COCONUT PLANTER'S MANUAL

FERGUSON'S

"ALL ABOUT THE COCONUT PALM."

FIFTH EDITION.

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(*COCOS NUCIFERA.*)

TREATING OF THE HISTORY AND CULTIVATION. CHEMISTRY AND PHYSIOLOGY OF THE PALM, - - AND ABOUT ITS COMMERCIAL PRODUCTS. - -

COMPILED BY THE LATE

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FIFTH EDITION

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HEAD OF COCONUT PALM.

Frontispiece.

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ILLUSTRATIONS.

[*For the Illustrations found in this book we are indebted to the Director of Agriculture, the Director of Statistics, Messrs. Plate & Co., the Colombo Commercial Co., Ltd., and "Trent Vale," to whom we tender our thanks —C. D.*]

PREFACE.

THE first edition of "All about the Coconut Palm" appeared in 1885, and for a considerable time the work held the field as *the* book of reference on Coconut Cultivation. But consisting as it did of a collation of information reprinted from the *Tropical Agriculturist*, it was of the nature of a *pot-pourri*, and, though of considerable interest from the general reader's point of view, furnished no reliable data from the planter's stand-point. Since the last edition was published in 1904, much has been learned about Coconut Cultivation and reliable authorities have published works on the subject. The most important of the latter are Hamel Smith's *Coconuts, the Consols of the East*, Prudhomme's *Le Cocotier*, Preuss' *Die Kokospalme und ihre Kultur* and Dr. Copeland's *The Coconut*; and to these we are greatly indebted in the compilation of this book.

In the present edition it will be found that the bulk of the material which has hitherto appeared has been eliminated owing to the information being quite out of date. Matters of historical—almost archæological—interest have also been omitted, and in their place more useful papers and abstracts have been inserted.

The *Ceylon Observer* Press has done a great deal of pioneer work as publishers, not only in launching the newspaper of that name, but also the *Tropical Agriculturist* and other pamphlets and monographs dealing with agricultural products. *The Tropical Agriculturist*, founded in 1881 by the late Mr. John Ferguson, C.M.G., long enjoyed a world wide reputation as the first Agricultural Journal in the East. In 1905 it passed into the hands of the Ceylon Agricultural Society, and ultimately into those of the Department of Agriculture, of which it is now the official organ. The present proprietors of the *Ceylon Observer* Press, while endeavouring to carry out the policy of Messrs. A. M. & J. Ferguson in their daily paper, are maintaining the same interest in matters agricultural which their predecessors took, and, as an earnest of that determination, are issuing this revised edition of "All about the Coconut Palm" in the hope that it will supply a need and appeal to all who are looking for information about what is admittedly the soundest agricultural industry of the Eastern Tropics.

The present work, as indicated, is only an improved edition of Ferguson's "All about the Coconut Palm," and, as such, is in the nature of a compilation and so lays no claim to originality.

For much of the information contained in it we are indebted, (besides the standard works already mentioned) to the following sources: —The *Tropical Agriculturist*, Bulletins and Leaflets issued by the Department of Agriculture, Handbook of Commercial and General Information for Ceylon, Official Reports and Returns, the authors of the papers reprinted and to Messrs. A. W. Beven, J. D. Vanderstraaten, A. K. Beven, A. Drieberg, A. E. Rajapakse and other planters whose assistance we take this opportunity of acknowleding.

INTRODUCTION.

AMONG the planters of an older generation, who specialised in Coconut Cultivation, and whose experience has contributed to our present knowledge, were the late Messrs. R. Davidson, W. B. Lamont, W. Jardine and W. H. Wright, followed by the late Messrs. G. T. Nicholas and F. Beven, and among those still living Messrs. J. D. Vanderstraaten and A. W. Beven—all of whom have written useful papers on the subject, a few of which are reproduced in the present edition. Some of the papers—and particularly those by the Government Agricultural Chemist and the Chemical Adviser to the Colombo Commercial Company, Ltd.—are specially valuable and authoritative; and one is hardly prepared to add to or take away from what they, as experts, have to tell us on the subject, especially of Tillage and Manuring. The Department of Agriculture, too, is every year adding to our knowledge of the Coconut Palm and its requirements. To the Government Mycologist and Entomologist we are indebted for the papers dealing with Pests and Diseases. As the work of the Agricultural Department progresses with the co-operation of an intelligent body of Coconut Planters, there is a prospect of a considerable accession of knowledge not only about cultural details, but also about such matters as seed selection, with a view to increasing the productiveness of the palm as well as improving the quality of individual nuts. When it is realised how much science has done, and is doing, for such crops as tea and rubber, we are led to hope for great things from our experts in Agriculture, Chemistry and Biology when they are freer to concentrate on what is often grandiloquently referred to as "the Consols of the East", but which, in respect of scientific investigation, has been the Cinderella among tropical industries. But we have reason to believe, from recent discussions in Committees of the Board of Agriculture, that the Coconut Palm is soon likely to come by its own.

Coconut Planter's Manual.

ORIGIN AND HISTORY.

Botanical evidence would seem to point to the fact that the coconut is a native of Tropical America, and that it was carried westward across the Pacific. From Polynesia, it is presumed, it reached New Guinea and Malaya, and thence found its way to Ceylon.

The botanist de Candolle was of opinion that its original habitat was the Eastern Archipelago, somewhere near Sumatra and Java, and that the nuts floated East and West.

According to local tradition the earliest known palms were on the southern coast near Weligama, where the medicinal value of coconut oil was discovered by King Kusta-Raja (whom the figure carved on a rock near Weligama is believed to represent)—a supposed leper. History tells us that it was along the South-West coast of the Island that coconuts came to be first established, a fact that would tend to support de Candolle's theory on the origin of the palm; but it may be that its propagation was fostered by the more enterprising inhabitants of the populous western side of the Island at a time when there was scarcely any settled population on the East coast.

Little interest seems to have been taken in coconut planting by the Portuguese, but with the arrival of the Dutch the cultivation of the palm was stimulated.

At the beginning of the last century, the western and southern coasts of Ceylon presented, with certain intervals, a fairly continuous grove of coconut palms, but it did not extend far inland (10 million coconut trees being the reckoning between Dondra Head and Kalpitiya). Bertolacci pointed out the large field for an extension of planting on the North-West coast around Chilaw and Puttalam, and he mentions that the peninsula of Kalpitiya was in his own time within 18 years changed from a barren unproductive area to an expanse of the finest plantations of this palm, so that the cultivation extended all the way from Colombo *via* Negombo nearly to Chilaw. Little or no coconut oil was, in the first quarter of the last century, exported from Ceylon to Europe.* To India between 1806 and 1813 there were annually sent about three millions of coconuts, 28,000 measures of oil, and 3,500 cwt. of copra, besides 20,000 cwt. of coir. The Arabs must have taught the Sinhalese how to prepare coir or cordage from the fibre of the coconut about the 13th or 14th century. The manufacture of coir (said to be best from unripe nuts) from the husk of the coconut acquired great importance in the time of the Dutch, as many as 3 million pounds—of cordage, chiefly—being supplied and exported principally to Batavia and the Cape of Good Hope. The port captains of Colombo and Galle were allowed to manufacture or sell on their own account: the former 600,000 lb. and the latter 500,000 lb. of coir cordage. In the early days of the British the manufacture fell off, the natives considering the work only fit for low castes; but at the present day it affords extensive employment to the inhabitants on the coast, especially in the South and West.

Systematic coco-palm cultivation by Colonists in Ceylon was first commenced in the Jaffna and Batticaloa districts in 1841, and a vast amount of money was lost over it from first to last, many of the plantations having passed out of the original proprietors' hands for a trifling percentage of their cost. In 1853, Mr. A. O. Brodie, Assistant Agent at Puttalam, reported that in the Chilaw-Puttalam district the cultivation was rapidly extending. From 1840 to 1850 was the era of planting by Europeans; then came a blank of

* In 1820 Captain Boyd, an Aberdeen navigator, in command of an East Indian trader (the partner afterwards in the firm of Acland, Boyd & Co.) is said to have taken home the first cargo of coconut oil ever exported from Ceylon. There was, at that time, no market for this article in England, and when the cargo arrived home there was some difficulty in persuading any one to purchase it. At length some relatives of the captain, proprietors of a wool mill, reported on the fitness of the oil for lubricating purposes, and a sale was effected. In 1832 or 1833 Acland, Boyd & Co. established the first oil mill worked by steam, and the export trade in coconut oil then became a favourite mode of utilising the savings of civilians and military men. Master Attendant, then Capt., Steuart also took a cargo of coconut oil home about 1820, utilising plantain stems to fill up the interstices between the casks. Another account has it that Governor Sir R. Wilmot Horton established the first coconut-oil mills worked by steam power at Colombo and made the first shipment of oil on Government account to London and that Messrs. Acland, Boyd & Co. then bought the mills (St. Sebastian) and got out an engineer of their own, the late Mr. Rudd, Senr. In the Government Calendar for 1835, one entry in the Directory portion for Colombo is:—"The Steam Engine in the charge of Mr. H. Rudd". Some years after Messrs. Wilson & Archer started the Belmont (now Hultsdorf) mills, Mr. David Wilson's father having invented a process for separating the fat from the oleine of the coconut oil, so making it (coconut oil) to keep liquid in cold; this gave a great impetus to the trade.

Uncultivated Coconut Garden.

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ten years, and then the Ceylonese began to embark upon the cultivation, and in the Western and North-West Provinces especially they brought many thousands of acres of jungle under cultivation, more especially along the valley of the Mahaoya between Negombo and Polgahwela, since 1866, and later in the Chilaw Puttalam district and in the Eastern Province. This movement was a result of the growing prosperity of the people through the money circulated by the coffee enterprise from 1850 onwards, and of the Government unlocking their low-country reserves of Crown land.

Since then further extension has taken place in all parts of the Island, and districts where a low rainfall makes dry-farming compulsory are being exploited.

Originally coconut cultivation was confined to the coast and to sea level under the impression that proximity to the sea was a *sine qua non*; but this theory having been exploded, we now find it carried on round Kandy, Peradeniya, Gampola, the Dumbara valley, Matale, and up to Badulla 100 miles from, and 2,000 feet above, the sea. At higher elevations the nuts tend to become small. Though the palm will grow even at 4,000 feet elevation it does not fruit at such high altitudes.

FACTS AND FIGURES FROM OFFICIAL SOURCES.

The area under coconuts is about 900,000 acres. The chief coconut-growing districts are Colombo, Henaratgoda, Veyangoda, Negombo, Chilaw, Puttalam, Kurunegala, Galle, Matara, Batticaloa and Jaffna. Along the western and southern coast line, the trees are chiefly used for the production of toddy to be supplied to arrack distilleries.

The cost of opening land for coconuts may be said to be about Rs. 600 per acre—the expenditure being spread over ten years—but the bulk of it would be incurred during the first three years.

The necessary labour may be reckoned, at a cooly for four or five acres, at 40 to 75 cents a head. Picking is generally done by contract at about 50 cents per 1,000 nuts.

Advances are made up to 50 per cent of the value of estates and interest recovered at 8 to 10 per cent. The purchase period is put at ten to twelve years. A good coconut estate in full bearing will be worth Rs. 1,000 to Rs. 1,200 per acre.

The yield per tree per annum may vary on estates from 30 to 80 nuts, with an average of 45. The number of trees per acre runs from 60 to 80. The price per 1,000 nuts, under nominal circumstances, may be said to be between Rs. 50 and Rs. 75. In 1922 the number of coconuts exported was 22,317,747, valued at Rs. 1,825,226, of which nearly 90 per cent went to the United Kingdom.

The number of nuts required for a candy (5 cwt. or 560 lb) varies from 900 to 1,500. Copra is often prepared by contract, the contractor being paid Rs. 1 50 per 1,000 dried nuts supplied to him in husk. It is generally sorted into three grades, the usual percentages being 95 per cent of No. 1, 4 per cent of No. 2, and 1 per cent of No. 3.

The cost of production of a candy varies form Rs. 25 to Rs. 40. The price varies considerably and has touched Rs. 120 per candy, but normally is Rs. 60 to Rs. 80.

In 1922 the export of copra was 1,686,589 cwt., valued at Rs. 28,804,064, the United Kingdom, Denmark, Germany, Holland, Italy and Norway taking the largest percentages.

A candy (5 cwt.) of copra produces about 3 cwt. of oil. The price of oil is about double that of copra. Locally-made oil usually contains 1½ to 2 per cent of fatty acid.

The average shippers' buying prices of oil lie between Rs. 500 and Rs. 600 per ton. The unit of shipment is the shipping ton, which is 14 to 15 cwt. The bulk of the oil (55 per cent) finds its way to the United Kingdom—Germany, Egypt and Norway, too, taking a fairly large quantity. The poonac, or a cake left after the removal of the oil from copra, is largely used locally as cattle food. In 1922, 115,479 cwt. valued at Rs. 766,279 were exported.

The quantity of oil exported in 1922 was 554,626 cwt, valued at Rs. 14,924,985.

In the manufacture of desiccated nut, 1,000 nuts should yield from 350 to 400 lb. The cost of production is about 25 cents. per lb.

In 1922, 786,215 lb., valued at Rs. 20,159,183, were shipped, the bulk g ing to the United States of Amercia (36 per cent) and the

United Kingdom (40 per cent). The local price varies between 25 and 50 cents per lb.

In the manufacture of arrack it has been found that a tree produces from 6 to 12 drams of toddy per day, the fermented product containing from 4 to 8 per cent alcohol.

The cost price of toddy may be put at 30 cents. per gallon: it is retailed in taverns at from two to four times this value. In native stills 7 gallons of toddy give 1 oz. of arrack. The distillers' cost of production is Rs. 250 to Rs. 350 per leaguer of 150 gallons. The retail price of arrack is Rs. 10 to Rs. 16 per gallon. In 1921 the consumption of arrack in the colony was about 850,000 gallons and of toddy about 4,500,000 gallons.

