, a substantial production of excellent fibre is grown on rich soil at an altitude of 5/7,000 feet above sea-level, but the favourite area is the Usambara Province in Tanganyika Territory, with Tanga as its shipping port. In that district the Germans opened up the industry in 1893 and at the outbreak of the Great War the production had reached 20,000 tons. The ravages of war and the absence from the estates of the men in control reduced the production to 1,663 tons in 1920. Thereafter, the industry expanded rapidly and now constitutes the principal article of export from Tanganyika, with total shipments of 80,000 tons in 1937. In addition to the Tanga area, plantations are scattered at each side of the central line, which leads from Dar-es-Salaam to Lake Tanganyika, and in the south of the territory a flourishing industry has been established in the Lindi area, where labour is plentiful and the climatic conditions equally favorable.

Sisal is not a seasonal crop. It can be produced all the year round with a short break during the rainy season, which gives time for overhauling the machinery.

It is safe to estimate that capital has now been invested to the extent of about £15,000,000 for the sisal industry of British East Africa, which includes Tanganyika, Kenya, and to a small extent Nyasaland and Uganda. That there is room for expansion no one can deny, but it is of the utmost importance that there should be closer co-ordination between supply and demand so that the wide fluctuations in price which have so hampered the producer during the last few years shall be eliminated or greatly reduced; but sisal is fortunate in not being

* From an address given by Mr. A. Wigglesworth at the Empire Exhibition, Glasgow, being one of a series on Colonial Empire Products arranged by the Colonial Empire Marketing Board.

Printed in Plantations Supplement to the *British Trade Journal and Export World*, October, 1938, Vol. LXXVI., No. 909, p. 19.

under any control of production, so that this fact, and the absence of stocks, maintain a liquid position which in the long run must bring about greater stability in the industry than is possible under the conditions involved in such controlled commodities as rubber.

The users of sisal are constantly striving to promote improved quality of their manufactures. This entails a study of ways and means of supplying improved fibre. The close co-operation between the makers of spinning machinery and the research institutes is instrumental in securing far-reaching reforms and improvements in the fibre, so that it is now possible to spin it to 600 or 900 yards to the pound, in contrast to 170 to 200 yards, which was the best achievement when the fibre was less carefully prepared, and the machinery less efficient.

Latterly, a new type of plant has been discovered by the Amani Research Institute, which goes under the name of blue sisal, or botanically, *Agave amaniensis*. The leaf contains twice as many fibres, giving promise of a finer fibre which may lead to still finer yarns being spun. Investigations are now proceeding and the trade eagerly awaits the results of this interesting experiment. One problem in particular is receiving considerable attention at the present time. The decortication of the fibre produces under present conditions anything from 7 to 25 per cent. of waste fibre, which was formerly washed away and lost. Efforts are now being made to recover this lost fibre by submitting it to a process to prepare tow which can be used for filling mattresses, and in some cases for spinning. Recovery of this wastage will not only add to the output, but will correspondingly reduce the cost of the fibre, but it can only be done if prices are more remunerative than those now being paid.

Totalitarian countries are applying much skill, energy and capital to research on methods whereby they may convert one product into another, for instance, coal into "buna" or synthetic rubber, milk into textiles, &c., the cost is not considered. We, on the other hand, are concentrating on research to extend the utilization of certain products into new channels where they may be economically and profitably applied. There can be little doubt as to which system is likely to have greater permanence and to show more lasting economic benefits.

It is now clearly established that Africa, and principally East Africa, offers perhaps better advantages than any part of the world for the cultivation of this valuable fibre, which can be produced at a price which compares most favorably with the cost of competitive fibres such as Manila hemp from the Philippines; indeed, the Government of these islands has felt compelled recently to take steps to encourage improved conditions of their industry, by the constitution of a National Abaca Company, with a capital of about £2,000,000. East Africa, however, is not afraid of this competition, and under the stimulus of admirable research work the organization of the industry may be considered more up to date than that of any fibre industry.

[EDITORIAL NOTE.—Under the Papua and New Guinea Bounties Act of 1937, a bounty of £6 a ton is payable to producers of sisal and planters might well give consideration to sisal as a crop. Good stock material is available on application to the Department.]

UPLAND RICE.*

Upland or hill rice does not differ botanically from swamp rice. It does, however, require different climate and soil conditions. Swamp rice has to be grown in water for the greater period of growth, whereas this is unnecessary in the case of upland rice.

It should not be thought, however, that any kind of rice is a suitable crop for areas lacking in water. A crop of upland rice needs at least as much water as one of corn, and more than guinea corn. Rice also likes a fairly high temperature and a clay loam soil, though it will grow on lighter and more open soils provided the water supply in such soils is maintained.

Upland rice is planted in a similar manner to corn; the land is ploughed or forked in the usual way and the seed is sown broadcast, or drilled in rows of 2 to 3 feet apart, the seeds being 6 inches to 1 foot apart in the row. These spacings may be altered to suit conditions of high or low fertility. About 30–40 lb. of seed will plant an acre, depending on the variety and size of grain and various other conditions of planting. Cultivation is usually confined to two weedings, which should take place while the plants are small. Cultivation by means of animal drawn implements can only be carried out if the crop is planted in rows. Once properly established, the plants produce numerous tillers or suckers, and form a dense cover effectively preventing the growth of weeds.

The grain is borne in heads produced at the end of the stalks. With most varieties, the grain ripens in about a month after the heads have shot.

The crop period varies with the variety, but about six months is the average. Planting usually takes place at the beginning of the rainy season and the crop is reaped some six months later.

Reaping is done with sickle, the straw with the heads attached being made up into bundles for transport. Reaping should be done when the average head is ripe; as if the crop is left until all heads are ripe, there will be considerable loss due to "shattering", i.e., dropping of the grain. The bundles are usually dried for a few days before threshing.

The grain is removed from the head by beating against wooden trestles or by treading with animals; when still enclosed in the husk it is known as "paddy". The paddy is then winnowed in order to remove pieces of trash, &c. The grain has to be freed from husk. This can be done on a small scale in hand-mortars, but it is laborious business and results in a high percentage of broken grains. Small hand mills are now available for doing this work. Modern milling machinery removes the husk and the cuticle or skin and then polishes the grain. The result is "polished rice", which is the kind commonly sold in Jamaica. The embryo or germ is removed during milling, and the bran is a useful fodder, being high in protein and fat. The polished rice is, for this reason, a

* By J. M. McEwen, D.I.C.T.A., in the *Journal of the Jamaica Agricultural Society*, Vol. XLII., No. 6, June, 1938.

poorer food than the "brown rice", obtained by husking without polishing. The use of polished rice as the main food sometimes causes a deficiency disease known as "beri-beri", which disappears when brown rice is substituted. In British Guiana the grain is parboiled before milling, i.e., soaked in water, drained and steam is then blown through it. This not only makes milling easier, but reduces the percentage of broken grains, and also produces a more nutritious rice.

A fairly large amount of upland rice was grown in Jamaica during the war, and several articles on the subject are to be found in the *Journal of the Agricultural Society* for 1917 and 1918. The chief difficulty appears to have been that there was no machinery for milling the grain after it was produced, as in those days the small mills mentioned above were not available. Most of the cultivation was in Clarendon and St. Andrew. Yields of 40 bushels of paddy were recorded, though it is doubtful whether the average was over 25–30 bushels per acre. Twenty-five bushels of paddy should give from 15–17 bushels of milled and polished rice. The straw is useful litter for stables, and makes good synthetic farm-yard manure.

The number of distinct varieties is very large, and it is important that the suitability of a variety to local conditions should be determined by field tests before any extensive planting is made. In countries where rice growing is an important industry, it is customary for the Department of Agriculture to maintain stations for this purpose, and also to provide pure seed. Seed selection is of great importance, as bad characteristics, such as shattering or weakness of stalk, will cause considerable losses in fields grown from unselected seed.

SILVERFISH BOOK VARNISH.

Inquiries are often made for a preparation that can be painted over the covers of books to prevent damage by silverfish and cockroaches.

The following mixture has been tried successfully over a number of years both in tropical and temperate regions with consistent success:—

Shellac	½ oz.	or	10 grams.
Creosote	2 drahms	or	5 c.c.
Methylated spirit	8 oz.	or	160 c.c.

It is advisable to break the shellac up fairly small as it is slow to dissolve. Mix the ingredients together in a bottle larger than required for the volume, and keep shaking.

This varnish is painted over the covers and it is not sticky when dry, and gives a dull surface; it will, unfortunately, dull gold lettering on bindings.

THE SOLAR FERMENTARY FOR CURING SMALL QUANTITIES OF CACAO.

(*Circular prepared by Dr. F. J. Pound, Department of Agriculture, for distribution to peasant proprietors and small estates.*)

This method for curing small quantities of cacao has recently been perfected at the Imperial College of Tropical Agriculture by Professor Hardy and Mr. J. A. MacDonald and a detailed account of the process is printed in *Tropical Agriculture*, Vol. XIII., No. 7, pp. 171-174. Extracts from this paper are reproduced below:—

"Cacao produced by peasant proprietors accounts for approximately two-thirds of the world's total production, and this enormous quantity of cacao, in the neighbourhood of 350,000 tons annually, has all the faults of cacao fermented in separate small quantities. Thus, peasants' cacao is recognized by manufacturers to be of inferior quality and lower value than estates' cacao, the lower quality being in large measure due to the inferior methods of preparation employed by small holders. In this article a new fermentation method is described with which it is possible to ferment separate small quantities of cacao so that *the final product is equal in appearance and value to estates fermented cacao.*

"A single picking on a small property may often amount to no more than fifty pounds to one hundred pounds of wet cacao, and the practical difficulties of obtaining a satisfactory product, when such small lots of cacao are fermented by the usual methods, are well recognized. The trouble arises through the large area of surface exposed in relation to the volume of the mass of cacao beans so that too great loss of heat occurs. The high temperatures requisite for killing the embryo of the bean are therefore never attained, and the internal changes associated with proper fermentation do not take place or are incomplete. A small bulk of cacao is also apt to dry out too quickly. In an endeavour to increase the quantity of cacao available for fermentation, the small holder usually picks his cacao only at long intervals and includes unripe and overripe pods in his picking. The net result of all these adverse factors is that the majority of the beans are unfermented or only partially fermented, some are germinated, and those occurring at the edges are dried up and shrivelled, or may be covered with obnoxious and unsightly moulds. Peasants' cacao is therefore recognized by the manufacturers to be of poorer quality and lower value than estates' cacao.