Coir fibre, both "bristle" and "mattress," is both hand and machine extracted. A good deal is used locally, but in 1922 the total quantity of fibre exported as such or in the form of yarn and rope was valued at over 3¼ million rupees, the United Kingdom, Belgium, Germany and Japan being the chief importers. While the price of bristle fibre is in the neighbourhood of Rs 10 per cwt., that of mattress fibre is about a fifth of that value.

SCIENTIFIC DATA.

THE STEM.

The stem of the coconut, except on rare occasions, is an unbranched cylindrical column, which sometimes reaches a height of from 80 to 100 feet, with a diameter sometimes three feet or even less at the base. It is thus very clear that the stem needs great strength and elasticity to enable it to bear the weight of the crown of leaves and bunches of fruit it carries at the apex, and stand the force of strong winds which are so common on the seashore where the palm is usually found.

In monocotyledons, like the coconut, the cambium cells do not form a ring between the wood and the bark as we find it in rubber, since the fibro-vascular bundles never coalesce, but are irregularly scattered through the cellular system of the stem. They are generally crowded towards the circumference, which consequently becomes much harder than the centre, especially in woody monocotyledons like the coconut. From the mode of development of the fibro-vascular bundles, and the direction which they take in the stem, the trunk of woody monocotyledons does not usually increase in diameter beyond a certain point, and the cylindrical stems are nearly as thick at the top as at the base.

A section of the stem shows the distribution of the fibro-vascular bundles throughout the ground tissue which is made up of cells, the whole enclosed in a strong fibrous cortex or false bark. So that from its structure the stem is capable of standing great strain and bending to the force of the wind without breaking, while the root system, with its innumerable spreading branches, gives the tree such a firm grip of the soil that it is only under exceptional circumstances that it gets blown flat.

It is through the vessels in the bundles, distributed throughout the stem in association with fibres, that water with mineral plant food in solution taken up by the roots travels up to the leaves and is there converted into organic matter.

THE ROOT.

The coconut palm, like all monocotyledons, has no tap-root. The base of the stem, where it enters the ground, is usually conical and embedded to a depth of 2 or 3 feet. Its surface below, and for some distance above ground is covered with the butt-ends of roots, under half-an-inch in diameter, radiating from the tree in every direction. The normal length of the roots of full-grown trees varies from 15 to 25 feet, according as the soil is heavy or light. Sometimes they extend to well over 30 feet in poor, shallow soils. The old woody roots contain a central pith which tends to give them great strength and elasticity. The underground part of the stem carries from 4,000 to 8,000 roots which may be either unbranched, or develop 10 to 20 branches which rarely exceed three feet in length. Both the primary and secondary roots also bear numerous fine branches, which may again give rise to still finer branches. The finest roots last for but a short time. In heavy soils a larger root system is formed than in light ones, though in the latter the roots extend to a greater length.

The roots of the coconut are protected along their length by an external covering, or jacket, which adds to their strength and thus gives stability to the tree. When parts of old roots die they are generally

PLOUGHED FIELD.

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replaced by fresh growths from the living parts of the same roots. The direction of the primary roots is mainly horizontal. Some may go down to a depth of about three feet or so, but most are found at depths varying from 6 to 18 inches, according to the nature of the soil.

Roots will not grow any depth into water or a water-logged soil, while they cannot thrive in a very dry one: hence their tendency to grow downwards in a sandy soil. The best conditions for growth are a deep soil, with a deep water table, and the surface soil not allowed to become too dry. Surface cultivation is, therefore, to be commended, but not deep enough to destroy too many roots.

The tip of the root will be found to terminate in a tough structure called the root-cap, which serves to protect the growing point from injury. Just behind this is a region made up of a delicate structure, generally light in colour, through which water and soluble plant food are absorbed, for the coconut has no root-hairs like dicotyledons such as the mango and jak. When root growth is checked by drought this region almost disappears by encroachment of the tough external coat which invests the rest of the root.

On old coconut roots are often seen numerous, small, white root-like structures which are specialized roots adapted for breathing purposes. These breathing organs allow air to pass into the internal tissues of old roots which would otherwise die for want of air.

If a root be cut through, the end is promptly sealed up by a gummy substance, and no absorption takes place through it. The roots of the coconut freely absorb strong solutions of common salt without injury. The ordinary process of absorption is carried on most rapidly in the forenoon, less so in the afternoon, and very slowly at night. The tree does not appear to store up any great quantity of water, which passes freely out through the leaves. Anything, therefore, which interferes with evaporation from the leaves, will check absorption through the roots.

The finer roots appear to take up more water than the large ones. A calculation based only on the activity of the main roots showed that a tree takes up about six gallons a day; but, by a determination of the evaporation from the leaves, this must be far below the actual figure. Investigations have shown that the average growth of roots is rather more than three feet per annum.

THE LEAF.

The water taken up by the cells of the absorbent region of the roots travels from cell to cell into the vessels that are found in the central vascular bundles along which it ascends till it reaches the stem and finally the leaves. There, travelling along the midrib and veins and through the leaf tissue, it finds its way out by the stomata. As a result of this evaporation (transpiration) there is left in the leaves a residue consisting of the mineral (including nitrogenous) food of the tree derived from the soil. The stomata are small openings in the epidermis of the leaf and, in the coconut, occur only on the under surface. Provided the tree is well supplied with moisture the stomata are full open in the daytime when the sun shines. If not well supplied, they narrow down as the water in the leaves decrease, so as to reduce transpiration. At night they are closed. Transpiration will be most active if the roots supply water as fast as it is evaporated ; and, as a result, the tree will get the maximum of plant food from the soil.

About 98 per cent of the water evaporated passes out through the stomata of the leaves ; but transpiration is also regulated by a strand of tissue which runs along the sides of the midrib on each half of the leaf blade, and acts like a hinge. When the leaflets are well stored with water, the cells of the hinge, which are colourless and delicate, become turgid or swollen and cause each side of the leaflet to expand. With a poor supply of water the cells of the hinge become flaccid or slack, the two parts of the leaf blade collapse and present a smaller surface to the sun, so that there is less evaporation. Transpiration is increased by light, warmth, a dry atmosphere as well as by wind. It is hindered by darkness, cold, a moist condition and a still atmosphere. The most important factor influencing tanspiration is light, and for this reason the tree must be fully exposed to it. Encroaching shade from other trees, too closely planted palms, high weeds, etc., is objectionable. In the hottest part of the day, or during drought, the closing down of the two sides of the leaflets is an indication that the quantity of water taken up by the roots is less than what is needed for transpiration, which is, therefore, reduced by the automatic action of the hinge lessening the surface of the leaflets exposed to the sun. What ultimately regulates the amount of water transpired is the amount that can reach the leaves. (The leaf can also, when necessary, draw upon the moisture within the plant, and the deficit will be made up by water taken up by the roots at night when transpiration is at a minimum.) In the mornings and evenings water does not avaporate as fast as it is brought in and the leaflets tend to spread out: so in the evening their width will be as great as in the early morning, showing that any shortage of water experienced during the day has been made up.

It has been found that, under normal conditions, a leaflet evaporates about 10·8 grams of water in a day. Allowing 150 leaflets per frond and 25 fronds to the tree, the whole tree will evaporate 40·5 litres or about 9 gallons per day, through its leaflets. But taking the very lowest record loss, viz., 28 litres per day, the annual transpiration per tree would be represented by 10,220 litres, equivalent to about 2,250 gallons.

The plant food taken up by means of transpiration will, under the most favourable conditions, make up for the loss in nuts and leaves removed off the land, and meet the requirements of the tree for its growth. Allowing a loss of 16 leaves per annum and calculating 8·5 per cent of each leaf as ash and nitrogen, the loss of matter taken up in solution by the roots will be about 4,080 grams. Again with each nut the tree loses of ash and nitrogen 33·84 grams in the husk, 3·36 in the shell, 13·83 in the kernel, 5·97 in the milk, or a total of 57 grams. Supposing the tree produces only 20 nuts a year, the loss of plant food per tree per annum through the nuts would be 1,140 grams, or a total loss in leaves and nuts of 5,220 grams (between 11 and 12 lb.) This would need 10,220 litres (about 2,250 gallons) of water as already calculated. In old leaves (from eight months old to time of fall) transpiration is greatest. During severe drought the old leaves drop faster than usual, and in this way, the tree is saved loss through transpiration at a time when the reduction of evaporation is an urgent matter.

It is in the leaf that the mysterious change from inorganic into organic matter takes place with the formation, first, of starch and sugar, and later of the oil that we find in the nut. For this the presence of sunlight is essential. As already stated it is through the stomata that oxygen passes into the leaves and carbonic acid passes out, according to a process of respiration which is similar to that in animals: while through the same openings carbonic acid gas is taken up from the air, the carbonic being retained to meet the requirements of the plant, and oxygen given out which purifies the atmosphere.

Within the cells of the leaf the carbon obtained through the leaves, and the mineral plant food and water brought up by the roots, meet and become changed from inorganic to organic matter.

THE FLOWER.

The "flower" of the coconut, using the term in its popular sense, first appears between a leaf and the stem, as a spear-shaped flat structure. At this time it is completely enclosed in a continuous covering which is known as a spathe. It takes several weeks to attain its full length, and meanwhile it gradually becomes more cylindrical, especially in the upper half. When full grown, the spathe splits longitudinally down the side which faces outwards, and the flower opens out. The splitting usually begins at a point near the apex and takes several hours to complete; it may take more than twenty-four hours.

To avoid confusion we must now alter our terms and use some of the long words which are supposed to be the failing of the botanist. The "flower" of the coconut is not a simple flower, but a collection of flowers, and the whole collection is an "inflorescence." The inflorescence is branched, and each branch bears numerous flowers. When the inflorescence is enclosed within the spathe, the branches lie close to the main axis, and the whole is so tightly packed that it is quite impossible for any of the individual flowers to open before the spathe splits. Sometimes a few of the flowers expand as soon as the spathe splits: at other times none open until the branches of the inflorescence have spread out.

A coconut inflorescence bears, as a rule, two kinds of flowers—male and female. The male flowers are crowded together, from the tips of the branches downwards, and these are the first to open. Each male flower has six floral leaves, three small and three large, which spread out in star fashion. Within these are six stamens which provide the pollen necessary for the fertilisation of the female flowers. And in the centre of each male flower is a short column which terminates in three small teeth, at the base of each of which is a nectary. The male flowers are borne in hundreds, or even thousands, on each inflorescence.

The female flowers are situated lower down the branches of the inflorescence than the males, and there are comparatively few of them. On young trees at Peradeniya, while the number of male flowers on an inflorescence runs into thousands, there are not more than about a dozen female flowers and there may be none at all. When the inflorescence

Young Unopened
Female Flower.

Fully Opened
Female Flower.

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opens, the female flowers are seen as more or less spherical bodies, somewhat resembling nuts, and hence the idea has arisen that the flower has been fertilised and the nut formed, before the inflorescence opens. As will be evident later, that conception is quite erroneous.

The female flower, like the male, has six floral leaves, but they are much larger and thicker. When the inflorescence opens, these floral leaves are tightly folded over the inner part of the flower and completely hide it. They are so tightly wrapped over that the outside, at first glance, appears to be continuous, and that is the reason why the female flower has been thought to be the fruit. Inside the floral leaves is an oval body composed chiefly of the tissue which will develop into the husk of the fruit, while the embryo coconut is a minute structure at the very base of this. After the inflorescence opens, but before fertilisation has taken place, this mass of tissue continually increases in size and ultimately forces apart the floral leaves, disclosing only its rounded upper surface which is surmounted by a white nipple. This nipple is marked by three equidistant grooves which meet at its apex and thus divide it into three triangular sections. When the female flower is ripe, these three segments separate and stand erect as three teeth, exposing the stigmatic surface on which the pollen must fall in order that the flower may be fertilised. These three teeth constitute the stigma. It is impossible for fertilisation to occur before the stigma is ripe, and that does not happen until long after the opening of the inflorescence. The stigma ultimately turns brown and the tissues round it collapse, forming a small, black, more or less circular area containing three shrivelled teeth, at the apex of the young fruit. The six floral leaves do not increase much in size, but form the whorl of small "leaves" at the base of the fruit.

"Pollination" is the application of the pollen to the stigma. As the pollen and the stigma are in separate flowers, male and female respectively, in the case of the coconut palm, there must be a transfer of pollen by some means or other from the male flower to the female. Now, when the coconut inflorescene expands, the male flowers open first. (This, by the way, is not peculiar to the cocount, but is quite a common phenomenon in palms.) The inflorescence is then, if we consider the ripe flowers only, entirely male, and it continues entirely male until all the male flowers have opened and fallen off. This male phase may last for from three and a half to five weeks, After all the male flowers have fallen, a period of from two to five days elapses before the female flowers begin to open. These then begin to open at the rate of two or three per day, and during this time the inflorescence is entirely female. The duration of the female phase depends upon the number of female flowers: at Peradeniya, it lasted for from one to seven days. Each female flower is receptive for about twenty-four hours (or less); after twenty-four hours the stigma begins to turn brown.

It will be seen from the above how erroneous was the idea that the female flowers were fertilised before the inflorescence opened. Not only is that impossible, but fertilisation cannot occur until three or four weeks after the opening of the inflorescence. Moreover, it follows from the above data, that a female flower cannot be fertilised with pollen from a male flower of the same inflorescence, for all the male flowers have disappeared before the female flowers open.

Whence then is the pollen which fertilises the female flower derived? Well, the coconut, as is common knowledge, produces inflorescences in continuous succession, and if they appear rapidly enough, or if the flowering period of each is sufficiently prolonged, it may happen that, before one inflorescence has finished flowering, the next may have begun, and in that case it is possible that the female flowers of the first may be pollinated from the male flowers of the second. In other words, the flowering periods of successive inflorescences may overlap, and then the female flowers may be fertilised with pollen from another inflorescence on the same tree. Overlapping was found three times during the year. It may be more frequent in the low country. Failing this overlapping, pollination can only be effected by pollen from another tree.