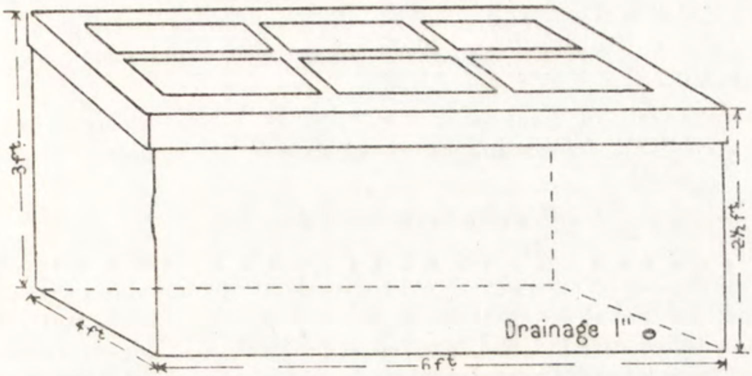
"The crux of the fermentation problem appears to be the protection of small quantities of cacao from excessive evaporation and cooling. If this can be done effectively and cheaply, then there is no reason why a good quality product should not be obtained by the ordinary method of natural fermentation which has proved satisfactory with large quantities under estate conditions."

What is the Solar Fermentary?

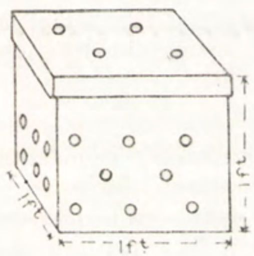
The solar fermentary is essentially a large box with thick walls to prevent escape of heat and a glass lid to trap the sun's rays. Inside this large box are placed small covered boxes filled with cacao beans with an adequate supply of water to keep the whole of the interior very humid. The small boxes of cacao may contain as little as 50 lb. of wet beans and several such boxes may be used at the same time inside the large box.

The first solar fermentaries were made of wood, 6 feet long, 4 feet wide and 3–4 feet high with double walls giving a 3-inch air space. The space between the walls may be packed with dry straw or coco-nut fibre to give better insulation.

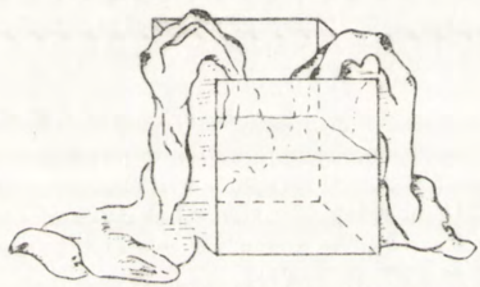
Other boxes have been constructed of tapia, using wood only for the corner posts and sills. The glass top is now made slanting to drain off water more easily and is hinged at the back for easy opening. The floor of the solar fermentary may consist of only rough stones if desired but a wood floor with spaces for drainage is better if it can be included.



The Solar Fermentary for curing small quantities of Cacao



Drainage and aeration holes also in base and lid



Pitch Oil tin, Water and Wick

The small boxes may conveniently be made as illustrated with sides about 1 foot pierced with drainage holes and lined with banana leaves before filling with cacao beans. It is very important that the supply of water is included and a pitch-oil tin with sacking wick is quite satisfactory for this purpose. If the inside of the fermentary is painted black this gives additional advantages.

The solar fermentary must be built in an open space so that it gets all the heat possible from the sun's rays. There is no need to turn the beans or even to open the lid of the fermentary once it is in operation although for the purpose of inserting another box of beans, opening for a few seconds will not do any harm.

Fermenting should be continued for six days uninterrupted.

Reports.

All the reports received for cacao fermented in this way, whether it is estates' cacao or peasant proprietors', have been thoroughly satisfactory and several brokers and manufacturers place the solar fermentary product in a class above normal Trinidad plantation grade. If a peasant proprietor who at present has no adequate fermenting facilities wishes to build one of these solar fermentaries he can do so using his own labour for a cost of $5.00 or $6.00. The glass top is the only expensive item. There will then be no reason why he should not receive top market prices for his product if he carefully follows the instructions given above. A difference of only 1 cent per lb. for properly cured cacao would soon repay the cost of the fermentary.

Here are quotations of some of the samples of solar fermentary cacao submitted to Port-of-Spain dealers and European brokers for reports—

A.—Port-of-Spain Reports.

"The dealers' reports show that small lots of 40 lb. to 60 lb. wet cacao could be successfully fermented in a wooden sweat-box enclosed in the solar fermenting frame. The final product of 15 lb. to 23 lb. dried, cured cacao beans was better fermented, had a better external and internal appearance, and higher value on the local market, than cacao fermented in large batches (2,000 lb. to 4,000 lb. wet weight) under the ordinary estate conditions obtained in Trinidad. The solar fermenting frame seemed to be very effective in producing an even fermentation throughout this small mass of cacao. The surface layers were free from mould, and as well fermented as the central portion. This is in direct contrast to the results obtained with small lots of cacao fermented under ordinary conditions. The low value of these samples was largely due to the inferior quality of the surface layers, which either became mouldy or dried and shrivelled during the fermentation process."

B.—European Reports.

1. "Both samples were well up to the standard of good quality Trinidad in the raw bean and there is no special criticism to make of the break."

2. "If the sample is intended as a test of the quality that can be prepared by the solar fermentation system for small quantities of cacao, the experiment may be regarded as very successful."

A FORMULA FOR MEASURING RAINFALL.

Pour the rain into any graduated glass—such as an apothecary's glass—the exact capacity of which is known either in cubic inches or fluid ounces. If the measure gives fluid ounces, reduce these to cubic inches by multiplying by 1.733. Then the formula for reduction is: R = A upon $3.1416 \times O2$. Where R is the rainfall in inches, A the number of cubic inches of rain in the glass, and O the semi-diameter of the funnel in inches, R should then agree with the amount shown by the graduated glass supplied with the gauge.

SOIL FERTILITY, NUTRITION AND HEALTH.*

(By Sir Albert Howard, C.I.E., M.A., formerly Director of the Institute of Plant Industry, Indore, Central India, and Agricultural Adviser to States in Central India and Rajputana. Reprinted from "Chemistry and Industry," by kind permission of the Society of Chemical Industry.)

In order fully to apprehend our subject, it is necessary to look back nearly 100 years and pass briefly in review the great industrial era of the nineteenth century, making the development of agricultural science and practice during that period of remarkable material prosperity and suggesting wherein it has proved inadequate to ride the storm in which those years culminated—a storm as unforeseen as it has proved disastrous to agriculture.

In the year 1840 Liebig published his celebrated essay entitled "Chemistry in its Applications to Agriculture and Physiology," embodying his well-known mineral theory on the substances found in the ashes of crops. Up to this time, the fertility of the soil had been maintained by means of some form of organic matter, such as farmyard manure, supplemented by suitable crop rotations, including fallows; the accepted view that soil required humus was unchallenged. From 1843 onwards experimental theory centred in the new thought advanced by Liebig; the idea that stimulation must of necessity mean progress gained credence in an age when progress was the watchword; soil chemistry, as we know it to-day, was born. With the further development of the Liebig tradition at Rothamsted and elsewhere, came steady progress in the manufacture and use of artificial manures. After the Great War, when the factories engaged in the fixation of atmospheric nitrogen for the manufacture of explosives had to find other markets, the use of nitrogenous fertilizers in agriculture increased, until to-day the majority of farmers and market gardeners in this country base their manurial programme wholly on the cheapest forms of nitrogen, phosphates, and potash on the market. What may be conveniently described as the NPK mentality dominates farming practice alike in the experimental station and the countryside. Vested interests entrenched in time of national emergency have gained a stranglehold.

What has been happening to the land during these 100 years? For a time all seemed to be well and agriculture shared in the general prosperity. Just as soon, however, as the original store of humus, which is found in all fertile soils, began to diminish a number of subtle changes made their appearance. Insect and fungous diseases increased and it became necessary to combat these with poison sprays; animal diseases are now rife. Deeper and more extensive cultivation became a necessity and increase in production was the only goal. Old-time tests such as taste and quality in produce were abandoned, and at a moment when, had they been applied, they would have shown clearly in what direction chemical manures were leading us. For artificial manuring leads tortuously to artificial demand, and it has not been enough that we should regulate production to demand. Agricultural policy must achieve a definite goal, and that goal is neither the economic necessity of the hour nor yet the building up of emergency reserves—it is the health of the nation.

* From *The Planters' Chronicle*, 11th June 1938.

The species of account that Mother Earth is likely, sooner or later, to present to those who misuse her resources may be examined in the United States of America. There the vast heritage of reserve fertility created in the past by the forest and the prairie has been used up to produce the large and ever-increasing quantities of food and raw materials needed by the urban populations engaged in commerce. The early settlers proceeded to cash in their humus mine and had no thought but to get rich quickly. The whole subject of soil fertility remained unexplored; such questions as the correct balance between animals and crops did not arise. Large crops were obtained without manure of any kind and while the original store of organic matter lasted all appeared to go well. To-day the bill is in the hands of the American people and their Government. In 1935, an eminent American engineer uttered a solemn warning that if the soil were to be continuously squandered, as then, the country might expect "less than a hundred years of virile national existence".

Over vast areas of the country the loss of organic matter has been followed by the destruction of the crumb structure; the compound soil particle has lost an essential constituent—the cement provided by humus. In the drier wheat areas, like Dakota, farms are blowing away; the deserts are on the march. In the tract drained by the Mississippi River the destruction of the crumb structure has been followed by loss of soil permeability to such an extent that the land is unable to drink in the rainfall and extensive erosion has been the inevitable result. It has been stated that the denuded areas approach in size all cultivated Germany. Over-stocking, over-cropping, over-stimulation, the wholesale destruction of timber—these are the malpractices which destroy fertility.

The lessons taught by the middle west and by the prairie provinces of Canada, where agriculture has collapsed with such dramatic suddenness, are being repeated in certain areas of this country which have been regularly manured with artificials only. Both the North American and the British methods of crop production have shown themselves to be lacking in the one thing that matters in agriculture—permanency.

Let us examine a system that will pass the test of permanency; let us turn to China, where the system of agriculture is at least 4,000 years old, and note the major respect in which it differs from our own. In China the processes of decay invariably receive as much attention as the processes of growth. Every possible kind of waste—vegetable, animal, and human—is carefully collected and put back into the soil. Animal residues, and more especially urine, are utilized to the full. This has been done for 40 centuries, and Chinese agriculture presents the one unanswerable argument in its favour—success. The soil has continued to maintain a dense population without the importation of food from other countries; the good earth is handed on as a great possession from one generation to another. We have here a remarkable example of practice anticipating theory.

The striking contrast between the failure of western science to maintain soil fertility and the success of the methods followed by the peasants of China was one of the factors which gave rise to the Indore process for the conversion of vegetable and animal wastes into humus. The immediate consideration, however, was the need for increasing the fertility of the soil of India in order that improved varieties of crops might come into their own. The introduction of improved varieties by themselves yielded only a small increment; the combination of improved varieties plus improved soil conditions doubled the crop and left the land in good condition.

The Indore process is simple. A layer about 6 inches deep of mixed vegetable wastes is lightly covered with about 2 inches of farmyard manure followed by a good sprinkling of earth. If any wood ashes are available these are added with the soil. The proportion of mixed wastes to farmyard manure must not exceed 3:1 by volume. The sandwich process is repeated until the material in the heap or pit is after fermentation 3 feet thick. The layers must be kept moist, but not wet, lest the air supply be interrupted. The moistened heap should resemble, as far as possible, a pressed-out sponge. The temperature rapidly rises to about 150 degrees Fahrenheit and the whole mass becomes covered with greyish-white mycelium. After two or three weeks the heaps or pits are turned and watered if necessary. A second turn and watering follows at the end of six weeks from the start, by which time the mass has crumbled and turned black. In three months from the beginning the carbon: nitrogen ratio falls from 33:1 in the original mixture to about 12:1, when the humus, which resembles old leaf mould, is ready for the land.

Over-acidity, faulty aeration, too much moisture, or an unsuitable site—any of these may present a passing problem in this country. Such problems must be tackled bearing in mind the special circumstances giving rise to them. In no case yet have they proved insoluble.

The process is a partial reversal of the work of the green leaf. In the cells of the leaf simple substances obtained from the soil and the atmosphere are synthesized by means of the energy of sunlight into carbohydrates and proteids. The fungi and bacteria in the compost heap practically undo this synthesis until a comparatively stable condition of organic matter is reached in the shape of humus. This is the real food of the soil and of the crop. The second stage in breaking down the materials made by the leaf is only reached when the soil organisms oxidize humus into simple substances once more which can be absorbed by the roots of plants. The wheel of life has then completed a single revolution.

It is not difficult to understand that the use of artificials in feeding the crop direct side-tracks a portion of Nature's essential round; artificial stimulus applied year after year, and at the same time, must inevitably breed evils, the full extent of which are as yet dimly seen. The relation between quality and yield, for example, does not lend itself to scientific formulae. The time may come when yield will depend entirely upon quality, but quality can never under any circumstances depend upon yield. Factory-made manure is the weak link in the chain of agricultural economics.

In devising the Indore process the various methods of dealing with soil fertility all over the world were naturally studied, as well as the work of the experimental stations in manuring, from the time of Liebig onwards. The result was illuminating. The practice of the peasants in China—the Farmers of Forty Centuries—suggested the desirability of making the fullest use of every form of vegetable and animal waste. Most of the research work underlying the Indore process was found scattered through the literature, very much as materials lie about in a builder's yard before the building is erected. Everywhere fragments of a larger question were to be found. The nearest approach to the Indore process was made by Rothamsted, where, however, the investigators made two fatal mistakes: (1) the use of chemicals instead of urine as an activator in breaking down vegetable wastes, and (2) the patenting of the ADCO process. Urine consists of the drainage of every cell and every gland of the animal body and contains not only everything needed by the fungi and bacteria which makes humus, but all the accessory growth substances as well. ADCO merely supplies nitrogen and minerals as well as lime—a far inferior base to the wood ashes and soil used in the Indore process. It focuses attention on yield rather than on quality. Further, the patenting of a process always places an investigator in bondage; he becomes a slave to his own scheme. Progress then becomes difficult, or even impossible.

The adoption of the Indore process all over the world has been very rapid. Thanks to the help of Major Grogan, D.S.O., and Sir Milsom Rees, G.C.V.O., practically every coffee estate in Kenya and Tanganyika had adopted the method by the end of 1933. Tea, sugar, sisal, cotton, coco-nuts, maize, and other large-scale industries soon followed. In 1935, a beginning was made in Great Britain, where now a number of estates, farms, and market gardens are busy converting all their wastes into humus. Some of the experimental stations in this country have followed the lead of the live wires in the farming community.

The Indore process has already outgrown its early beginnings. The underlying principles have enabled the problem of green-manuring to be solved; an uncertain method of enriching the soil has been converted into something which can be relied upon. This development was worked out during the last two years on the potato areas of South Lincolnshire which have begun to suffer from a shortage of humus. After the pea crop—grown for canning—has been harvested, the land is immediately drilled with beans. The sown area is then covered with a layer of crushed straw from the shelling machines followed by a thin layer of farmyard manure. The Indore process then sets in on the surface of the soil. The beans grow through the fermenting mass and at the end of September are ploughed in with the layer of finished compost. Decay is rapid and by the time the fields are planted in potatoes the following spring the resulting humus has been incorporated in the soil and is ready for nitrification. This modification is known as sheet composting—the making of humus in a thin layer all over the surface. Catch crops of beans or mustard or a crop of weeds can also be manured with humus, or a farmyard manure, before plough-in in the autumn, when sheet composting again takes place. The turf of old pastures or old leys can be converted into humus in a similar fashion. The Indore process has in this way been applied with success to no less than three important practical problems—green-manuring, the effective utilization of weeds and stubble, and the better utilization of the old turf of grassland.

Another important development has also taken place. In India, Ceylon, and Africa, town waste and night soil are now being converted into humus by the Indore process. In some cases, as in Nairobi, the production of humus from town wastes is being carried out on a commercial scale and Humetco—the trade name for the compost—has been on the market for some time. In Great Britain developments are taking place in the same direction. Dust-bin refuse is being used on a large scale as a constituent in the compost heaps for such crops as fruit and hops, and also in ordinary farming practice.

The adoption of the Indore process is not confined to the British Empire. Some of the papers describing the method have already been translated into German and Spanish, and I believe a Danish version is in process of preparation.

The most important development of the Indore process in Great Britain concerns the proper use of dustbin refuse, of seaweed, and of the vast stores of organic matter in the old turf of grassland. As is well known, the contents of the dustbin in this country are either buried or burned. Very little finds its way back to the land. Yet this material is exactly what is wanted in the compost heap in a country like Great Britain, where so much green waste (which is liable to pack in the heaps) is available, and where the total volume of plant residues is not so great as in the tropics. Town wastes perform two useful functions: (1) they help to aerate the heaps and to absorb the surplus rainfall, and (2) they increase the volume of the resulting humus.

The harvest of the sea is now only imperfectly reaped in the form of fish. Much of this harvest—the seaweed thrown up on the shore—is still largely wasted, although it is perhaps the most effective constituent of a compost heap that occurs in this country. A few examples are needed in which the seaweed brought in by the tide is composted with the municipal wastes of seaside towns, the resulting humus being used for intensive vegetable growing. A suitable beginning might be made at Worthing, in Sussex, where large quantities of seaweed are thrown up on the beach and where no agricultural use is made of the wastes of the town.

The proper utilization of the organic matter in the turf of pastures and leys is now one of the chief items on the programme of the Welsh Plant Breeding Station at Aberystwyth. Professor Stapledon is constantly urging the ploughing up and re-seeding of grassland, which, of course, involves the manufacture of humus in the surface soil. Another similar application of the Indore process is the system of milking-bails devised by Mr. Hosier on the chalk downs of Wiltshire.

It is a fact that British agriculture does not supply one-half the total food consumed. Common sense, therefore, dictates that those articles of diet in which supreme freshness is (or should be) the sole criterion of their true nutritive value should be home-grown. This means intensive cultivation (and incidentally a high rate of employment); it means also improvement and indeed curtailment of those 16,000,000 acres of permanent pastures in England and Wales, which Professor Stapledon once confessed in public made him "see red"; it means increasing livestock; and it means all this in the national interest. Now the conversion of agricultural and municipal wastes into humus for increasing the fertility of the soil has a direct bearing on health. It will in all probability be the means by which a new forward move in preventive medicine can be initiated. There exists to-day a considerable body of evidence which supports the view that the fertility which follows the regular application of humus is the surest foundation upon which to build the health of a nation. There is undeniably a close connexion between quality and health, but it defies analysis. The word "bloom" subtly suggests both. Quality in produce, although difficult to define, is saleable.

In the case of the wheat crop raised on Viscount Lymington's estates in Hampshire, careful records have been kept of the life of wheat straw when used for thatching. Wheat straw from fields manured with organic matter, partly of animal origin, lasts ten years as thatch; straw from similar land manured with artificials last five years. What the difference in quality is between the two sets of grain has not yet been determined. In Worcestershire experienced merchants are convinced that the highest quality crops are always produced with farmyard manure.

In vegetable growing the effect of organic manuring quality can be seen on a large scale on Mr. Secrett's farm on Walton-on-Thames. Mr. Secrett uses practically no artificials and raises his produce on fermented stable manure. He stands at the head of his profession as regards quality.

At the Iceni Nurseries at Surfleet, Captain Wilson has been converting all waste products into humus by the Indore process since November, 1935. The result has been amazing as regards the improvement in quality. Further, in a memorandum to members of the British Association visiting his estate on 4th September, 1937, Captain Wilson states—

"The method of humus-making which has been employed is known as "The Indore Process" and it has proved remarkably successful. The output in 1936 amounted to approximately 700 tons and in the current year will probably be about 1,000 tons.