This last point suggests interesting possibilities. Suppose, for instance, that in a given plantation, none of the inflorescences "overlapped," and that all the trees produced their inflorescences at the same time. There would then be no pollen available when required! It is evident that one condition for efficient pollination is that the different trees should produce inflorescences at different times, not all at the same time. How far is this fullfilled? Do trees of the same variety in the same environment tend to flower at the same time? Do trees of different varieties tend to flower at different times? Is a plantation of mixed varieties more prolific than one of one variety only?

How is the pollen conveyed from the male to the female flower? The pollen of the coconut consists of simple spherical grains without

Coconut Palm Grown From a Green Nut.

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any special adaptations, and the structure of the male flower is, on the whole, equally simple. But the male flower possesses three nectaries at the bases of the teeth which crown the central column, and the secretion of these nectaries undoubtedly attracts insects. The stigma of the female flower also furnishes "nectar," so that the visits of the insects to both male and female flowers are assured. Bees and hornets appear to be the most frequent visitors, but further observations are required on this point.

In considering the potential insect visitors to flowers in the Tropics one has always to take into consideration the ubiquitous ant. At first sight it seems posssible that this insect may take part in the conveyance of pollen from the male to the female flower, especially when the periods of the inflorescences overlap. In that case they might convey pollen from one inflorescence to another on the same tree. But it is improbable that they should convey pollen from one tree to another, because the journeys of this species, as a rule, do not extend to two trees.

There is, however, a special provision on the female flower of the coconut which more or less effectually excludes ants from the work of pollination. The region below the stigma, almost the whole of the area which is exposed when the female flower opens, bears a large number of pores. When the flower is ripe these exude a quantity of moisture which, at least in fine weather, forms a ring of liquid round the stigma and prevents the ants reaching the latter. It is not uncommon to see a crowd of black ants congregated round the edge of this ring. It is probable that, as is usual in cases of this kind, the liquid contains some sugar, so that the ants obtain what they want without robbing the stigma. In any case, it keeps the ants away from the stigma. The position of these water pores can be clearly seen on the young fruit where they are indicated by small whitish spots. These spots owe their colour to masses of minute crystals which are deposited by the liquid.

As far as insect visitors are concerned, therefore, pollination effected by bees and hornets. But from the structure of the flowers it is most probable that the wind is also responsible for the transference of pollen, to a great extent.

As has already been stated the male flowers far outnumber the females. The vast majority of the flowers on the coconut inflorescence are male. I have seen inflorescences which did not bear any female flowers.

When a tree first begins to flower, the earliest inflorescences frequently bear male flowers only. One such tree produced five male inflorescences, Thus for the best part of a year a tree, though flowering, may not produce any nuts. If, as my information stands, this occurs side by side with trees which bear mixed inflorescences from the first, it would point to a difference in jât, rather than a difference in previous treatment. In that case, the early history of the parent plants ought to be known when selecting nuts for seed, for it is obviously an advantage to have trees which bear nuts from their first flowers.

There is a theory, which appears to be supported by some evidence, that in cases where plants bear two kinds of flowers, male and female, on the same or different individuals, those which grow near the upper limit of the species are male.

As already stated, "overlapping" occurred thrice—in October 1912, May 1913, and September 1913. Evidently an interval between successive inflorescences not exceeding about thirty days is necessary to ensure over-lapping. That requires the production of twelve, or more, inflorescences per annum, whereas on the tree under notice there were only nine.

The interval between successive inflorescences varied from 24 to 58 days. On the average, the intervals at the beginning of the year were longer than those later. The largest interval occurred in the driest season though the intervals are not solely governed by rainfall—[*Extract from an article by Mr. T. Petch in the " Tropical Agriculturist " for December, 1913.*]

THE NUT.

The nut consists of four definite parts—the husk, shell, meat and water. The following statement gives the percentages of each component as reckoned from 1,000 nuts, taken from sea-shore and inland trees :—

Parts.	Sea-shore.	Inland.
Husk ...	38'0	30'8
Shell ...	11'9	12'7
Meat ...	27'4	30'1
Water ...	22'7	26'4

Coconut Palm Grown From a Yellow Nut.

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The following table shows the composition of the components of a single nut reckoned in grams ($28\frac{1}{3}$ grams = 1 oz. avoirdupois):—

Parts.	Nitrogen.	Phosphoric Acid.	Potash.
Husk ...	1·609	0·017	3·915
Shell ...	0·660	0·459	0·947
Meat ...	4·683	1·740	2·475
Water ...	1·542	0·171	1·313

Allowing 70 trees to the acre and 40 nuts per tree per annum, the annual loss in ash constituents per acre would be in pounds:—

Ash Constituents.	In Nuts.	In Leaves.	Total.
Nitrogen ...	52·29	27·88	80·17
Phosphoric Acid ...	14·72	21·69	36·41
Potash ...	53·28	65·84	119·12

The following analysis by Walker gives the percentage of the various components of the nuts:—

	Sea-Shore Nuts.		Inland Nuts.	
	lbs.	Per cent.	lbs.	Per cent.
1,000 Nuts ...	5,198	100	5,027	100
Husks only ...	1,973	38·0	1,546	30·8
Nuts without Husks	3,225	62·0	3,480	69·2
Shell and Meat only	2,043	—	2,153	—
Water in Nut ...	1.181	22·7	1,326	26·4
Shell (Dry) ...	620	11·9	640	12·7
Meat only ...	1,423	27·4	1,513	30·1

An analysis by Walker of the Copra from 1,000 nuts gave the following results [the percentage is of total weight of nut in husk] :—

	Sea-Shore Nuts.				Inland Nuts.			
	Sun Dried.		Grill Dried.		Sun Dried.		Grill Dried.	
	lbs.	Per cent.	lbs.	Per cent.	lbs.	Per cent	lbs.	Per cent.
Copra ...	664·6	12·8	726·4	14·0	710 3	14·1	732·6	14·6
Oil ...	400.8	7·7	437 5	8·4	420·4	8·4	417·5	8·3
Moisture in Copra ...	—	9·2	—	8·6	—	9·8	—	10·1
Oil in Copra ...	—	60 3	—	60·2	—	59·2	—	57·0

FIELD CULTURE.

The details of field culture are dealt with fully by the scientific officers as well as practical planters, whose papers we have reprinted. There are, however, one or two points about which there is some difference of opinion and which might therefore be discussed. One is with reference to the position in which the nut should be placed in the nursery. Some favour the vertical and others the horizontal position. Petch condemns the latter as tending to produce a bulbous stem which he considers a sign of weakness. He favours the vertical position but with a slant to one side, Another point is the "spacing," or distance apart, at which coconuts should be planted. Up to within recent years the common spacing adopted was 24 by 24 feet, giving about 75 trees to the acre; but as the result of experience this has been increased. Jardine was of opinion that, except on the richest soils, a good distance was 26 feet. Copeland favours 30 feet, placing, as we are inclined to think, undue weight on the importance of sunlight for transpiration. In saying this we do not, of course, wish to minimize the need for the free access of light and air to all parts of the plant. Light and air are prime necessities for healthy growth, but in providing for them there is danger of adopting too wide a spacing and losing in crop. Most people would be disposed to agree with Jardine, who, though he did not have the advantage of our present knowledge of coconuts, was a close observer and a thoroughly practical planter with very definite views. Still another important question is whether clean weeding should be practised on coconut estates.

PLOUGHING WITH BUFFALOES

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This is fully and ably discussed in the Colombo Commercial Company's *brochure*, which makes a very good case for clean weeding. The old practice of keeping a large number of cattle for the manuring of the estate is one which is dying hard; but, with the introduction of a more thorough tillage system and a regular programme of manuring with artificial fertilisers, it will not be long before an estate with grass growing amongst the palms will be a rare sight, particularly in the drier parts of the island where the preservation of a soil mulch as a means of conserving moisture is bound to become a practical detail of the first importance.

The good effect of ploughing and harrowing in coconut cultivation is now generally acknowledged, and untilled lands left in high weeds are not so frequently met with today. Within the past few years the use of the tractor in agriculture has been demonstrated, and some of the larger estates are employing this method of tillage. Here is what the Director of Agriculture has to say on the subject:—

Tractors have now been utilised upon coconut estates in Ceylon for the past three years and useful work both in ploughing and in disc-harrowing has been performed.

The tractor is capable of performing much deeper ploughing than when animal traction is employed and work can be done even in very dry weather when the ground would normally be too hard for work with either cattle or buffaloes. Similarly, heavier and larger implements can be utilized for harrowing and work thereby performed more rapidly. In some quarters there is a belief that on the sandy coconut lands of the coastal regions good deep disc-harrowing with tractors would afford adequate cultivation.

The initial cost of a tractor and its outfit is heavy and therefore only the larger estates are likely to be in a position to afford the capital outlay, but it is possible that neighbouring estates could co-operate together to purchase a tractor outfit for use upon their estates or that provision could be made by the owner of a tractor to hire it for work on other estates in the neighbourhood.

Similarly, it is possible that organizations could be formed solely for hiring tractors to estates for definite contract work.

Such co-operation for the use of tractors for hiring out for definite pieces of work is common practice in all countries where tractors have now found a place in their agricultural economy and is well worth serious consideration by coconut growers in the Colony.

The tractor to be an economical unit must find continuous work throughout the year, and if an estate is not large enough to provide this work then other arrangements should be made whereby the maximum output is obtained. If such co-operation is possible or if hiring companies can be formed there are good prospects before tractors on the coconut estates of the Colony.

The general consensus of opinion amongst progressive coconut growers is that cultivation in the drier districts should not be carried on at too frequent intervals. The maintenance of the humus-content of the soil has to be kept continuously in view and if green manure plants are not grown between the rows of coconuts then a certain amount of grass and weeds should be allowed to grow in order that they may be turned into the soil.

The effects of the deeper ploughing which will be possible with the use of tractors will be watched with interest and coconut planters are asked to keep accurate records of the crops from those fields which have been deep ploughed and subsequently thoroughly cultivated.—[*The Director of Agriculture in the "Tropical Agriculturist".*]

Draining will be found dealt with by Mr. A. K. Beven, and the subject of manuring exhaustively treated of by the Agricultural Chemist (whose authority will be readily acknowledged) as well as in the publications of the Colombo Commercial Company, and in Trent Vale's Chapters. It should be mentioned, with regard to packing husks round the trees and filling trenches with fallen coconut leaves, that the Government Entomologist fears that this may encourage the breeding of beetles.

There are some people who think it a mistake to manure coconuts for the reason that when once manured they must always be manured. To this the only reply would be that if it pays to manure there is no reason only it should not be done regularly and continuously. Indeed, except on rich, virgin land, the intelligent planter will always keep up the fertility of his soil by the judicious application of manure.

There are three ingredients that should always be found in a manure mixture or supplied in a manuring programme, viz. : nitrogen, phosphoric acid and potash. It may be stated as a general fact that nitrogen is mainly directed to the production of leaf, phosphoric

CLETRAC TRACTOR.

To face page 21.

acid of fruit, and potash of wood; but we know that other parts of a tree, such as the husk of the coconut for instance, may be rich in potash. Indeed, from analysis, it is clear that the coconut palm uses up a notable amount of this ingredient, which should, therefore, be well represented in any manure mixture.

Dr. Copeland tells us that the appreciable effects of manure must not be expected for two or three years after application, since it must follow an improvement in the general vitality of the tree It is possible that within a year the results may be found in larger nuts or in the production and ripening of more nuts on each bunch; but the production of a larger number of bunches, that is, the more rapid succession of bunches, is not to be looked for under two or three years, since it must follow a general improvement in the thriftiness of the tree. Copeland points out that the number of bunches cannot be greater than the number of leaves produced and this depends on the rate of development of the leaves from the growing point of the palm. Dissections made show from 17 to 23 and 25 undeveloped leaves which are not visible except by dissection. With the microscope we might find more. If it is assumed that there are 24 such undeveloped leaves at the growing point, and that 16 of these are developed in a year, the youngest of the undeveloped leaves will need 18 months to appear at the top of the crown. After the leaf is visible it will take another six months for the flowers to appear in the axil of the leaf, and nine months more for the production of fruit. It will thus be over two years before the full effects of manure can increase the rate at which new leaves are formed and thereby the production of crop.

"Good treatment of the coconut," says Copeland, "is a full system of procedure, not a single act, or a spasmodic burst of attention." Unless the soil is kept in good condition by proper tillage and its water resources be carefully controlled, the effect of manures will be disappointing.

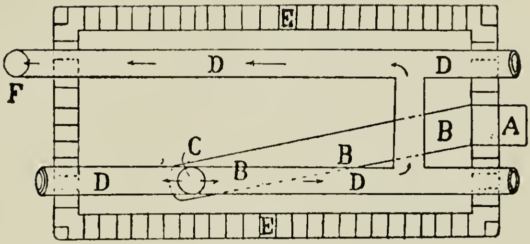
The investigations being carried out on coconuts by the various tropical Departments of Agriculture are bound to throw much light on the influence of cultural details on the palm, about which we have still a great deal to learn.

The use of lime in coconut cultivation is a matter about which there is much difference of opinion among planters, many of whom incline to the belief that it is a dangerous practice; but this is altogether a mistaken idea. Liming, when practised under proper advice, results in much benefit, particularly in the case of heavy clay soils and those containing a large proportion of vegetable matter, helping in the one case to make the soil more open and less resistant to the movement of the roots, and in the other correcting the acidity which is generally associated with an excess of humus; while in both cases it assists in the conversion of potential into available plant food. The presence of lime in the soil in some proportion is, of course, essential, since it is ordinarily the base which, in combination with nitric acid, resulting from the oxidation of ammonia, goes to form the nitrates which are of such importance as plant food. Mr. A. W. Beven is in favour of small doses of lime (10 to 12 cwt. per acre) every other year, instead of larger quantities at longer intervals.