"As a result of this utilization of humus the land under intensive cultivation, has already reached a state of independence, and for the last two years no chemicals have been used in the gardens at all either as fertilizers or as sprays for disease and pest control. The only wash which has been used on the fruit trees is one application each winter of lime sulphur, and it is hoped to eliminate this before long."

In Madras, McCarrison found that grain produced with farmyard manure contained more vitamins than that grown with minerals. In a recent lecture at the Royal Institution, this investigator summed up his long experience on nutrition as follows:—

"What I want you to learn from this lecture is that it is the foodstuffs themselves that matter to you, rather than any chemical ingredient of them. These when properly combined in the diet, supply all the food essentials, known and unknown, discovered or undiscovered, needed for normal nutrition, provided they are produced on soils which are not impoverished. For if they be produced on impoverished soils their quality will be poor and the health of those who eat them—man and his domestic animals—will suffer accordingly. Man is literally created out of the earth, since it is the earth that supplies, through the agency of plants, materials out of which he is made. If, therefore, he is to derive all the benefits which the earth is so ready to yield to him he must employ his intelligence, his knowledge, and his labour in rendering it fit to yield them to him. In this country impoverishment of the soil goes on apace because we take out of it in the form of crops more than we put into it in the form of animal and other organic manures. This impoverishment leads to infertility of the soil and this, in its turn, to a whole train of evils; pasture of poor quality; poor quality of the stock raised upon it; poor quality of the foods this stock provides for man—meat, eggs, milk; poor quality of the vegetable foods he raises for himself; and faulty nutrition with resultant disease in plants, beasts and man. Out of the earth are we and the plants and animals that feed us created and made, and to the earth we must return the things whereof we are made, if it is to yield again foods of a quality suited to our needs."

The evidence in favour of the view that disease resistance in plants and animals depends on soil fertility is also considerable.

My own experience in India from 1905 to 1931, is summed up in a paper on the "Role of Insects and Fungi in Agriculture," published in *The Empire Cotton Growing Review*, XIII, July, 1936, p. 191. I have had no reason to alter this opinion; rather my conviction as to its truth has strengthened. I said then—

"Insects and fungi are not the real cause of plant diseases, and only attack unsuitable varieties or crops improperly grown. Their true role in agriculture is that of censors for pointing out the crops which are imperfectly nourished. Disease resistance seems to be the natural reward of healthy and well-nourished protoplasm. The first step is to make the soil live by seeing that the supply of humus is maintained."

The most striking confirmation of my views has been supplied by commercial vegetable growers all over the country who use humus only for growing their products.

In regard to animal diseases, my experience in India was very similar. From 1910 onwards, I was allowed to have my own oxen at Pusa, Quetta, and Indore, and I made full use of these animals for the study of disease. The greatest care was taken in the selection of the breed and of the type of animal; the feeding, hygiene, and management was as near perfection as I could make them. For twenty-one years—1910 to 1931—I was able to study the reaction of well-fed animals to the epidemic diseases such as rinderpest, foot and mouth disease, septicaemia, and so forth, which frequently devastated the countryside. None of my animals were segregated; none were inoculated; they frequently came in contact with diseased stock. No case of infectious disease occurred. The reward of well-nourished protoplasm was a very high degree of disease resistance, which might even be described as immunity.

A simple explanation of the results described in the last portion of this article is that a fertile soil enables the green leaf to carry out the synthesis of carbohydrates and proteids in an effective manner. Two important results then follow:—(1) insects and fungi find such crops unpalatable, and (2) the organisms which are associated with the diseases of animals fail to flourish. The energy of sunlight through the agency of a fertile soil can therefore be effectively transmitted, first to the plant and then to the animal. It follows from these results that there must be a common baseline—soil fertility—in all future work connected with nutrition. If this is not ensured confusion and uncertainty will result. The research structure must above all things, have a firm foundation; the results obtained in the various countries and at the various centres must be comparable. It will not be sufficient in the future to work on material of varying nutritive value. In the past investigators have used such produce as existed; they have rarely grown their experimentl material on really fertile soil and based their experiments on the very best produce Nature can provide; the agricultural basis of much of the reasearch structure is therefore faulty.

Research upon the lines I suggest pre-supposes, of course, a conscious and deliberate forward policy in agriculture, based upon land in good heart and vigorously pursued in perhaps the greatest of all national interests—health.

PYRETHRUM IN KENYA.*

(*V. A. Beckley.*)

Although the industry is only five years old, Kenya pyrethrum is now established on the market and with a good reputation. This rapid progress is attributed in great part to the close co-operation between planters and the Department of Agriculture. Cultural and other notes of general interest include the following: Pyrethrum (*Chrysanthemum cinerariaefolium*) requires a deep, well-drained soil; it is intolerant of too rich or even slightly water-logged soils. When required in great quantity, plants still have to be raised from seed. Nevertheless, the plant is easily raised from cuttings or division and the life of the plantation is not shortened thereby—in spite of the contrary opinion held in other pyrethrum growing countries. The vegetatively propagated plants are altogether easier to handle than seedlings and flower sooner. In Kenya, the plant is self-sterile, so that too rigorous a selection must not be practised, another reason against stringent selection being the variability of pyrethrin content between strains which show no outward sign of difference. The theoretically optimum time for picking is when the last florets are about to open. This is impossible commercially. In Kenya, where the flowering period is continuous for ten months, a plant will bear flowers in all stages of development. Various adjustments of picking periods and methods are adopted to secure a good average of mature flowers and the length between the former is largely dependent on the climatic conditions associated with increasing altitude; thus, at 6,000 feet in warm weather, opening may take nine days, whereas, at 9,500 feet in cool weather, it may take three weeks. The daily task for an average picker is 30 lb. The annual yield varies with altitude from 4 cwt. per acre at 5,500 feet to 10–15 cwt. at 9,500 feet. Much remains to be learned about the response of the plant to climate in growth, flowering and pyrethrin content. Just before passing into a resting season with the dry weather, the plants are cut back, originally to remove dry flower stalks which interfere with picking, but now also because a definite degree of pruning appears necessary to maintain the plants in good production. Pyrethrin content appears to diminish as the flush ages and probably with age of plant also, but evidence at present is contradictory. At present, the profitable life of a plantation, usually 4–6 years, is only terminated by depression of yield through weed growth. Since, in drying, a fresh flower loses 75 per cent. of its weight and the climate is often moist, artificial drying is necessary and a suitable dryer capable of local construction has been evolved. The principle of this is an upward draught of air heated by passing over a flue system, which is forced through a series of trays containing the flowers. Attention to certain details which are described ensures in this dryer a very attractive sample with the natural colour of the flowers unaffected. Methods of grading, sampling and baling are briefly described.

* From I.A.B. Imperial Bureau of Horticulture and Plantation Crops—Horticultural Abstracts. Vol. VIII., No. 2, Abs. 462, June, 1938.

(An abstract from Bulletin, Imperial Institute, London, 1938, 36 : 31–44, bibl. 7.)

THE SALAD WAY TO HEALTH.*

(Miss G. L. Roberts (Narridy).)

A special feature of scientific eating is making the right use of fresh, uncooked vegetables and fruits in the form of salads. The blood-stream of man contains sixteen chemicals, and these chemicals are the absolutely necessary substances for keeping and renewing health. "The blood is the life," and unless the blood is furnished with the right materials in the right quantities, the body will suffer in some way.

A free use of salads will purify the blood and restore tone to the system. A green salad should form the chief dish of one meal every day. The advantages of raw food are that it prevents quick eating, ensures an ample supply of vitamins, and stops excessive seasoning and the use of superheated fat.

To Prepare Lettuce for Salads.

Salads can be the most tempting of dishes, or the reverse, according to the way the "greens" are prepared. A little extra trouble taken with these makes all the difference between resignation to the salad course or relish of it. Pull off the outside leaves of the lettuce, then wash quickly. Dry the lettuce thoroughly; break it with the fingers; do not cut it. Use the best olive oil and lemon juice.

Dressing the Salad.

Mix a little salt (vegetable salt for preference) with a spoonful of lemon juice and sprinkle evenly over the lettuce, turning it all the time to get it evenly coated. Then sprinkle the oil in the same way. Do this immediately before serving. A salad is spoiled if left standing. Rubbing the bowl it is served in with a cut onion gives a pleasant flavour. This is a plain dressing with oil and lemon only. When other dressings are used, serve them separately in small jugs. Salads offer the enterprising housewife unlimited opportunities for making attractive and artistic meals, which add appreciation to the knowledge of scientifically prepared food.

Some Good Combinations for Salads.

Raw spinach, sliced carrots, and onions, all cut very finely. Carrots, turnips and young green peas. If the peas are not young, cook all vegetables. Cooked artichokes and onions. Cooked Brussels sprouts and potatoes. Cooked asparagus and celery. Grated carrots, lettuce and beet. Celery, apple and lettuce. Cabbage, celery and apples with grated coco-nut. Tomatoes, grated carrots, cabbage. Tomatoes, cucumber and lettuce. Tomatoes, cucumber, sliced apple and carrots. Watercress, lettuce and spring onions. Beetroot, cabbage, carrots and lettuce. Carrot, apple, celery and raisins on lettuce. Grated carrot, apple and grated nuts. Radishes, cabbage, lettuce and leeks. Mustard and cress, radishes, lettuce and onions.

* From *Journal of Agriculture* (South Australia), September, 1938, p. 221, Vol. XLII., No. 2.

Salad Dressings.

Never use vinegar for salad dressing. The food value of salads served with oil dressing is very high. The oil furnishes heat and energy and the vegetables supply valuable salts and a large percentage of water. Salads refresh without fatiguing, and strengthen without irritating.

French Fruit Dressing.—½ cup olive oil, ¼ cup orange juice, 2 teaspoons lemon juice, 1 teaspoon honey. Beat together until creamy. This may be varied by adding pineapple, grape, or grapefruit juice.

Plain Salad Dressing.—4 tablespoons olive oil, 2 tablespoons each of honey and lemon juice. Mix thoroughly with an egg beater. Use with any vegetable salad.

Mayonnaise Dressing.—To be used with vegetable salads. Yolk of 1 egg, 1 cup of olive oil, 2 teaspoons of lemon juice. Beat the yolk in a mixing bowl, adding the oil drop by drop. When this begins to thicken add a few drops of lemon juice and few more drops of oil until the desired thickness is obtained. For fruit salads add 1 tablespoon of honey.

Sunshine Dressing.—To 3 teaspoons of minced mint, add 3 teaspoons of honey. Cover and let stand in the sunshine for three hours. Add ¼ cup lemon juice. Strain. Serve on any salad that blends with mint. To this dressing may be added 6 teaspoons olive oil. Oranges or limes may be substituted for lemons.

POINTERS ON GOAT RAISING.

(By Carlos X. Burgos, Animal Husbandman.)

(Circular No. 185, Bureau of Agriculture, Manila.)

The raising of goats for meat purposes in this country is not difficult and does not require much time and effort by the owner. In fact, in every province goats can be found. They are usually unprovided with shelter other than what they may find for themselves, which may be a leaning tree, a log, an abandoned shack, a camarin empty, ermitas or what not. Very few ever take the trouble to build them comfortable sheds where they would be protected from rain and enemies.

They thrive on well-drained lands, and for this reason no places are better adapted to their breeding and keeping than rolling hilly sections and mountainous regions unsuited for raising crops.

According to our farm statistics for 1920, Pangasinan, Cebu, Illoilo, Capiz, and Leyte lead in the production of goats.

As the industry develops, the tendency is to raise goats for their milk also. To answer queries, therefore, as to methods and advantages of goat-raising, and in the hope of improving the present practices, this circular has been prepared.

Breeding and Selection.

It is best to start always with a small flock, preferably of pure breeds, or selected mestizos, but when these are not available, native scrub goats will do. Select the largest males for breeding. Fairly good breeding females should be placed in the breeding flock in the ratio of from 12 to 15 females to each male. The number of the females may be increased depending, of course, upon the constitutional vigour of the male. Goats should not be bred from until 16 to 18 months old. When allowed they breed even at 5 to 6 months old. Practice selection continuously and be sure to dispose of all undesirable stock and surplus males.

Feeding.

Goats will keep in good health and condition only where they have plenty of range and where they can find a variety of weeds and wild grains at all seasons. They especially relish ipil-ipil, aroma, and madre de cacao leaves and acacia pods. The idea prevailing is that goats live on almost nothing. This is incorrect and, moreover, they pay better if fed grain in addition to pasture grasses. It is particularly advisable to supplement the green feed of the animals with grain when they are pregnant or being milked. At the Alabang Stock Farm a mixture of equal parts of tiqui-tiqui (guintok in Visaya), corn meal and mongo meal is given every afternoon to *pregnant animals and those with young*. The amount is about a pint condensed milk-canful to each animal. It may be given moist or as a dry mash. Thin animals should be given this ration every once in a while also, and all need extra feeding if the pasture is not good. For the mongo meal may be substituted leguminous crops such as cowpeas, mani-manian, utao or soy beans, and others. The animals can be pastured on a field planted with the above-mentioned crops or rations of same can be given to them at night in the shed while sheltering. It is better to feed in feed racks so that they can not pull the feed out and drop it on the floor where it will be trampled on. Guinea grass and para grass are good for goats to pasture on.

The place where the animals roam for food should be abundantly provided with shrubs and bushes, as they are very fond of these. Goats eat all kinds of tree leaves. They even eat paper or any dry leaf of a tree. They eat weeds or anything else they can find in the field. It is a curious fact that goats, while pasturing, eat a little in one place and then a little in another place. They are always roaming about everywhere while grazing, but it has been noticed that, if put on guinea grass pasture, they eat the tender leaves of one hill before they go on to another hill. In a "saluyot" field they do the same. They eat all the leaves and leave practically nothing but the stalk.

There should be easily accessible for the animals a clean water supply. Otherwise they should be given fresh water regularly in clean containers at noon and in the afternoon. The water should be fresh and clean every time. *Salt should always be available,* as it is indispensible to digestion for goats as for all other animals. Rock salt is preferable.

Shelter.

Like other animals, goats need comfortable quarters to take refuge in at night and during hot or rainy days. A good shed can be made of bamboo and nipa. At least 2 square metres of space should be allowed for each goat. The shed should be low and the ground elevated. A platform should be built to serve as a resting place, especially when the ground floor gets wet. Well littered pens for pregnant goats and for those having young should be provided. This will separate them from the herd and from constant molestation by the males. The building should be located on a high place to ensure drainage. Where the main herd is kept, keep long benches or logs, sufficient for every one of the herd. They always prefer a hard dry elevated surface to lie on.

Three partitions should be provided—one for the pregnant, one for those having young, and another for the herd. The males should not be allowed to mix with the herd at night. Those for sale should be castrated or have a separate shed, as otherwise they may breed with the females in the herd.

The quarters and premises should be kept clean and dry all the time. A box for the excreta or manure should be provided. Later this should be scattered over the grass fields to fertilize the soil of the cultivated grasses.

Care and Management.

There should be shade trees in the pastures intended for goats.

The animals should be in the pasture at about eight in the morning and be driven back to the shed at noon. At two o'clock in the afternoon they should be driven again to the field to stay until sundown. Keep them away from dewy pastures, as dewy grass is liable to cause bloating. It is best, therefore, not to pasture very early in the morning while the grass is still wet with dew.

Animals that have just dropped kids should be confined and fed in pens for about a week or more until the young ones are strong enough to run with their mothers. Give them extra care. Give green and concentrated feed as suggested above. Give clean water every day. After the kids are dropped bury the afterbirth. When there is a sign of caked udder (hardened udder) a massage with hot water should be administered *right away.*

Young kids often have diarrhœa and sticky dung stuck to the anus. Wash the dung off with 5 per cent. creoline solution. Give the mother plenty of green grass.

The mother of ordinary goats may be milked after the kids are about three or four months old and regular milk goats much earlier. A goat that milks around a litre a day is considered a good milker. The lactation period is maintained from six to nine months. Any objectionable odour from the milk will be obviated if the billy goats are kept away from the milking nanny goats and rigid cleanliness maintained.

Have some sort of milking bench 35 centimetres high, one metre long and 60 centimetres wide. Build at one end a feed box and have on both sides two boards to keep the milking nanny on the bench.

Diseases.

Foot-rot.

Foot-rot generally attacks sheep and goats when their feet are always wet. They should *not* be allowed to run on wet ground. The dirt easily collects between the hoofs and stays wet and causes the disease. Bad smelling and wet quarters breed the foot-rot disease. Animals infected with the disease have swollen feet and are lame. The feet smell bad and generally exude a foul discharge. This is an infectious disease. It is best to separate the healthy ones and treat the affected animals with 450 grams of copper sulphate dissolved in 5 litres of warm water, allowing them to stand with their feet in the solution for five minutes. The infected place should be disinfected with 10 per cent. creoline solution or lime. As before said, *keep the place clean and don't allow the goats to get this disease.*

It is best to trim the hoofs of the animals twice a year. This will help keep the foot-rot disease away.

Constipation.

Constipation may occur among the kids. Give them a dose of castor-oil or epsom salts.

Gid.

Gid sometimes prevails among goats. This is a parasite disease that attacks the brain and spinal cord of the animal. The cause is the presence of a larval tapeworm in the brain of the goat. The dog is also a host to this parasite. In the latter it develops in the intestine into a segmented form about 2 to 3 feet in length. These segments at the tail-end are full of eggs; they break off and pass out with the fæces and are thus propagated in the pasture. Animals that may chance to eat or swallow these eggs when drinking are sure to get the disease.

The animal attacked by this disease commonly turns in a circle. It may nibble grass for a while and all of a sudden raise its head and turn in a circle. This action is repeated by the giddy animal many times. When it is driven to its shed it walks with the head sideways.

To eradicate this disease, it is best to destroy the heads and brains of goats that die of it by burning; and by keeping dogs nearby free of tapeworms. The meat of a giddy animal is claimed by some to be good to eat provided it comes from a fat animal, but otherwise it should also be burned. However, it is *never* advisable to eat the meat of a diseased animal.

Stomach Worms.

The Bureau of Agriculture has had deaths among its goats along about the middle and towards the end of the rainy season. On opening the fourth stomach and the intestines of the dead, many twisted white stomach worms were found about 1 to 2 centimetres long. The symptoms previous to death were general weakness, loss of flesh and excessive diarrhœa.

Once the disease is detected, it is best to move the animals as often as possible to a fresh pasture and treat the entire herd with a solution of copper sulphate, which is extensively used in South Africa for sheep and cattle with stomach worms.

To prepare the solution, take 90 grams of clear blue crystals of copper sulphate and dissolve in 7 litres of warm water. (It is better to boil first part of the water and dissolve the crystals.) Give from 50 to 200 cubic centimetres of this solution per head depending on size and age. Dose animals while standing on all fours. Repeat this process after ten days. Bury deep or burn all the dead.

Miscellaneous.

Goats are claimed to be practically immune to tuberculosis, and for this reason goat milk is always preferable to cow milk for infants and invalids.

Proper care and strict sanitation will ensure success to any engaging in this industry.

MARKET FOR PAPAIN.

Papain is the dried latex tapped from the papaw fruit. This extract contains certain medicinal properties which are invaluable in the manufacture of various digestive preparations. The enzyme contained in it is required for making chewing gums, special foods and other pharmaceutical preparations. The value of papain, therefore, depends chiefly upon the enzyme content of the product. The only country producing crude papain on a commercial scale, if any, at present is Ceylon. The papaw tree (*Carica papaya*) grows not only in Ceylon, but in many other parts of the tropics, too. The increasing demand for papain has induced planters in East Africa and other tropical areas to investigate the possibilities of the production of papain. Recently, small supplies of this commodity from these areas were reported to have reached the London market.

The cultivation of the papaw tree is chiefly carried on in the Kegalla, Kandy, and Kurunegala Districts in Ceylon. A deep and well drained loamy soil and sufficient protection from strong winds are necessary concomitants if the best results are to be obtained. In Ceylon, the papaw tree also grows successfully as a catch-crop during the waiting period of return from tea or rubber. The production of crude papain in Ceylon was essentially a cottage industry which was carried on by peasants on a small scale, but the recent increase in the demand for this commodity encouraged the cultivation of the papaw tree on almost a commercial scale. Many small pure plantations therefore sprang up, and the increased production resulted in swollen exports to Europe and the United States of America.