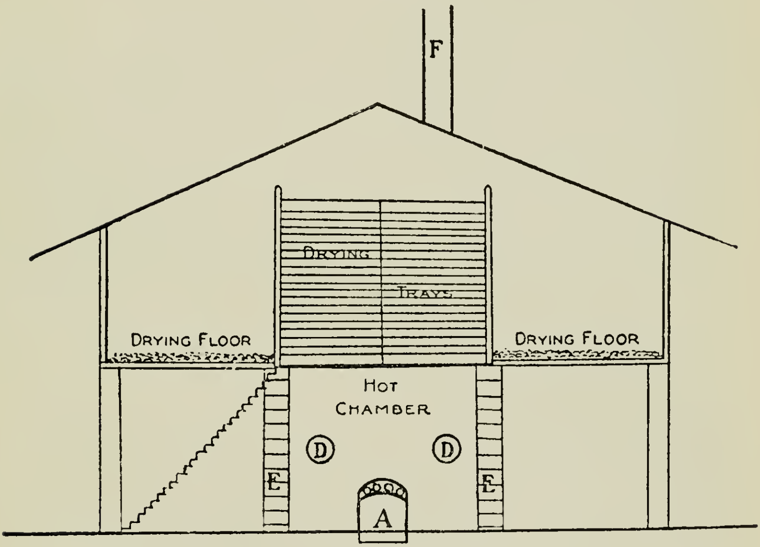
COCONUT PRODUCTS.

COPRA.

Only mature nuts should be used for making copra, and after these are plucked they should be stored for from 2 to 4 weeks. The number of nuts that go to a Candy (560 lbs. or 5 cwts.) of copra may vary from 900 to 1,500—1,100 to 1,200 being an ordinary average. After husking the nuts and splitting them open, drying may be done in one of the following four ways :—In the sun, on a grill over an open fire, in a specially constructed drying room, or in patent driers. Drying entirely in the sun from start to finish is a slow process, taking about a week, and is only possible in dry districts where the weather can be depended upon. This method produces a high quality copra. In Cochin sun drying is done very carefully on mats. In ordinary copra-making the first drying is frequently done in the sun till the kernel has sufficiently shrunk for removal from the shell. The after-drying is continued on the grill till the copra crackles. The ordinary grill is made of wood, usually coconut-wood, with shallow pits underneath in which there are open fires, the fuel used being coconut husks or shells or both. In this way the kernels are subjected to the action of direct heat for six or eight hours. If care be taken to properly regulate the heat, and to produce the minimum of soot, copra of good quality could be produced. A very fine copra is turned out in drying houses with the furnace at one end and hot air distributed by pipes through the building. There are a number of these in the Island and in view of the satisfactory results they give, it is surprising that they are not more extensively adopted. Various forms of "Driers'



GROUND PLAN.



SECTION.

COPRA DRYING ROOM.

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suitable for copra-making have been designed. Hamel Smith has designed a simple rotary drier made by David Bridge & Co. at Manchester. There is another designed by F. A. G. Pape, turned out by the same firm. Both these are described and illustrated in "Consuls of the East." Dr. Copeland in his work on the Coconut makes reference to the tunnel drier designed by a German Engineer; a steam-heated desiccator planned by the Phillipine Bureau of Agriculture; and the "Magdalena" drier designed by Pedro Bonito. The following is a description (with a diagram) of a tropical drying house in Samoa referred to by Copeland :—The house, the outer walls of which are supported on wooden posts set in cement, stands over a small room of brick and mortar 16½ feet long, 7½ wide and 7½ high. Set into the wall of this hot room, at the middle of one end, is a fire-place. A flue of stones runs from the fire-place obliquely towards the other end of the room where it is connected by a vertical piece of piping with a horizontal system of sheet iron flues consisting of two length-wise sections and the necessary cross-wise connections. The iron flues, made from sheets, are nearly a foot in diameter. The ends project beyond the walls and can be opened when the pipes need cleaning. The last flue ends in a chimney of suitable height—say 30 to 40 feet. The course of the smoke is shown by arrows in the diagram. The drying room proper is directly over the heating room and a very little larger, and the floor between them is merely a grating. The copra may be placed on coarse coir matting laid over the grating. The temperature is kept as nearly as possible at 112° F.

DESICCATED COCONUT.

The desiccated coconut industry was started in the Colony in the early 'eighties. Originally it was in the hands of a few European firms, to whom orders came from Europe and America, but gradually Ceylonese took to its manufacture, and mills are now to be found scattered over the Western and North-Western Provinces, and, to some extent, the Southern Province.

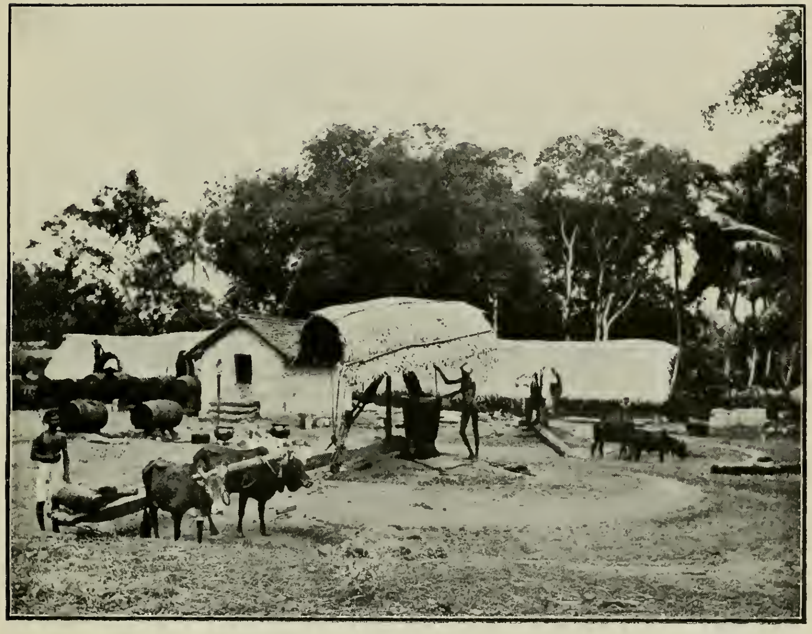
The first necessity in the manufacture of D.C. (as it is called for short) is carefully selected, well-matured nuts. The price of these ranges according to quality, and nuts which yield over 350 lbs. of D.C. per 1,000 are much sought after. The best of these yield up to 400 lbs. and a little over. After being picked the nuts, with the husks on, are allowed to season for about a month in the heap, so as to facilitate husking. They are then husked and taken to the mill, where they undergo a sorting, small and faulty nuts being rejected. The selected nuts are finally put away in a store to be issued and used as necessary.

The first operation in the process of manufacture is shelling. This is done by hand with a light hatchet, though in some mills the circular saw is employed to do the work. Shellers are very expert in the use of the hatchet, and work with almost incredible rapidity. When well practised they are able to shell 2,000 nuts a day. The shelled nuts are then thrown into a long tank made of wood or masonry, into which water is led. The next process is paring or shaving, usually done by women with the aid of spoke-shavers kept well sharpened, to remove the reddish rind and leave a pure white kernel. At the same time the kernel is broken open to let the coconut water escape. The more expert will deal with 1,250 to 1,500 kernels per day. As soon as shaving is done the kernels go back to the water, which is sometimes treated with lime to secure a whiter product, as exposure to the air, and especially the sun, discolours them, and so affects their quality. Little boys are employed to rub off with pieces of tin like graters any specks of red rind which the women may have left. The nuts, after thorough washing, are then removed to the disintegrating machines, in which they are treated, so as to produce various grades. In one it is ground to a mass and comes out like the grated coconut used for curries. In others it is cut into chips, strips or threads. The product of the machines is removed to the desiccators and dried at a temperature of 160° F. It is then spread out on a lead lined table so that any discoloured particles may be picked out, and after being graded by means of hand sieves or sifters, is packed in tea chests, lead and paper lined, and consolidated with the aid of a screwpress till each chest contains 130 lbs. Finally the chests are nailed and hooped.

The rates of payment for husking, shelling and paring are about the same. It used to be 50 cents, but has now risen to 60 cents per 1,000.

Of the by-products nothing is allowed to go to waste. The shells are sold for fuel or converted into charcoal for gas engines. The parings and sweepings are dried and sold to chekku men who get oil and poonac from them. The coconut water is collected and some oil recovered from it. When there was a shortage of acetic acid for rubber coagulating, this water was allowed to ferment and served as a substitute.

In selecting a site for a desiccating mill it is necessary to consider the following points:—(1) facilities for securing a regular supply of nuts; (2) transport facilities; (3) a good and reliable water supply; (4) availability of labour; (5) fuel supply.



Expressing Oil by "Chekku."

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The following is an estimate by a practical miller of the cost of erecting a desiccating factory to deal with 30 to 40 thousand nuts per day of 18 hours. [Cheaper types of buildings, without iron work, could be constructed for about half the cost].

		Rs.	c.
Structural Iron work complete	...	7,884	01
Roofing Sheets complete	...	3,858	63
Guttering and drainage piping complete	...	534	51
Cladding sheets complete	...	604	88
Wood stringers and iron fittings for cladding including bolts, etc.	...	126	10
"Jay" wood window frames complete	...	398	50
Teak doors and window sashes including glass	...	1,370	78
Iron fittings and screws for above including door locks, etc.	...	236	14
Painting	...	900	00
Cement	...	2,472	00
Contractors work including all necessary masonry work, concrete foundations for pillars, concrete floor, dwarf brick walls and cement plaster to inside and lime plaster to outside of walls complete with erection of all iron work and of painters	...	6,330	05
	Rs	24,715	60
Machinery *	...	48,000	00
	Rs.	72,715	60
Contingencies	..	1,500	00
	Rs.	74,215	60

Say Rs. 75,000

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* MACHINERY.

(Including cost of erection).

One 64 B.H.P. Gas Engine complete		12,000	00
Eight Desiccators complete	...	28,000	00
Five cutters complete (2 for ordinary and 3 for fancy grades)	...	5,000	00
Shafting complete	...	2,000	00
Sifter complete	...	1,000	00
	Rs.	48,000	00

N.B.—These prices are subject to market fluctuations.

OIL AND FIBRE.

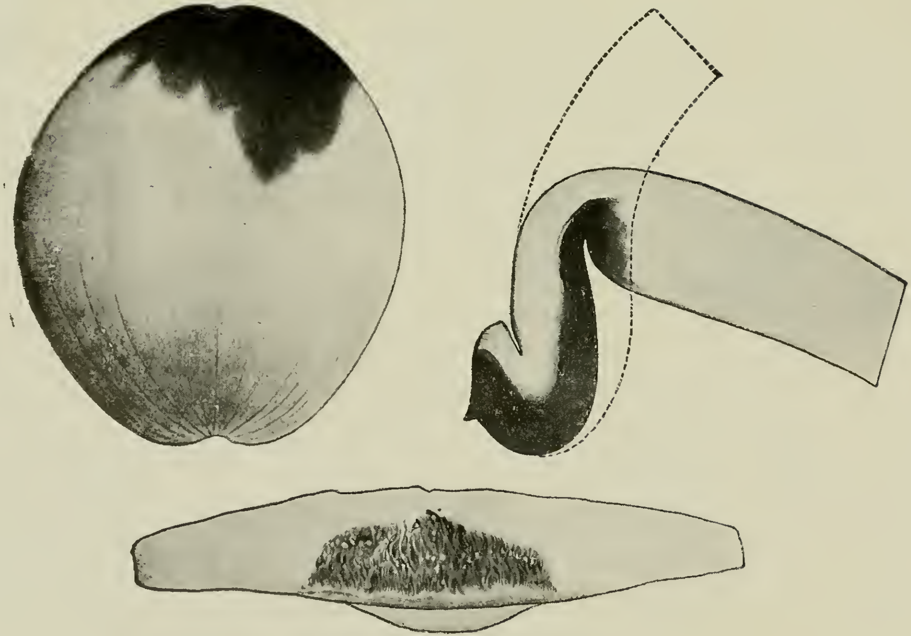
The expression of coconut oil by means of the "Chekku" or bullock mill has been carried on from comparatively remote times. The chekku takes a load of from 30 to 40 lbs. copra and calculating at six full charges a day, should deal with 5 to 6 cwts. This ought to give a yield of somewhat less than 1½ cwt. oil and the balance in poonac.

These crude mills are being superseded by up-to-date oil-extracting machines, though in many parts the chekku is still seen at work. In modern oil factories there is first a macerating process and then the expression of the oil by powerful presses. Sometimes there is a first cold pressure for the best quality of oil, and afterwards pressure with heat. The oil is thereafter left standing to clear by sedimentation or is clarified by means of pressure fillers. The best mills on the Continent are able to extract 70 % and over of oil, provided the copra is thoroughly dried. With ordinary copra, however, the percentage is about 65.

Along the Southern coast of Ceylon it is a common sight to see the husks of coconuts which have been steeped in water—generally brackish—being beaten out by women with the aid of rude mallets. This primitive method of extraction is responsible for a considerable quantitiy of fibre which finds its way to Galle and Colombo. In recent years a great many fibre mills have been set up in the coconut-growing districts, chiefly round about Colombo, Negombo and Kurunegala.

After the separation of the husks from the nuts, the former are taken to the soaking tanks, where they are left immersed in water till they become pliable. They are sometimes first put through a machine which crushes them, breaking the outer skin and flattening the fibrous layer beneath. Next the husks are taken to the extracting machines which are worked in pairs, the first known as the breaker being set with coarse teeth for breaking up the husks, and the second, or finisher, fitted with finer teeth for combing the fibre, which is then washed and dried.

The fibre known as bristle or brush fibre is that which remains in the operator's hand, after the husks have been submitted to both machines, while the spinning or mattress fibre is carried through the machine and passed out. The bristle fibre is further combed by hand



Nut Fall and Leaf Droop.

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and graded according to length and colour and when dry is ready to be made up into packages. The fibre passing through the machine (mattress fibre) is subjected to further treatment in a special machine which teases out all non-fibrous fragments with which it is associated and delivers the fibre only in a clean condition. The refuse from the machines, which is of no commercial value, is what is known as coir dust. The fibre is then pressed into bales of from 2 to 3 cwt., measuring from 9 to 13 cubic feet.

DISEASES AND PESTS.

I.—DISEASES.