The papaw tree comes into bearing in between eight and twelve months according to the degree of fertility of the soil and remains fruitful from four to five years. Production after the third year, however, is said to be less remunerative and it is therefore considered that the trees should not be retained thereafter.

The fruits should be tapped in the early hours of the morning. In Ceylon, tapping is always completed by 10 a.m. The fruits are not tapped daily, but at intervals of 4 to 5 days or more until they cease to yield latex. A knife of bone, glass or sharp-edged bamboo should be used instead of a steel knife in order to prevent discoloration of the latex. The actual tapping is no more than making shallow longitudinal incisions about an inch or two apart in the rinds of the fruits when they are still green, but fully grown. Further tappings may be carried on between the previous incisions made in the rind. A glass or porcelain receptacle held beneath the fruit collects the juice, which, on exposure to air, coagulates rapidly.

The yield of papain depends upon the soil in which the trees are grown, the variety, and the number of fruits per tree. The average yield of the dried juice per acre is about 100 lb. per annum in the first year of tapping on flat land

and 80 lb. per annum on hilly or rocky ground. In the second year, the yield diminishes by about half the quantity produced in the previous year. In Ceylon, as much as 175 lb. of the dried latex have been obtained per acre of good soil in the first year. Approximately 4½ lb. of fresh latex make 1 lb. of dry papain.

Immediately after collection, the fresh latex should be dried without delay in order to prevent putrefaction and decomposition. The addition of a trace of formalin solution to the latex as it is collected obviates this danger. So that valuable time may be saved in the process of drying, the coagulated latex may be squeezed lightly in a cloth or may be pressed through a colander or perforated plate for removing some of the water. There are two methods of drying the latex—sun-drying and oven-drying. If the former method is adopted, care must be exercised to see that the enzyme properties of the papain are not destroyed by over-baking it. The best results can be obtained by spreading the product on coarse linen stretched on frames and moving it frequently so that the drying is as even as possible. The temperature should be below 100 deg. F. This method of drying papain in the sun is suitable only where small quantities of the product have to be prepared such as in a peasant industry. But where huge quantities have to be treated on a commercial scale or where weather conditions do not permit of satisfactory drying in the sun, the oven forms a desirable drying apparatus. On large estates a hot air chamber can be employed, but the small producer would find it more suitable to use a drying stove. One form of such dryer consists of a chamber, 3 feet high, 3 feet wide and 6 feet long, the sides and ends of which are built in brick. About 1 foot from the top the chamber is divided horizontally into two compartments by a sheet of iron; beneath this, at one end, a small fire grate is constructed, whilst at the opposite end a chimney is built to lead the smoke from the lower compartment. In order to obtain an even heat in the upper compartment a layer of sand about 2 inches thick is spread on the iron sheet. The coagulated juice is spread on brown linen, stretched upon the frames which are made to fit the top of the dryer. As mentioned above, the temperature must be kept at a low level and at no time should exceed 100 deg. F. Coco-nut shells or charcoal are used as fuel in this dryer and the process of drying is completed in about six hours. This method of drying, it is urged, gives an almost white papain.

When completely dry, the papain should be roughly ground and then packed in air-tight tins enclosed in wooden cases, each containing about 100 lb.

The two grades of the product generally marketed are sun-dried and oven-dried papain. The oven-dried variety fetches a better price in the market on account of its very close approach to whiteness in colour and, in the United Kingdom, usually commands a premium of 3d. to 6d. per lb. over sun-dried. The underlying factor, nevertheless, which determines the value of the drug is the degree of enzyme activity in papain. It will be observed from the subjoined table that, in 1927, the average price obtained for papain was as much as Rs. 8.04 per lb., as against Rs. 1.96 per lb. in 1936, which was the lowest level reached in the last decade. There was a slight recovery last year to Rs. 2.14 per lb. The phenomenal increase in shipments to the United Kingdom and the United States of America in recent years, indicates a systematic extension of *papaya* cultivation in Ceylon, larger output and keener competition amongst exporters.

EXPORTS OF PAPAIN FROM CEYLON.

Countries.	lb.	lb.	lb.	lb.
United Kingdom	69,947	71,361	63,328	75,474
Australia	..	..	..	50
Canada	..	47	716	1,430
France	520	15,702	2,974	1,099
Germany	331	936	2,219	2,016
Holland	..	..	..	..
United States of America	32,780	67,228	158,726	116,447
Belgium	200	..	..	..
Cochin China	..	..	..	..
Total Quantity	103,778	155,274	227,963	196,516
Total Value	Rs. 590,849	Rs. 638,516	Rs. 447,165	Rs. 420,920
Average Value	Rs. c. per lb. 5.69	Rs. c. per lb. 4.11	Rs. c. per lb. 1.96	Rs. c. per lb. 2.14

(From the *Ceylon Trade Journal*, Vol. II, No. 12 December, 1937.)

CLIMATOLOGICAL DATA.

RABAUL (BOTANIC GARDENS)—LAT. 4° 12′ S., LONG. 152° 11′ E.; HEIGHT ABOVE M.S.L. 40 FEET.

Month, 1938.	Bar. Cor. to 32° F. M.S.L. and Standard Gravity from 9 a.m. and 3 p.m. readings.	Amounts of Clouds Means of— 9 a.m., 3 p.m., 9 p.m.	Clear Days.	Highest Barometer Reading (Corrected).	Date.	Lowest Barometer Reading (Corrected).	Date.
January	29.757	7.2	8	29.878, 9 a.m.	12th	29.634, 3 p.m.	26th
February	29.758	8.5	6	29.917, 9 a.m.	26th	29.622, 3 p.m.	8th
March	29.756	6.2	11	29.874, 9 a.m.	3rd	29.663, 3 p.m.	24th
April	29.771	5.8	17	29.880, 9 a.m.	28th	29.668, 3 p.m.	4th
May	29.783	4.5	22	29.908, 9 a.m.	20th	29.685, 3 p.m.	2nd
June	29.866	5.5	18	29.914, 9 a.m.	10th	29.694, 3 p.m.	3rd
July	29.807	5.8	24	29.894, 9 a.m.	23rd	29.720, 3 p.m.	15th
August	29.799	4.5	25	29.894, 9 a.m.	8th	29.693, 3 p.m.	22nd
September	29.797	5.0	24	29.896, 9 a.m.	12th	29.672, 3 p.m.	19th
October	29.825	4.8	21	29.920, 9 a.m.	12th	29.681, 3 p.m.	28th
November	29.766	6.5	12	29.898, 9 p.m.	12th	29.657, 3 p.m.	6th
December	29.728	7.0	14	29.845, 9 a.m.	2nd	29.621, 3 p.m.	28th
Total	357.413	71.3	202	358.718	..	356.010	
Average	29.784	5.9	16.8	29.893	..	29.667	
Extremes	29.866 June 29.728 December	8.5 February	25 August 6 February	29.920	12.10.38	29.621	28.12.38

CLIMATOLOGICAL DATA—*continued.*

HUMIDITY AND RAINFALL.

Month, 1938.	Humidity.			Rainfall. Monthly, 1938.	Average Rainfall Since 1914.	Greatest Monthly Rainfall.	Year.	Least Monthly Rainfall.	Year.	Wet Days, Monthly, 1938.	Wet Days, Average Since 1914.	Greatest Fall in 24 hours.	
	Mean, 9 a.m.	Mean, 3 p.m.	Mean, Monthly.									1938.	Date.
January	79	79	79	12.10	14.32	37.74	1916	4.77	1918	23	21.0	3.01	16th
February	83	83	83	11.33	10.59	23.54	1923	3.38	1921	22	12.7	2.98	8th
March	76	65	70.5	5.96	9.53	22.23	1919	0.00	1915	20	18.8	0.90	29th
April	76	69	72.5	7.17	9.66	18.57	1925	0.93	1937	13	17.9	1.45	8th
May	76	66	71	4.02	5.07	11.27	1930	0.74	1932	9	13.2	1.47	27th
June	79	69	74	3.22	3.42	7.78	1923	0.79	1914	12	12.5	1.21	27th
July	79	65	72	1.25	5.55	18.00	1930	0.09	1914	7	14.6	0.28	10th
August	71	56	63.5	1.36	4.33	12.45	1937	0.36	1924	6	14.7	0.60	19th
September	68	56	62	2.20	3.67	7.15	1921	0.32	1914	6	12.5	0.91	5th
October	72	62	67	6.70	5.21	11.86	1928	0.62	1914	10	12.5	2.66	9th
November	75	65	70	5.34	6.41	14.23	1912	1.73	1933	18	15.5	1.08	30th
December	79	72	75.5	11.87	10.32	16.22	1919	3.66	1933	17	18.2	1.99	30th
Total	913	807	860.0	72.52	88.08	..	..	..	..	163	184.1	18.54	..
Average	76.1	67.2	71.7	6.04	7.34	..	..	..	..	13.6	15.3	1.54	..
Extremes	83 Feb.	56 Aug., Sept.	83 Feb., 62 Sept.	12.10 Jan., 1.25 July	14.32 Jan., 3.42 June	37.74 Jan.	1916	0.00 March	1915	23 Jan., 6 Aug., 6 Sept.	21.0 Jan.	3.01	16.1.38

CLIMATOLOGICAL DATA—*continued.*

TEMPERATURE.

Month, 1938.	Mean.		Monthly Average, 1938.	Highest Maximum.	Date.	Lowest Minimum.	Date.	Lowest on Grass.	Date.
	Maximum.	Minimum.							
January	89.3	74.5	81.9	93.5	22nd	72.0	16th	70.0	16th
February	87.3	75.9	81.1	92.1	1st	73.0	27th	72.0	2nd
March	90.8	73.9	82.3	97.0	16th	72.0	30th	69.0	31st
April	90.1	74.1	82.1	92.5	15th, 17th	72.0	10th	70.0	10th
May	90.9	73.4	82.1	94.1	6th	71.0	4th	67.8	24th
June	89.7	73.3	81.5	93.0	6th	71.8	28th	69.0	28th
July	89.8	72.8	81.3	93.5	31st	70.3	3rd	67.7	23rd
August	92.3	73.0	82.6	95.3	29th	70.9	26th	68.0	26th
September	92.7	73.2	82.9	97.0	28th	70.9	12th	67.0	27th
October	91.6	73.5	82.5	96.5	1st	69.8	26th	64.6	26th
November	90.7	73.8	82.2	94.5	6th	70.2	29th	66.4	4th
December	90.0	74.2	82.1	93.2	23rd	72.2	14th	71.0	6th, 16th, 27th
Total	1085.2	884.7	984.6	..	..	..	..	..	..
Average	90.4	73.7	82.05	..	..	..	..	..	..
Extremes ..	92.7 Sept.	72.8 July	82.9 Sept. 81.1 Feb.	97.0	16.3.38 28.9.38	69.8	26.10.38	64.6	26.10.38

CLIMATOLOGICAL DATA—*continued.*

STANDARD TIME OF SUNRISE AND SUNSET AT RABAUL, 1939.