The following is a list (drawn up by the Department of Agriculture) of the known diseases to which the coconut palm is liable:—

(1) Root diseases: *Fomes lignosus* and *Fomes lucidus.* (2) Stem Disease: *Thielaviopsis paradoxa* (a stem bleeding disease). (3) Leaf diseases: *Botryodiplodia* sp. (Leaf break or leaf die-back), *Desmotascus cocoes*, *Helminthosporium incurvatum*, *Pestallozzia palmarum* (grey blight), *Phoma cocoicola*, *Phytophthora* sp. (Leaf drop), *Septoria cocoes*, and *Sphærella Gastonis.* (4) Bud diseases: *Bacillis coli* (Budrot) and *Phytophthora* (or *Pithium*) sp. (Budrot). (5) Fruit disease: *Phytophthora* sp. (Nut fall.?)

The more important of these are referred to in the following notes:—

Budrot. The first indication of the disease in young trees is the withering of the youngest unfolded leaf. This eventually turns brown and can be pulled out of its sheath when is is found to end in a soft brown evil smelling mass. The decay of this leaf is followed by the death of the other fronds in succession proceeding outwards and downwards. Finally only a conical stump remains on the top of the stem. If the dying fronds are removed and the bud exposed the "Cabbage" will appear not as usual white and clean but a discoloured putrefying mass with an abominable odour. This "rot" attacks and destroys the whole of the cabbage and only stops on reaching the hard woody part of the stem. The latter and the roots remain quite healthy, and the tree dies as a result of the destruction of the terminal bud or growing point.

The organisms responsible for this decay are according to Petch, bacteria which are abundantly present in the rotting tissues. These organisms would appear to find an entrance to the cabbage along the youngest leaf. Owing to the scattered way in which the disease occurs it is thought probable that it is propagated by insects In the case of old trees the fruits generally fall off while the leaves tend to droop and finally drop away leaving a sickly top which is eventually knocked over by the wind. In older trees the bacterica probably enter the cabbage *via* the fruit stalks. The destruction of a tree is usually complete within three months, frequently much less. Close planting and interplanting with other trees is thought by Petch to favour the disease by preventing evaporation of moisture from the roots. The nature of the disease and the manner of growth of the palms make it impossible to find a remedy, though measures can be adopted for checking the spread of the disease. The affected trees should, as soon as they are discovered, be felled and the terminal bud immediately burned. The difficulty of reaching the affected part of the tree makes disinfection by bluestone impracticable, but a solution of it (1 lb. to 20 gallons of water) may be sprayed with advantage over the young parts of trees in the vicinity to prevent their infection. But by adopting drastic measures as soon as the disease appears in one or two trees, it is possible to keep it in check.

Root Disease.—As root disease usually brings about a stoppage of the water supply its effect resembles that of drought, but unlike drought-stricken trees it occurs as a rule as isolated cases. The fungus (*Fomes lucidus*) that causes root disease is an old one and the disease itself has finally existed since the introduction of the Coconut, and there is no reason to apprehend any serious danger from it.

The appearance of the disease is indicated first by a drooping of the outer leaves which hang down round the stem. The nuts fail to set and with the fall of the outer leaves the palm is left with a cluster of upright leaves at the top. In this way it dwindles away, the leaves becoming yellower and smaller and the tree ceasing to bear till finally the whole tree dies off with the decay of the bud.

Affected trees should be felled and the butt end dug out and burnt with 2 or 3 feet of stem above. This should be done as soon as the outer leaves have withered and the tree has become barren. There is no evidence that the mycelium of *F. lucidus* can live independently in the soil or travel through it, but it is advised that a trench 2 feet deep be dug round the site of the affected tree as far as possible from

Leaf Break Disease of Coconut: Early Stage.

The disease is caused by a fungus— *Botryodiplodia*—which usually gains entrance after Pestalozzia and attacks weak palms.

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the hole which should be left open for at least a year. There is no chance of treatment by internal application of fungicides.

There is no difficulty in distinguishing between bud rot and root disease. In the former case the central spike withers first, in the latter the outer leaves wither first.

STEM DISEASE.—This is the common bleeding disease which for a time caused great alarm amongst planters, and is the subject of a voluminous report by Petch, who, however, does not attach much importance to it. There may be cases of actual death, but these are comparatively few. The appearance of the bleeding spots which exude a viscid liquid is too familiar to need minute description. In spite of the cutting out of affected parts any effect of the disease on the crop does not appear to be appreciable. The fungus responsible for the disease (*Thielaviopsis ethaceticus*) is parasitic on the sugarcane in which it causes the "Pineapple disease." The diseased part should be completely cut out till all discoloured tissue is removed. This can be conveniently done by means of a 1-inch chisel and mallet, care being taken to slope the lower end of the cut to allow water to flow away. The excised tissue must be burnt. The exposed inner tissue should then be protected by a coating of hot coal tar after scorching the wound by means of a lighted torch of rags dipped in kerosene oil. The disease is propagated by spores from tree to tree, and this transference may be affected in many ways such as by coconut-pluckers, ants, squirrels, etc. The spores on being lodged in the cracks usually found on the stem would penetrate it and start the disease, and fresh spores would again be brought to the surface by the liquid that exudes from the diseased patch. Often the patch may be a small one, but when treatment is being carried out it is frequently found that the disease is very extensive underneath, and requires considerable excision.

NUT-FALL.—This phenomenon was fully investigated by Mr. C. H. Gadd, Assistant Government Mycologist, Ceylon, who has summarised the result of his latest observations as follows:—

The fall of nearly full grown, but immature, nuts from the coconut palm has hitherto been regarded as being primarily due to fungus attacks. The failure to find a causative organism always associated with the disease has given rise to the view that its cause may in some cases be purely mechanical, or due to adverse physiological or environmental conditions.

The discovery that a species of *Phytophthora* was usually present on fallen nuts led to the suggestion that the disease might be prevented by the application of a fungicide such as Bordeaux Mixture. Experiments in 1923 to determine the value of this spray as a preventive of nut-fall gave negative results. The number of fallen, but immature, nuts in the sprayed plot was approximately equal to that in the unsprayed plot. The climatic conditions of that year were unfavourable to the growth of the fungus and the pathogenic organism was not found on any of the fallen nuts examined from either plot. In view of the absence of a pathogenic organism it became evident that causes other than fungus attack might lead to a similar diseased condition.

A serious case of fruit fall of coconuts before maturity is reported from Indo-China, in December, 1920. The appearance of the fruit suggested a parasitic disease, but comparative analyses of the soils of various plots led to the conclusion that the fundamental cause was the insufficient nourishment of the roots, which was remedied by the application of nitrogenous manures. The description of the disease and the presence of certain organisms on the fallen fruits suggests the the condition known in Ceylon as "Nut fall." Observations in Ceylon, however, do not lead to the same conclusion, viz., that its cause is an insufficiency of nitrogenous manures. Nut-fall in Ceylon is known to occur in plots which are regularly and liberally manured. whereas it is absent from other plots which rarely receive any manurial treatment.

The discovery that the abscission of fruits of *Juglans californica quercina* is due to water deficit beyond a certain limit, and that a similar cause also leads to the fall of Citrus fruits, may throw some light on the problem of nut-fall of coconuts in Ceylon.

A water deficit has already been shown to affect the setting of young coconut fruits in Ceylon. Following a prolonged period of drought, there is an increased fall of the female flowers, or "button nuts," as they are frequently termed. The fall of such "buttons" had previously been attributed mainly to the lack of fertilization, but, undoubtedly, other factors besides fertilization play an important part in bringing this about. The June drop of peaches in Delaware was generally attributed to incomplete fertilization, but an examination of a large amount of cytological material gave conclusive evidence that June drop was not the result of improper fertilization but of other physiological factors. It has also been ascertained that moisture is

LEAF BREAK DISEASE OF COCONUTS: LATE STAGE.

The disease starts on a terminal leaflet of an older leaf and extends along the midrib, killing pairs of leaflets which turn brown. Finally the leaf breaks about the middle, and the withered end hangs down. Diseased parts should be cut and burnt

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an important factor in the setting of tomato fruits, and that by an efficient conservation of soil moisture "blossom drop" of tomatos can be reduced.

The above, together with the fact that an increase of button fall of coconuts follows a period of drought, leads to the conclusion that the abscission of youngest fruits may be caused by a deficit of soil moisture beyond a certain limit. That a similar cause may lead to the abscission of larger grown fruits is worthy of consideration.

Nut-fall of coconuts in Ceylon occurs principally during the rains of north-east monsoon. Nut-fall therefore occurs, not when there is a deficit of moisture, but during the wettest times of the year. This on the face of it would appear to negative any idea that a deficit of soil water is a contributory cause of nut-fall.

The root system of the coconut palm, however, is peculiar in many respects. The roots have no root hairs, and water can be absorbed only through the epidermis of a short region of the root immediately behind the root tip. The remainder of the root is covered by a rigid shell, called a hypodermis, which is impermeable to water. When the growth of the roots is checked by dryness or other unfavourable condition of the soil, the hypodermis is formed nearer to the tip and ultimately no absorbing zone at all is left. Coconut roots are therefore ill adapted to the absorption of large quantities of water. In nature, no roots will grow to any distance into water, nor into a level of soil where water stands, and a rise in the water level ultimately kills the submerged roots.

The hypodermis is impermeable not only to water but also to air. The roots are to a large extent dependent on special breathing organs or Pneumatophores for the their air supply. These breathing organs are specialised roots and their structure is such that open ærial communication is maintained through the pneumatophore to the internal tissues of the parent root. Consequently the coconut requires an open, well ærated soil, and any tendency towards water-logging will interfere with the air supply to the root. An excess of water in the soil may therefore seriously interfere with the vital processes of the roots, leading to a reduced absorption of water and ultimately to the death of the roots. This in effect becomes equivalent to an actual water shortage.

Nut-fall of coconuts occurs principally in the Galagedara side of the Kurunegala district, and is there most prevalent during the rains of the north-east monsoon. The soil is a heavy loam which becomes very hard during the dry weather, but is sticky, with a tendency towards water logging, during heavy rains. The soil conditions during heavy rains may become deleterious to the coconut roots and thus lead to the premature dropping of the fruit.

Climatic conditions during the north-east monsoon are favourable for fungus growth, so, at this season, nut-fall as caused by pathogenic organisms may be expected to be prevalent. Nut-fall, however, frequently occurs at this time even in the absence of any causative fungus. In view of the above it is suggested that heavy rainfall may produce conditions of the soil adverse to the healthy growth of the root system of coconut palms. This, without the intervention of any pathogenic organism, may result in the abscission of immature fruits. —(*See also* Bulletin of the Department of Agriculture, No. 53.)

II —PESTS.

THE RHINOCEROS OR BLACK BEETLE OF COCONUTS.

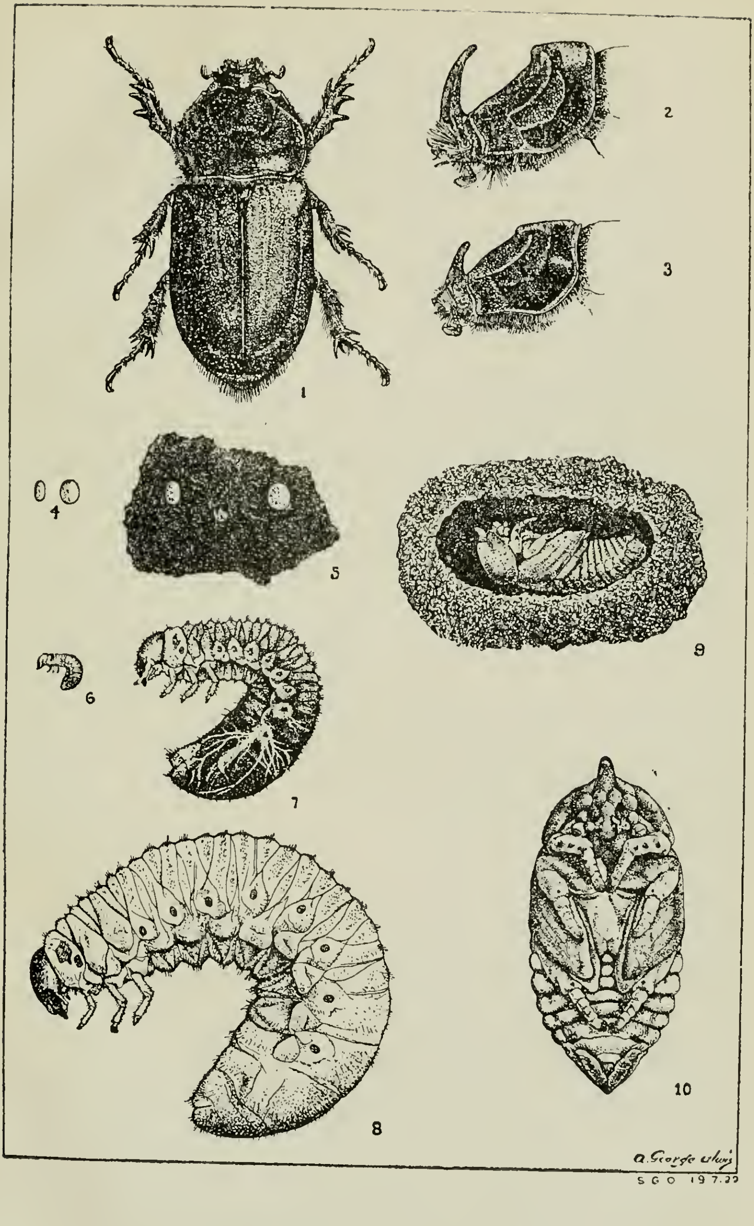
(*Oryctes rhinoceros.*)

Introduction.

This leaflet, dealing with the Black Beetle pest, is one of the series of coconut pest leaflets which are being issued by the Department of Agriculture to give coconut planters full information about the three most important insect pests of the coconut palm, and about the measures which should be taken to control them. The leaflet on the Coconut Caterpillara, nother important pest, and that on the Red Weevil of coconuts will follow this. These three pests cause serious losses to the coconut industry in many districts, and the position which this crop now occupies as one of the main industries of the Island makes it essentital that all coconut growers should take measures to check the ravages of these three pests wherever they occur.