Date.	Sunrise.	Sunset.	Date.	Sunrise.	Sunset.
	h. m.	h. m.		h. m.	h. m.
January 6	5 46	6 7	July 7	5 58	5 52
13	5 49	6 10	14	5 59	5 53
20	5 53	6 12	21	6 0	5 55
27	5 54	6 12	28	6 0	5 55
February 3	5 56	6 13	August 4	5 58	5 55
10	5 58	6 13	11	5 58	5 55
17	5 58	6 12	18	5 56	5 55
24	5 58	6 10	25	5 53	5 53
March 3	5 58	6 8	September 1.. ..	5 51	5 51
10	5 57	6 6	8.. ..	5 47	5 50
17	5 57	6 3	15.. ..	5 44	5 49
24	5 54	6 1	22.. ..	5 40	5 47
31	5 53	5 57	29.. ..	5 38	5 46
April 7	5 52	5 54	October 6	5 35	5 44
14	5 51	5 52	13	5 32	5 43
21	5 49	5 49	20	5 29	5 42
28	5 49	5 48	27	5 28	5 43
May 5	5 49	5 46	November 3.. ..	5 27	5 44
12	5 49	5 46	10.. ..	5 27	5 44
19	5 50	5 46	17.. ..	5 28	5 46
26	5 50	5 45	24.. ..	5 28	5 47
June 2	5 52	5 46	December 1.. ..	5 30	5 51
9	5 53	5 46	8.. ..	5 31	5 53
16	5 54	5 47	15.. ..	5 35	5 57
23	5 56	5 49	22.. ..	5 39	6 0
30	5 58	5 51	29.. ..	5 42	6 4

PHASES OF THE MOON, 1939.

RABAUL.

January—
6–Full moon .. .. 7.30 a.m.
12–Last quarter .. .. 10.10 p.m.
20–New moon .. .. 11.27 p.m.
29–First quarter .. .. 1.0 a.m.
6–Perigee .. .. 9.0 p.m.
21–Apogee .. .. 9.0 a.m.

February—
4–Full moon .. .. 5.55 p.m.
11–Last quarter .. .. 2.12 p.m.
19–New moon .. .. 6.28 p.m.
27–First quarter .. .. 1.26 p.m.
4–Perigee .. .. 10.0 a.m.
17–Apogee .. .. 12.0 noon

March—
6–Full moon .. .. 4.0 a.m.
13–Last quarter .. .. 7.37 a.m.
21–New moon .. .. 11.49 a.m.
28–First quarter .. .. 10.16 p.m.
4–Perigee .. .. 9.0 p.m.
17–Apogee .. .. 1.0 a.m.

April—
4–Full moon .. .. 2.18 p.m.
12–Last quarter .. .. 2.11 a.m.
20–New moon .. .. 2.35 a.m.
27–First quarter .. .. 4.25 a.m.
1–Perigee .. .. 11.0 p.m.
13–Apogee .. .. 7.0 p.m.
28–Perigee .. .. 8.0 p.m.

May—
4–Full moon .. .. 1.15 a.m.
11–Last quarter .. .. 8.40 p.m.
19–New moon .. .. 2.25 p.m.
26–First quarter .. .. 9.20 a.m.
11–Apogee .. .. 3.0 p.m.
23–Perigee .. .. 10.0 p.m.

June—
2–Full moon .. .. 1.11 p.m.
10–Last quarter .. .. 2.7 p.m.
17–New moon .. .. 11.37 p.m.
24–First quarter .. .. 2.35 p.m.
8–Apogee .. .. 9.0 a.m.
20–Perigee .. .. 6.0 a.m.

July—
2–Full moon .. .. 2.16 a.m.
10–Last quarter .. .. 5.49 a.m.
17–New moon .. .. 7.3 a.m.
23–First quarter .. .. 9.34 p.m.
31–Full moon .. .. 4.37 p.m.
5–Apogee .. .. 12.0 mid-night
18–Perigee .. .. 9.0 a.m.

August—
8–Last quarter .. .. 7.18 p.m.
15–New moon .. .. 1.53 p.m.
22–First quarter .. .. 7.21 a.m.
30–Full moon .. .. 8.9 a.m.
2–Apogee .. .. 10.0 a.m.
15–Perigee .. .. 6.0 p.m.
29–Apogee .. .. 1.0 p.m.

PHASES OF THE MOON, 1939—*continued.*

September—		**November—**	
7–Last quarter	6.24 a.m.	4–Last quarter	11.12 p.m.
13–New moon	9.22 p.m.	11–New moon	5.54 p.m.
20–First quarter	8.34 p.m.	19–First quarter	9.21 a.m.
29–Full moon	12.27 a.m.	27–Full moon	7.54 a.m.
13–Perigee	4.0 a.m.	8–Perigee	7.0 a.m.
25–Apogee	7.0 p.m.	20–Apogee	5.0 a.m.
		December—	
October—		4–Last quarter	6.40 a.m.
6–Last quarter	3.27 p.m.	11–New moon	7.45 a.m.
13–New moon	6.30 a.m.	19–First quarter	7.4 a.m.
20–First quarter	1.24 p.m.	26–Full moon	7.28 p.m.
28–Full moon	4.42 p.m.	3–Perigee	5.0 p.m.
11–Perigee	11.0 a.m.	18–Apogee	2.0 a.m.
23–Apogee	9.0 a.m.	29–Perigee	9.0 p.m.

ECLIPSE, 1939.

A total Eclipse of the Moon, 3rd May, the beginning and ending visible generally in Australia, New Guinea and Western Pacific Ocean. Magnitude of Eclipse, 1.82 (Moon's diameter, 1.0). Begins, 3.28 a.m. Ends, 6.55 a.m. *Total Phase*: Begins, 4.40 a.m. Ends 5.43 a.m. (*Rabaul time*).

NOTES.

RAINFALL AND MOON PHASES IN THE TROPICS.(1)

On the low-lying east bank of the Demerara River, about 8 miles from its mouth, is situate Diamond Plantation, the largest sugar factory in British Guiana, located approximately at 6 degrees 42 minutes North and 58 degrees 10 minutes West. Preserved at Diamond is a valuable record of the daily rainfall for the past 46 years. Through the courtesy of the plantation authorities, I have been able to secure a copy of the register.

So many farmers and planters in the West Indies and British Guiana have faith in the new moon or the full moon bringing rain, that it seemed of value to determine, from the Diamond data, what actual foundation there is for the belief.

Popular belief does not definitely fix the fall of rain for the actual date of the new or full moon, but for some time near the date. Thus one frequently overhears such remarks as: 'It will be new moon to-morrow and we should get some rain to-night or to-morrow," or "the moon is full to-night so we may get some rain to-night or to-morrow." It was therefore decided to compare the average rainfall for (*a*) the three-day period made up of the day before new moon, the new moon day and the day after the new moon; (*b*) the three-day[1] period immediately preceding (*a*); (*c*) the three-day period immediately following (*a*); (*d*) the three-day period made up of the day before full moon, the full moon day and the day following the full moon; (*e*) the three-day period immediately preceding (*d*); (*f*) the three-day period immediately following (*d*).

This was done for the year as a whole and for the dry seasons only, since it might be argued that it is only during the latter that farmers are worried about rain and trouble to note the supposed relationship between precipitation and moon phases. At Diamond the weekly rainfall averages less than 2 inches from the week ending 21st January to that ending 29th April, and again from the week ending 12th August to that ending 25th November. These periods were taken as constituting the dry seasons. During the rest of the year the rainfall averages more than 2 inches per week.

(1) Reprinted from *Nature*, Vol. 139, No. 3510, February 6, 1937.

The results obtained for 259 new and 261 full moons (1914-1934), for the whole year, and for 147 new and 146 full moons, for the dry seasons, are set out in the accompanying table.

COMPARISON OF AVERAGE RAINFALL (1914-34) IN INCHES AT NEW AND FULL MOON WITH RAINFALL PRIOR AND AFTER AT DIAMOND, E.B., DEMERARA, BRITISH GUIANA.

—	New Moon.			Full Moon.		
	3 Days prior (b)	3 Days at (a)	3 Days after (c)	3 Days prior (e)	3 Days at (d)	3 Days after (f)
Year ..	0.81 + 0.06	0.82 + 0.07	0.78 + 0.07	0.85 + 0.08	0.74 + 0.06	0.93 + 0.09
Dry Season ..	0.50 + 0.06	0.51 + 0.07	0.51 + 0.08	0.48 + 0.07	0.50 + 0.07	0.62 + 0.10

The differences between the means are as follows:—

	Whole Year.	Dry Season.
a and b	0.01 ± 0.092	0.01 ± 0.092
a „ c	0.04 ± 0.099	0.00 ± 0.106
d „ e	0.11 ± 0.100	0.02 ± 0.099
d „ f	0.19 ± 0.108	0.12 ± 0.122
a „ d	0.08 ± 0.092	0.01 ± 0.099

It will be seen that none of the differences is significant and that there is no support whatever for the belief that there is likely to be more rain at the new or full moon than during the days just before or just after these phases. It is of interest to note, too, that the average rainfalls for the new moon and full moon periods are very similar.

C. Holman B. Williams.

TABLE OF SEA DISTANCES (in Miles).

From Rabaul to—	
Aitape..	613
Ambunti	702
Buin ..	313
Buka Passage	173
Dutch Border	700
Finschhafen	368
Gasmata	218
Kalili ..	35
Kavieng	163
Kieta ..	258
Lae ..	417
Madang	411
Manus..	340

From Rabaul to—	
Marienberg	515
Mortlocks	310
Muliama	120
Pondo ..	96
Salamaua	422
Samarai	428
Sepik Mouth	477
Sydney	1,845
Talasea	174
Tasmans	460
Wewak	530
Witu ..	182

ERRATUM.