Nature of the Damage.

The Black Beetle is one of the most important insect pests of coconuts in Ceylon, and is generally prevalent wherever coconuts and other palms grow. The damage is done by the beetle stage, which bores in the crowns of healthy young and older bearing palms for the purpose of feeding on the juice or sap which flows from the wounds



RHINOCEROS OR BLACK BEETLE.

1, Female. 2, Horn of Male. 3, Horn of Female. 4, Eggs. 5, Eggs in Dead Stem. 6, 7, & 8, Larvæ. 9, Cocoon with Pupa. 10, Pupa—front view.

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which it makes. The beetle itself rarely causes serious injury to coconut palms in Ceylon, since it is not known to breed in healthy palms, and since it appears to be controlled to some extent by its natural enemies, but its importance as a pest is mainly due to the fact that its injury is often followed by the attacks of the Red Weevil, which lays its eggs in the wounds made by the Black Beetle, and the grubs of which kill young palms and seriously injure the older bearing palms.

The results of the damage done by the Black Beetle may be seen in the ragged appearance of the leaves or fronds, which are often badly notched, sometimes on both sides. Or the leaf stalks may be pierced with large holes near the base so that they sometimes break in high winds. This characteristic notching of the leaves and piercing of the leaf stalks results from the beetles having bored through portions of the young leaves and leaf stalks while these were still closed up within the heart of the palm crown. Again, older palms may often bear permanent scars or pits on their trunks as the result of past injury to the crown of the palm by the Black Beetle.

A Declared Pest.

The importance of the Black Beetle as a pest of coconuts in Ceylon has been realized for many years, and it was declared a pest under the Ordinance as far back as 1907, but, apart from the collection and destruction of the beetles, no serious attempt has been made to reduce its numbers. It is hoped that a fuller knowledge of the habits of this pest may lead to a more general interest being taken to keep it in check.

Life-History and Habits of the Different Stages.

Beetle.—The Rhinoceros or Black Beetle is a rather large dark brown to blackish insect (figure 1), with a horn projecting slightly backwards from the top of the head. This horn is usually longer in the male (figure 2) than in the female (figure 3.) The mouth parts are not formed for biting and chewing, as in many other beetles, but the jaws are adapted for chiselling out small pieces of fibre and pith while the beetle is forcing its way into the heart of the palm crown. The horn is used in tearing out the fibrous strands which are gradually pushed out as the beetle works its way in. The beetle, therefore, does not bite off, chew, and swallow portions of the palm tissues, but bores into the softer parts of the bud and sucks up the sap as it flows from the wound. The beetles are active about dusk and after dark, but during the day they are usually to be found in the crowns of palms, in decaying palm stumps and logs, and in heaps of manure and other refuse.

Egg.—After feeding and mating the female beetles lay their eggs in almost any dead and decaying vegetable matter which will provide food for the grubs. A list of such breeding places is given later. The eggs are whitish to creamy white. They are rather narrow when freshly laid (figure 4, left) but gradually swell to more than double their original size, becoming almost round (figures 4 and 5, right) just before hatching.

Grub.—The eggs hatch in about two weeks into small whitish grubs with a light brown head and six legs (figure 6). They have mouth parts suitable for biting and chewing their food which consists of decaying vegetable matter. This passes through the body, giving it a bluish-grey colour in parts, especially towards the hinder end. The dark colour of the grubs is especially noticeable when the yare about half grown (figure 7). The older grubs, while usually feeding on fairly soft decaying matter, are able to bore their way into the harder portions of the palm stumps and logs which are gradually hollowed out and reduced to mere shells. The grubs are usually full grown (see figure 8) in from three to four months, but may take longer, and are a dirty white colour, which is mainly due to the fact that the dark undigested food is gradually expelled from the body after the grubs stop feeding in preparation for the pupal or cocoon stage.

Pupa or Cocoon.—The full-grown grub forms its pupal or cocoon cell in various places depending on the nature of its breeding ground. The cell may be made in the soil under manure or refuse heaps, or in the hard walls of partially decayed stumps and logs, or in the soft vegetable mould usually found in stumps and logs occupied by the grubs. Figure 9 shows a pupal cell, half natural size, which was found to be composed of the vegetable mould in a hollow coconut log. The grub, after constructing its pupal cell, gradually shrinks to about two-thirds its former size and changes into the pupal stage. The pupa or cocoon is light brown in colour and somewhat resembles the beetle in shape and size (figure 10). The pupal stage lasts between three and four weeks, after which the beetle comes out of the pupal case inside the cell, but remains inside the cell for several days before making its way out to feed.

Abandoned Coconut Estate with Numerous Dead Trees in which Coconut Beetles are Breeding.

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Breeding Places of the Grubs.—As mentioned above the eggs may be laid in any place where there is likely to be sufficient decaying vegetable matter on which the grubs can feed. The grubs, sometimes known as "manure poochies," are usually to be found in any heap or pit containing cattle or other manure or other decaying refuse, such as coconut husks and leaves, empty cacao pods, and paddy straw. They also breed freely in the decaying stumps and logs of such palms as coconut, palmyra, areca, &c., especially in the drier districts. They may also be found in young and older palms which have been left standing after having been killed by the Red Weevil grubs, or which have died from other causes. They are occasionally found in dead and decaying stumps of old dadap and of jungle trees. Most of the above breeding places are usually to be found in any locality where coconuts and other palms grow, and they are particularly common in towns and villages and on estates where coconuts are grown without careful supervision.

Control Measures.

A knowledge of the habits of the Rhinoceros or the Black Beetle will enable coconut planters and others to carry out the following measures of control, which include measures against the beetles, and measures against the larvæ or grubs.

Measures against the Beetles.

The collection and destruction of the beetles appear to be the method of control which is generally employed, but it is impossible to check the pest by this means alone if the grubs are breeding in large numbers in the neighbourhood. The beetles are usually caught while feeding in the crowns of coconut palm, either by spearing them with a specially made slender barbed piece of iron, by hooking them out with a piece of stout wire, or by digging them out. In many cases the cure does more harm than the disease, since the wounds made by the beetles may be enlarged and then often left untreated, with the result that decay sets in or the wounds become attractive to egg-laying Red Weevils, the grubs of which either kill or seriously injure the palms.

The beetles should be carefully extracted and then the wound should be plugged with coconut fibre soaked in tar, or with a mixture of sand and tar, and the hole stopped with clay. Another method used with success in the Dutch East Indies is to extract the beetles and fill the hole with a mixture of 1 part coarse salt and 2 parts sand. The hole is then closed with clay.

The main objects of these measures are to remove and kill the beetles and to prevent the wounds from decaying or from being attractive to the Red Weevil.

Measures against the Grubs.

ON ESTATES.—Keep all coconut estates and gardens as clean as possible.

Split up and burn all decaying palm logs and stumps and kill the grubs and other stages of the Black Beetle found therein.

Clean out the holes beneath old decayed palm stumps and fill these in with earth or sand to prevent further breeding of grubs.

Cut down all old standing dead and dying palms to ground level, split up and burn the stems, and dig up the stumps or cover them over with earth or sand to a depth of at least 6 inches.

Remove and burn all young palms killed by the Red Weevil or by disease, as these will soon breed the Black Beetle grubs.

Clean up every three months all manure and coconut refuse lying in heaps, in pits, or in trenches and kill all the grubs found therein.

IN TOWNS AND VILLAGES.—Clean up all manure and refuse heaps and pits every three months. Use the manure on the land and burn the refuse at frequent intervals.

Split up and burn all old palm stumps and logs in private compounds and kill the grubs and other stages.

General Measures.

All palm stems which are to be used for building purposes, fence posts, temporary bridges, &c., must be split up within three months after cutting. Whole logs can only be used for posts, &c., if the ends are tarred thoroughly or protected from rotting.

It is important that all measures of control against Black Beetle should be carried out by all coconut estates and gardens, and by all towns and villages in the coconut areas.

NATURAL ENEMIES.

The grubs, pupæ, and beetles are occasionally found to be killed by a green parasitic fungus (*Metarrhizium anisopliæ*), and the grubs and pupæ are sometimes devoured by the predaceous grubs of another beetle.

J. C. HUTSON,

Peradeniya, July 1, 1922. *Government Entomologist.*

Coconut Red Weevil (Rhynchophorus Ferrugineus).

Showing Damage done to Stems.

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THE RED WEEVIL OR PALM WEEVIL.

(Rhynchophorus ferrugineus).

In the opinion of the writer the Red Weevil is the most important pest of the three in Ceylon, since it is prevalent in all coconut areas, and is capable, in the larval stage, of killing young palms and seriously injuring older palms. Much of the damage done to the crowns of palms by the Red Weevil larvæ is attributed to the Black Beetle, which often seems to be regarded as the more serious pest of the two beetles. It is true that the larvæ of both the Black Beetle and Red Weevil may sometimes be found in the crowns of dying palms, but in such cases it is the Weevil grubs which are usually responsible for the dying condition of the palms; while the Beetle grubs have only come in after the palm has begun to decay. The differences between the various stages of the two beetles and their close association with each other will be explained elsewhere in this leaflet.

Nature of Damage.

The Red Weevil, as indicated above, is probably the most serious pest of coconuts in Ceylon, since it breeds actually in living palms, which are in many cases killed or seriously injured. This pest does practically no damage to palms in the weevil or adult stage, beyond making small holes or punctures with its snout or proboscis in any wound or soft spot. These punctures may be made partly for feeding and partly for the laying of eggs. The damage is done by the larvæ which hatch from these eggs and tunnel about inside the palm, eventually eating out a fairly large cavity inside the crown or the trunk. Since the larvæ work entirely inside a palm, the injury is often not detected until it is too late to save the palm. Quite young palms, four or five years old, are quickly riddled and killed off by an attack of weevil grubs, while the injury to palms a few years older is often fatal, since they may be attacked anywhere from the crown to the base. Injury to the crown is almost invariably fatal unless detected early, and results in the withering and collapse of the young central leaves. In cases where the trunk or the base is attacked, the injury may sometimes be detected by the oozing of a brownish liquid, or small pieces of chewed fibre, from a small hole in the trunk or at the base. If the infestation is noticed in the early stages, the palm can sometimes be saved by prompt removal of the larvæ and treatment of the wound.

Old palms may sometimes be attacked in the crown, usually after injury by Black Beetle, and in such cases the results may be fatal.

Old palms are rarely attacked in the trunk or at the base, since by that time the tissues have become too hard to permit larval development, even if these are still attractive to egg-laying weevils.

A Declared Pest.

The Red Weevil was declared a pest under the Ordinance in 1907 at the same time as the Black Beetle, but no general campaign has been waged against this pest. The collection of weevils and the treatment of injured palms is carried out on some estates.

Life-History and Habits of the Different Stages.

Weevil.—The Red Weevil or Palm Weevil is one of the largest of the weevils or snout-bearing beetles. It is usually about 1½ inches long, including the snout, and is generally of a reddish-brown colour, with black markings behind the head. It varies considerably in size, colour, and markings. The usual shape is indicated in figure 1 In both sexes the mouth parts are lengthened in the form of a slender and slightly curved snout or proboscis, which bears a very small pair of biting jaws at the end and a pair of antennæ near the base. The snout of the female is more slender than that of the male, which bears a small "brush" of short hairs on the upper side near the end. The weevils in the adult stage do very little feeding on the palms, but can live for two or three months after emerging from their cocoons. They may sometimes be seen flying about during the day, but are less active after dark. They are quickly attracted to and palm which has been injured by wind, or by knife wounds, or which has been bored by the Black Beetle. Diseased palms are also attractive. Any injured or diseased palm is a favourable breeding place, and the female beetles flock there to lay their eggs. Experiments recently made in the Dutch East Indies with marked Red Weevils indicated that they can detect favourable breeding places at a distance of 1,000 yards, or more than half a mile.

Eggs.—The eggs are small, slender, and whitish to creamy-white and are usually about 1-10th of an inch long by 1-25th of an inch broad. They increase very little in size before hatching in from four to five days. A list of places in which eggs may be laid on a palm is given below (see Habits of Oviposition).

Grubs or Larvæ.—The newly hatched grubs are small and whitish, and in general appearance they closely resemble the full-grown grubs.

RED WEEVIL (RHYNCHOPHORUS FERRUGINEUS).
Showing Damage done to Young Palms.

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They have a light-brown head with jaws strong enough to enable them to bore their way about inside the palm. They have a stout fleshy body, but no legs. They feed on living plant tissues inside the palm, being entirely surrounded by their food, and protected during the whole period of their development into beetles. They are full-grown in two or three months, and then form their cocoons wherever they happen to have been feeding inside the palm. As many as fifty larvæ may sometimes to be found in a single palm.

Cocoons and Pupæ.—The fully developed grub forms its cocoon by winding around itself a number of tough, fibrous threads to form a stout compact hollow cell, within which it remains quiet for a few days. During this period it gradually shrinks to about two-thirds its former size, having stopped feeding. It then changes in the pupal stage, remaining in this stage for about two weeks. The pupa is pale brown at first, but becomes slightly darker before the emergence of the weevil. Figure 6 shows the pupa with the snout, legs, and wings closely applied to the underside of the body.

Weevil.—After about two weeks the weevil comes out of its pupal skin, but remains inside its fibre cocoon for about two weeks before making its way out into the open. In some cases the cocoons are packed so tightly within the cavity in the palm that some of them are pressed out of their normal shape, and the weevils fail to develop properly and die inside. Preliminary breeding experiments carried out under laboratory conditions at Peradeniya indicate that the complete life cycle from egg to weevil takes about four to five months, but the period of development may be shorter under natural conditions and in the coastal districts.

Habits of Oviposition.—Under laboratory conditions the female weevils laid a few eggs almost daily during a period of over a month, but unfortunately most of them were killed off by a fungus disease. During this period the greatest number of eggs obtained from one female was 231, while others laid from 50 to 200 eggs before being killed by disease. Fuller details will be published later. In the Dutch East Indies the maximum number of eggs obtained from a single female Red Weevil was 531, and it seems highly probable that under natural conditions in Ceylon a female weevil may lay considerably more than 200 eggs.