Mr. R. J. A. W. Lever, Entomologist, Suva, Fiji, has kindly drawn our attention to an error in the bibliography of the article on "Coco-nut Improvement by Seed Selection and Plant Breeding," written by the Economic Botanist (See *New Guinea Agricultural Gazette,* Vol. 4, No. 3, July, 1938, reference No. 38, of the "Literature Cited"). The reference should have been as follows:—

Lever, R. J. A. W., (1935).—"The Green Coco-nut Bug (*Amblypelta cocophaga China*) and Induced Nut-Fall in the Coco-nut". B.S.I.P. *Agricultural Gazette,* Vol. 3, No 4, pp. 9-10, October, 1935.

It is pointed out that the work dealing with the particular figures mentioned was printed and published before the joint author, named in the other reference quoted, had arrived in the Protectorate. This mistake is acknowledged, so that workers interested may correct the bibliography of the article on "Coco-nut Improvement by Seed Selection and Plant Breeding".

NOTE RE "COCO-NUT THREAD BLIGHT."

With reference to the article on "The Diseases of Coco-nuts in New Guinea" also by the Economic Botanist (see *New Guinea Agricultural Gazette,* Vol. 3, No. 1, pp. 77-79), Mr. R. J. A. W. Lever has supplied the following interesting notes:—

You may be interested to know that I took a specimen of coco-nut pinna, infected with "thread blight" to the Imperial Mycological Institute, when on leave (i.e., in 1937).

The specimen was from Vella Island, British Solomon Islands, and, when I showed it to Messrs. S. Ashby (Director of the Institute) and E. Mason, it was found to be identical with *Corticium penicillatum* Petch, which, therefore, shows it occurs elsewhere, besides New Britain and New Ireland.

It is commented that this Department recognizes this disease as being very prevalent in Bougainville Island which, although part of the Mandated Territory of New Guinea, is really portion of the Solomon Islands Group.

PRACTICAL ASPECTS OF COPRA DETERIORATION.*

In this paper, Mr. Cooke has dealt with all the practical aspects of quality in copra. The entomological and mycological aspects of the same subject have been dealt with in Special Bulletin, Scientific Series, No. 20, of the Department of Agriculture, S.S. and F.M.S.

There is no real reason why bad copra should be produced anywhere in the world for, apart from very slight differences in oil content in the nuts of different countries, the quality of the meat is the same in all ripe coco-nuts from healthy palms all over the world. Differences in quality are due only to differences in care in the preparation of the copra and its subsequent handling, and it calls for no great amount of care, no high technical knowledge and no great expense, to prepare very good copra. For years the Departments of Agriculture of all copra-producing countries have been trying to educate local producers to prepare good copra, and to induce local traders to encourage its production. Yet even to-day the general standard of quality of the world's copra is appallingly low in comparison with the standards of every other primary agricultural product that enters into world trade.

Undoubtedly one factor that contributes to this is the fact, explained by Mr. Cooke (pp. 26 and 27), that, as copra deteriorates, while its oil becomes more acid, while moulds destroy its substance, it unfortunately happens that simultaneously the oil content of the remainder rises. Thus, though deterioration involves loss of weight and loss of quality in the oil and in the cake, yet no decrease—even a slight increase—occurs in the first figure the buyer looks at—the oil content of the sample.

This fact, however, does not entirely explain the present unsatisfactory condition of the world's copra, for, despite it, the miller of copra is prepared to pay more for good copra than for bad. The higher value of the good oil and cake that he can make from good copra outweighs the greater proportion of oil that he can get from bad copra. The reason why the amount of deterioration that occurs in copra is so great as compared with that in other comparable products, such, for instance, as palm oil, palm kernels, or cocoa, seems to lie in the system by which it is handled on the world's markets.

If one ships palm kernels, palm oil or cocoa from West Africa to Liverpool, New York, Hamburg or London, one sells on definite well-known clauses which specify the grades of quality with considerable accuracy and which are substantially the same in all these markets. In the case of the two former products, not only can one thus sell on a clause closely defining the quality of the produce, but the contract also provides for the payment of premia, or deductions of allowance, according to the variation of the parcel from the standard quality specified in the clause. In the case of cocoa, the system of futures, spot markets and defined grades provides more elaborate machinery serving the same purpose of combining the advantages of forward sale or purchase with a final adjustment of price with very great exactitude according to the exact quality.

* From a review by O. T. F. in the *Malayan Agricultural Journal* XXV., No. 12, 1937, on "The Practical Aspects of Copra Deterioration," by F. C. Cooke, Special Bulletin, General Series No. 28, Department of Agriculture, S. S. & F. M. S., 1937, 49 pp., 3 plates.

For copra we have simply the two grades of f.m.s. and fair mechantable, and the forward sale of these grades as such. Compared to the grade definitions in other products the meaning of these copra terms is extremely vague. They really amount to little more than "fair average quality for the country concerned" and a quality distinctly lower than f.a.q. but still recognizable as copra. This vagueness of definition of grades and the inability to buy or sell a standard grade forward with subsequent accurate adjustment of the spot price according to the quality delivered, militate to discourage the buyer in the country of origin from paying more for superior quality. Until he does so, efforts to induce the producer to prepare a better quality naturally meet with little response.

This situation also renders almost impossible the introduction of any satisfactory system of official grading at source, such as has been introduced in recent years in respect of nearly every other important primary agricultural product that is marketed wholesale.

The special contracts made by some estates for regular sale of "estate quality copra" are not a contradiction of the statements made above; for though in such sales the buyer may get the exact quality he wants and the seller get the extra price his quality deserves, both have to sacrifice the great advantage of trading in the open market. In any event, this only affects estates, not the small holders who produce a large proportion of the world's copra.

The considerations set out above are not theoretical ones. Let any one who is interested in the matter ask, for instance, Messrs. Cadbury or Messrs. Rowntrees, if they would like to buy cocoa under the same conditions as copra is bought; and further, ask them if they think that the quality of cocoa from West Africa would be what it is to-day if there were not accurate definitions in the standard clauses of defining grades of cocoa.

Mr. Cooke discusses the range of quality of copra and the conditions under which it is marketed. He continues with a concise statement of the causes of deterioration and of the methods by which such deterioration may be obviated and concludes with a section on copra grading. The technique of preparation of copra must vary to suit local conditions, especially that of climate; but his recommendations are of a general character and simple to follow, so that there appears no good reason why the results of his investigations may not be translated into practice by producers at no great expense, and to the ultimate benefit of the industry.

REPORT ON SOIL SAMPLES FROM AIYURA AGRICULTURAL STATION, UPPER RAMU, NEW GUINEA.

(By J. S. Hosking, Division of Soils, Council for Scientific and Industrial Research, Waite Institute, Adelaide.)

The following notes accompanied the eighteen soil samples, representing three profiles, sent in by R. F. Brechin, Officer-in-Charge of the Agricultural Station, Aiyura :—

Nos. I. and II. profiles may be regarded as representative profiles of the soil in the bush country (of about 25 acres) now being cleared for Cinchona and Coffee Arabica. As many hundreds of tons of fallen timber, dead and decaying branches and leaves and leaf-mould remain on the surface, the surface samples are not a complete indication of the total organic matter present, or of the ash content.

No. III. profile is typical of the "alluvial flats" at Aiyura. Approximately 1,000 acres of this type of soil is present. This area is entirely grassland at the present time.

It is asked that the soil samples be subjected to the same analyses, as were the samples previously forwarded from Ramu, for comparative purposes. It will also be of interest to see how the bush country soil at Aiyura compares with the best Cinchona soils in Java."

The result of the soil analyses by Mr. Hosking is described as follows:—

The three profiles, first and second from the "bush" country and the third from the alluvial flats at Aiyura, are very similar to those already examined from the Upper Ramu Valley.

The soils are podsolised and consist of a thin layer of litter overlying a surface soil layer of dark brown to grey brown loam rich in organic matter to a depth of 12 inches over grey brown to light yellow brown (the yellow shade increasing with depth), mottled sandy clay or light clay subsoils.

The soils are acid in reaction. In the surface they range from pH 5.2 to pH 6.3 and rise to between pH 6 and pH 7 at a depth of 12 inches; in the lower layers the pH falls off slightly.

An adequate plant food supply is indicated by the figures in Table herewith.

TABLE 3.—ANALYTICAL DATA FOR SOIL SAMPLES FROM AIYURA, UPPER RAMU DISTRICT, TERRITORY OF NEW GUINEA.

Location.	Profile Number.	Waite Institute Sample Number.	Depth in Inches.	Moisture.	Loss on Ignition.	Soil Reaction.	Nitrogen.	K_2O.	P_2O_5.
				%	%	%	%	%	%
Bush Country	I.	5364	Surface	9.4	45.4	5.2	1.18	0.25	0.27
		5365	6	5.1	13.6	5.8	0.25	0.08	0.16
		5366	9	5.2	14.3	6.1	..	..	..
		5367	12	4.2	12.8	6.6	0.14	0.07	0.12
		5368	24	4.9	11.6	5.6	..	..	..
		5369	36	4.6	9.6	5.6	..	0.06	0.15
Bush Country	II.	5370	Surface	8.2	35.5	5.9	0.85	0.16	0.25
		5371	6	4.9	15.3	6.6	0.27	0.11	0.16
		5372	9	4.3	13.1	6.6	..	..	..
		5373	12	5.0	12.8	6.9	0.17	0.17	0.14
		5374	24	4.2	12.4	6.5	..	..	..
		5375	36	4.3	12.1	6.4	..	..	0.15
Alluvial Flats	III.	5376	Surface	4.7	22.8	6.3	0.38	0.17	0.26
		5377	6	4.9	12.5	6.2	0.17	0.09	0.14
		5378	9	4.9	12.2	6.2	..	..	..
		5379	12	4.4	10.8	6.7	0.15	0.15	0.13
		5380	24	4.6	9.8	6.4	..	..	..
		5381	36	4.7	11.5	6.2	..	..	0.14

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