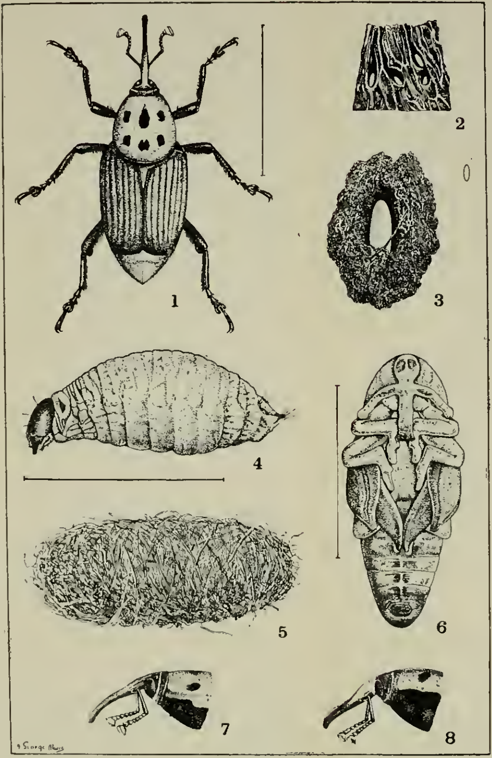
The female lays her eggs in any part of a palm where she can find a wound or a soft spot. She may either first make a small hole, sometimes $\frac{1}{3}$rd of an inch deep, with her snout, and then put an egg down into this hole with her long ovipositor. Or she may push an egg into a convenient crack or a soft spot with her ovipositor alone. The weevil often makes use of the holes bored into the crown of palms by the Black Beetle, or she may push her eggs into the soft tissues at the base of a damaged leaf stalk. Eggs may also be laid anywhere in the trunk where there is a soft spot or a wound, or they may be deposited at the base of palms where the bark has cracked. Young palms up to ten or twelve years old are specially liable to attack since they are more easily damaged, and therefore more attractive to egg-laying weevils than older palms.

Differences between the Red Weevil and the Black Beetle

Except that these two pests are both beetles, they are quite different in general appearance throughout their various stages of development and in their breeding habits. These differences have been brought out separately in leaflet No. 21 and in the present leaflet, but they are here contrasted together for convenient reference.

Beetles.—The Red Weevil is smaller and more slender than the Black Beetle, and is reddish-brown in colour, with a long slender snout projecting forwards and downwards from the front part of the head. The Black Beetle is a much larger and stouter insect, and is dark brown to blackish in colour wlth a horn curving upwards and backwards from the top of the head. The Weevil does practically no injury to the palm, but the Beetle damages palms by boring into the crown in order to feed on the sap.

Eggs and Larvæ.—The Weevil lays its small, slender, whitish eggs in any wound or soft spot on living palms, and its larvæ feed and develop inside the living parts of the palm, eventually killing it or injuring it seriously. The Beetle lays its rather broadly oval whitish eggs in dead palms, in manure and other refuse heaps, in old palm stumps and logs, and its larvæ feed and develop in such places, and have nothing whatever to do with living healthy palms, so far as is known at the present time. The Weevil larvæ are rather stout fleshy grubs, tapering at both ends, of a creamy colour and with no legs, whereas the Beetle larvæ are somewhat cylindrical, usually resting in curved position, of a dirty white to bluish colour, and have six rather long, jointed legs.



Red Weevil.

1, Adult. 2, Eggs in Leaf Stalk. 3, Eggs (enlarged). 4, Full-grown Larva. 5, Cocoon. 6, Pupa. 7, Head of Female. 8, Head of Male.

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Cocoons and Pupæ.—The cocoons of the Red Weevil are formed inside the cavity made in the living palm by the larvæ, and are made of fibrous threads wrapped closely round the pupa. The Black Beetle larva makes no regular cocoon, but forms its pupa in an earthern cell under refuse heaps, or hollows out a cell in the walls of old palm logs, or constructs a cell out of the vegetable mould in such logs. Both of these pests change into the adult stage from the pupa and the development starts all over again.

The Close Association of the Red Weevil with the Black Beetle.

These two pests are dependent on each other to some extent for providing breeding places, and it has been pointed out by other writers that they do far more damage working together than either of them would be able to accomplish alone. For instance, the Black Beetle bores a hole in the crown of a perfectly sound and healthy palm, which ordinarily would be proof against weevil attack. This injury, however, lets in the Red Weevil to lay its eggs in the wound, and its larvæ kill or seriously injure the palms. The dead or dying palm forms a suitable breeding place for the Black Beetle larvæ, which complete their development and emerge as beetles to injure more palms. Since these two pests are both more or less prevalent throughout the coconut areas in Ceylon, and are so closely associated with each in their attacks on the palms, it is of vital importance to the coconut industry that more attention should be paid to their control. The coconut palm during the first ten or twelve years of its life is particularly liable to injury by these two beetles, whose methods of attack are not so conspicuous as those of the Coconut Caterpillar, but far more deadly. There is still far too great a tendency among coconut growers to leave young palms to take care of themselves until they come into bearing, although there is a steadily increasing number of planters who are beginning to realize that the extra care and attention given to palms in their early years is well worth the trouble and expense involved, and may be regarded as a sound investment. This brings us to the measures of control which must be adopted, both remedial and preventive.

Control Measures.

The control of the Black Beetle, as outlined in leaflet No. 21, will help to reduce the number of injured palms in which Red Weevils are likely to lay their eggs and breed, and will therefore assist in the control of the weevil. These measures include the collection and destruction of the Black Beetles, the periodical cleaning up of all estates and gardens by the removal and destruction by fire of all dead palm stumps and logs, and the proper disposal of all manure and refuse heaps at regular intervals. But in view of the fact that the Red Weevil has its own peculiar breeding habits, it is essential that definite measures of control be taken against this pest also.

Remedial Measures.—All young palms up to ten or twelve years old should be visited frequently by the specially trained "beetlers" or beetle catchers, so that the attack may be detected in its early stages. As soon as the presence of weevil grubs is detected anywhere from the crown to the base of the trunk, the cavity formed by the grubs should be carefully excavated and all dead and decaying matter thoroughly cleaned out, leaving only the healthy tissues. The cavity should then be tarred several times inside and around the edges and finally filled in with mortar or cement level with the trunk. All larvæ, cocoons, and weevils removed from the cavity should be killed immediately. A bad attack in the crown can rarely be satisfactorily cured, and in such cases it is safer to remove and dispose of the palm so as to prevent further breeding of weevils and beetles. Older palms should also receive attention perodically, and the preventive measures given below will usually protect these.

Preventive Measures.—These are specially applicable to young palms up to ten or twelve years of age. Avoid unnecessary wounding of young palms, as all wounds are attractive to egg-laying weevils. It has been found in the Dutch East Indies that eggs may be laid even in wounds a month old.

Do not strip off old leaves, but allow them to drop naturally. When cutting the leaves for control of Coconut Caterpillar, leave at least two feet of the leaf-stalk on the palm.

All the wounds made by knives, cart wheels, &c., must be tarred immediately and thoroughly, especially in the case of young palms.

Palms which are growing on land which is subject to periodical flooding should be mounded up with soil at the base as a protection from weevil attacks. This measure should also be applied to young palms which have their roots exposed.

Food Plants.

The Red Weevil probably attacks almost any kind of palm which is in a sufficiently attractive condition, but it apparently prefers the coconut palm. It has been found attacking the palmyra (*Borassus flabellifer*), the date palm (*Phœnix dactylifera*), the cabbage palm (*Oreodoxa oleracea*), and *Livistona* palms. It probably also attacks the kitul or toddy palm (*Caryota urens*), the areca palm (*Areca catechu*), and the talipot (*Corypha umbraculifera*). It may be mentioned that the Black Beetle breeds in most of the above palms when they are in a dead or decaying condition.

Natural Enemies.

No natural enemies of the Red Weevil have been found so far in Ceylon.

J. C. HUTSON,
Government Entomologist.

Peradeniya, August 15, 1922.

THE COCONUT CATERPILLAR.

(*Nephantis serinopa.*)

The Coconut Caterpillar has been established for many years as a pest of coconuts on both the eastern and western sides of the island, but of late it has also appeared inland, though not to the same extent as in the coastal areas.

The damage is done to the fronds or leaves by the caterpillars, which eat away the underside of the leaflets, so that they turn grey and die. If the pest is allowed to spread, it sometimes happens that every single palm on an estate may become infested with the caterpillars, and all the fronds, except the youngest at the top of the palms, are killed. The nuts may be attacked and the vitality of the infested palm is lowered, so that there is a marked reduction in the crop during the next two years after a serious outbreak.

This caterpillar has recently been declared a pest under the Plant Pests and Diseases Ordinance, and measures should be taken to control it. A short account of the pest is given here, so that coconut growers may take notice of the caterpillar and the damage which it causes, and may know what measures must be adopted to control this pest.

Description of Stages.

The coconut caterpillar, like all other caterpillars, passes through four stages in its development: (1) Egg; (2) caterpillar; (3) cocoon; (4) moth. As will be seen below, the first three stages live actually on some portion of the leaves, while the fourth stage, the moth, is more active and can fly about. The moths, however, do spend most of their lives on or near the coconut or other palms, such as palmyra.

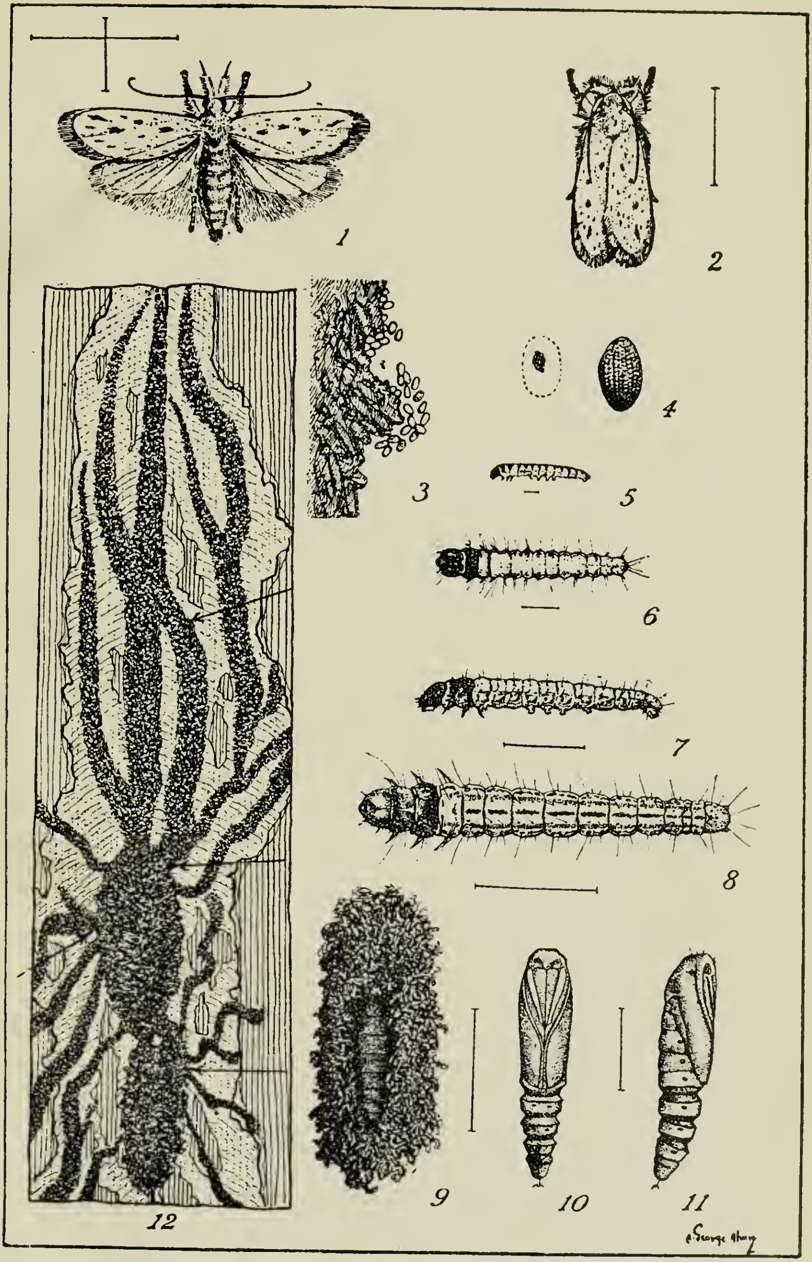
Moths.—The small grayish moths (see figure 1) are not very active as compared with other moths, and do not fly much unless disturbed. Their presence on an estate may be detected by shaking or beating the lower leaves smartly, and any small moths that fly away a short distance and soon settle down again are almost certain to be the coconut moth. They are also sometimes found resting under cadjan sheds during wet weather. The resting position of the moth is shown in figure 2.

Eggs.—The moths lay their eggs on the underside of the leaves, and, if the leaves have already been attacked by the caterpillars, the eggs are usually laid under the webbed galleries made by the caterpillars (see figure 3). The eggs are very small (see figure 3 and 4) and are not easy to find. They are whitish when freshly laid, but turn pinkish before hatching. A single female moth can lay more than 350 eggs during its life, which only lasts about two weeks.

Caterpillars.—The eggs hatch in about ten days into very small caterpillars. These cover themselves with a few threads, under which they start eating away small portions of the green underside of the leaflets. The galleries are extended, and are covered with some of the small pieces of leaf bitten off by the caterpillars and with small pieces of waste matter.

Cocoons.—The caterpillars are full grown in from six to eight weeks, and form their cocoons usually on the underside of the leaflets, covering these cocoons with small pieces of leaf and waste matter. Figure 12 shows the injury to a portion of a coconut leaflet caused by the caterpillars, and two cocoons are shown.

Moths.—The cocoon stage lasts about two weeks, after which the moths come out and are soon ready to begin egg laying for another brood of caterpillars.



Coconut Caterpillar.

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Damage done by the Caterpillars.—If the first brood of caterpillars has been a small one, it usually happens that only a few of the lower fronds on a few palms are slightly attacked and show small brown patches. In such cases the damage may not be noticed, or if it is noticed, the planter decides that no great harm has been done, and hopes that the pest will disappear. It is true that the pest does sometimes die off without doing much damage, which may mean that the caterpillars and cocoons have been destroyed by their natural enemies, such as parasites. At other times, if these parasites are not sufficiently numerous to check the caterpillars, it may happen that most of the first brood of caterpillars will develop into moths. These moths may spread over a wider area, and lay their eggs for a second brood of caterpillars. This brood is usually much larger than the first, and within a short time the planter finds that the attack has spread over, perhaps, 4 or 5 acres, and that the lower leaves of the palms originally attacked are beginning to turn a greyish-brown colour and die off. Unless control measures are taken at this stage, the pest will be liable to increase very rapidly, and will attack thousands of trees over large areas. All the lower fronds rapidly turn grey and dry up, and are no longer of any use to the palms. The nuts may also be attacked, and young nuts may fall as the result of caterpillar injury. Palms which have been weakened previously by coconut beetles, by diseases, or by starvation and neglect, may die after a bad attack of caterpillar, but palms which are usually kept healthy and well nourished recover rapidly from a caterpillar attack.

Food Plants.—Besides attacking the coconut palm, the caterpillars also feed on palmyra leaves, especially on the younger palms sometimes found along the road-sides, on cultivated lands, and on coconut areas. All infested leaves should be cut and burnt, otherwise the pest will continue to breed on the palmyras after the coconut palms have been treated, and will attack adjacent coconut palms later. The coconut caterpillars are also found sometimes on ornamental palms in bungalow gardens. If the attack is only a slight one and on small palms, the caterpillars can be destroyed by rubbing off the webbed galleries with a rough cloth. Badly attacked leaves should be cut and burnt.

Control Measures.

Cutting and Burning of Leaves.—As soon as the first signs of the caterpillars are noticed on a coconut area, it is important that prompt measures should be taken to check the pest before it becomes serious. The simplest remedy in an early stage of the attack is to cut off and burn all infested leaves or parts of leaves which show any traces of the caterpillar galleries. The infested material must be burnt within 12 hours of removal from the palms. The cutting and burning of infested leaves is recommended because it is the most effective method of killing the eggs, caterpillars, and cocoons of the pest which are on the leaves. This measure has been scheduled under the Plant Pests and Diseases Ordinance, and must be carried out by all coconut growers who have the pest on their palms. Coconut growers should not wait for the pest to disappear, but must treat their infested palms as soon as any injury is noticed. The cutting of a few leaves at this stage will not injure the palms, and will save their own and their neighbours' palms from serious injury and loss of crop.

Light Traps.—The cutting and burning of infested leaves will prevent the development of a large number of moths by killing the eggs, caterpillars, and cocoons which develop into moths. There will always be some moths left in an infested area, and these moths can be caught and killed by using light traps. These traps consist of an ordinary bullock cart oil lamp placed in the middle of a flat shallow pan containing water and some kerosene or coconut oil, to cover the water. A mixture of half kerosene and half coconut oil is suitable for the lamp. The pan should be at least 24 inches across, and should be raised about 4 or 5 feet off the ground on a platform made of sticks. The oil on the water is useful for preventing the moths from escaping after they fall into the pan, as they are killed quickly by the oil.

Acetylene lights may be used instead of oil lamps, but are more expensive. The oil light trap should be used at the rate of at least three to an acre, and should be used at the beginning of an outbreak on every favourable night, except on very wet nights or on bright moonlight nights. The use of light traps is not compulsory, but is recommended as a measure to be adopted at the same time that the infested leaves are being cut. It is important that the light traps should be kept clean so as to give a good light, and shoul be attended to regularly by responsible coolies. They can be stopped as soon as it is found that no more coconut moths are being caught. The coconut moths can be distinguished from other small moths which are caught in the traps by the fact that their

Coconut Palm with Fronds Skeletonized by Caterpillar of Nephantis Serinopa.

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wings are rounded at the tips, whereas the wings of the other moths are usually pointed.

Other Measures.—Bright fires are only useful if they are made of the coconut leaves which have the caterpillar pest on them. It has been found that the burning of small fires at night among the infested palms does not attract very many moths, and very few moths are killed, so that these fires are not recommended for general use at nights, unless the infested leaves cut during the day are burnt.

Smoky fires made by burning tar and sulphur are probably of no real value in controlling the pest. It is more effective to cut and burn the infested leaves than to try and kill the caterpillars by smoke.

Spraying the affected palms with a poison cannot be recommended for general use at present, until more extensive experiments have been made : so far as they have gone, a spray made up of 1 oz. Paris Green to 10 gallons water with 3 oz. lime added, gave positive results in favour of the sprayed trees.

General Remarks.—All coconut growers should endeavour to keep their palms in as healthy a condition as possible by cultivation and manuring, and the coconut area should be kept clean so as to prevent the coconut beetle from breeding and attacking the palms. Vigorous palms are not so badly attacked by the caterpillar as weaker palms, and they are able to recover more rapidly after a caterpillar attack. All coconut growers should be on the lookout for the first signs of the caterpillar pest, and should take measures to control it before it can spread over a large area when it is very difficult to control. All coconut growers in any district infested by the caterpillar should co-operate to keep the pest in check by seeing that their own palms are kept free from the caterpillar.

J. C. HUTSON,
Entomologist.

Peradeniya, June 4th, 1922.

Some Minor Insect Pests of Coconuts.

The Spotted Locust (*Aularches miliaris*) has several times during the last two years been reported as partially defoliating young coconut palms. This damage has usually occurred in fields which have been allowed to become ovrrun with thick grass and weeds, or in gardens where a variety of crops, including coconuts, is being grown on the same plot of land. The young locusts when in the wingless stage usually cluster together in large masses on the ground or on low branches and can be beaten down or collected into sacks and crushed or submerged in water,

In addition to the Coconut caterpillar (*Nephantis serinopa*) there are at least three other caterpillars which are occasionally found in small numbers eating the green leaves of coconut palms.

The "Bagworm" (*Psyche albipes*) covers itself with a case formed of small pieces of leaf and eats irregular holes in the leaflets, or sometimes eats away portions of the leaflets until only the midrib remains. The cases should be collected and destroyed.

The "Blue-striped Nettle-grub" (*Parasa lepida*) sometimes feeds on the leaflets, at first nibbling away small portions of the leaf surface and later eating right through the leaf. The egg-shaped cocoons are sometimes seen attached to the leaves.

The Hesperid caterpillar, *Gangara thyrsis*, occasionally attacks the leaves, but cannot be considered a pest.

Scale Insects.—There are several species of scale insects which are found on the leaves of coconut palms, but the only species which calls for any mention here is the "Coconut Scale," sometimes known as the "Transparent Coconut Scale" (*Aspidiotus destructor*). This scale is not the serious pest in Ceylon that it is in some other countries, as it seems to be controlled by parasites and by fungous diseases. The female scale is pale yellow and is usually seen as a minute yellowish spot under a thin papery covering. These scales are sometimes clustered so thickly on the underside of the leaves as to form a complete scurfy layer over the leaf surface. The upper surface of attacked leaves is usually marked with small yellowish spots which coalesce in a bad attack, giving the whole leaf a yellowish appearance, but this yellowing of the leaves may also be due to other causes. Small palms are sometimes attacked on the lower leaves, which can either be sprayed with kerosene emulsion, or removed and burnt. Attention to drainage, cultivation and manuring will maintain the vigour of the palms and help to keep down scale attack.

See also:—Bulletin of the Department of Agriculture, No. 58 and leaflets Nos. 20, 21, and 22.

THE PLANT PESTS ORDINANCE.

Ordinance No. 6 of 1907.

This Ordinance provides for the destruction of plant pests and for the sanitation of plants in the Colony. The Governor in Executive Council may proclaim in the *Gazette* (1) insects, parasitic plants; and fungi to be pests, (2) the measures for prevention, arrest, and eradication of such pests. The Governor may appoint for three years for any revenue district four to seven members to form a Plant Pests Board.

The Government Agent (or the Assistant Government Agent) shall be its *ex-officio* Chairman, and he may appoint its Secretary and other officers, and may convene meetings of the Board. On being satisfied of the existence within its jurisdiction of a proclaimed pest, the Board may enforce the carrying out of such preventive or remedial measures as are specified by the Governor in the Proclamation and are approved by the Committee of Agricultural Experiments. The owner or occupier of the land affected is liable both criminally and civilly to carry out the measures notified to him by the Board. The Board may through the Chairman authorize right of entry for purposes of inspection. The owner is not entitled to any compensation in respect of damage occasioned by the measures ordered, but the Governor in Executive Council may grant compensation for plants destroyed. The Chairman of the Board must notify the existence of any pest within its area to the Chairmen of Boards of adjoining districts, to the Government Agent, to the Colonial Secretary, and to the Chairman of the Committee of Agricultural Experiments.

The following Proclamations have been issued and are still in force:—

Pests.	Measures for Treatment.
I.—(*a*) Red coconut beetle (*Rhyncophorus ferrugineus*) (*b*) Black coconut beetle (*Oryctes rhinoceros*)	Destruction by fire of fallen or dead coconut trees. All unsplit coconut stems more than twelve months old must be removed from fences, and the further use of unsplit coconut stem for fences is prohibited. (July and October, 1907.)
II.—The fungus *Theilaviopsis ethaceticus*, causing the stem-bleeding disease of the coconut tree	Cutting out and burning the diseased parts of the tree, scorching the wound, and tarring it with hot tar. (February, 1908.)

Pests.	Measures for Treatment.
III.—Shot-hole borer (*Xyleborus fornicatus*)	Prohibition of removal of tea plants (other than leaf for manufacture and tea seed) or their reception by any estate within the prescribed area. (April 1912.)
IV.—The fungus *Phytophthora faberi*, where it is found to exist in Hevea	Collection and destruction by burning and burying with lime of diseased fruits. Excision and destruction by burning of diseased bark (cortex.) (March 1913.)
V—The species of *Phytophthora*, which causes nut and leaf fall of coconuts	Collection and destruction by fire of all diseased fruits and fallen leaves in affected fields, and destruction by fire of fallen or dead coconut trees. (November, 1917.)

THE ERADICATION OF ILLUK.

The "Illuk" of Ceylon is the lalang of the Straits (*Imperata arundinacea.*)

In a paper read before the Ceylon Agricultural Society in 1906, The Hon'ble Mr. John Ferguson discussed this subject very fully.

Mr. Ferguson refers to a method adopted by Tobacco Planters in Sumatra as described by Mr. Frederick Ponsforth :—

The only efficacious remedy for getting rid of this pest was thought to be to dig and turn the soil completely over 2 to 3 ft. and then to pick out and destroy every particle of the plant by burning. This is, of course, an expensive method and, though effectual, can only be resorted to in exceptional cases.

Moreover the planters observed that the Malay and other native settlers had a fairly efficacious and comparatively easy method of temporarily getting the better of any lalang surrounding their houses or which grew in their plantations. They did this by the simple process of pressing the lalang flat down on the ground whilst it was in full growth, with the aid of a bamboo pole upon which one or two men kneeled. They thereby caused the lalang to smother itself and this retarded its growth for a few months. I have witnessed this time after time in my wanderings among the Malay villages. The parent lalang grass flattened down in this way, died and rotted, and caused the land to be temporarily shaded from the sun, so that the new lalang shoots sprouting from the parent stock became too weak and frail to penetrate the thick outer covering of the old grass. Hence, regarding this,and bearing in mind that lalang must have sun, the planters decided upon making use of the lalang itself as a weapon of extermination.

The method thus adopted and which is now in use all over Smatra is to mow down the lalang by aid of an instrument called by the Malay a "Tajak," which consisted of a sharp heavy blade about four inches broad by $1\frac{1}{2}$ to 2 feet long, with a handle from 4 to 5 feet long sloping at an angle of 45° from the blade upwards when the tool is laid flat upon and parallel with the ground in a position for cutting. This long handle enabled the coolies to use the same constantly without suffering from that universal complaint among Asiatics of "Sakit Pingang" (or pain in the back). The lalang was thus hewn down close to the roots by this tool, and was then gathered up in bundles and carefully laid upon one side; the ground was then dug up or hoed about 4 to 6 inches deep sufficient to turn comp'etely over the thickest part of the lalang root; the implement used for this purpose is a big hoe, called by the Malays a "chunkol" and by the Tamils a "mamoty." It is usually very sharp and heavy and measures from 8 to 10 inches in breadth and is from 10 to 14 inches in length. The Malays and Tamils use a short handle from $2\frac{1}{2}$ to 3 feet long, but the Chinese use a handle from 5 to 6 feet long.

Each coolie is alloted a certain task, which he has to complete for his day's work before he can get a full day's pay. When the ground has been completely hoed over, it is then inspected by the supervising assistant planter in charge of the gang, and if the work is correct, permission is given to shade the ground with the lalang grass previously cut. This must be done very carefully, as not a vestige of ground must be visible to the sun's rays, otherwise the lalang will grow again.

The above remedy is very effectual, and is not expensive, and it seldom fails to completely rid the soil of the lalang. The roots that are left in the soil rot, and serve to make the ground more porous and to manure it. The operation should be attended to before the lalang goes to seed. The ground should also be left covered by the lalang for several weeks, and then just before planting one's crop it is well to give the ground another hoe over and bury the now rotten grass.

I have myself seen very excellent tobacco grown on lalang ground treated after the foregoing method, and it is well known how excessively tobacco take its richness out of any soil. Again, the tapioca plant is considered by the Malay and and Chinese cultivators to be a plant that can effectually combat against the grass if planted in a lalang field treated as above. I have often seen tapioca planted by the natives in the midest of a coconut plantation in order to kill the lalang which had sprung up. But this latter remedy is considered by some to be worse than the disease; for tapioca is said to do a large amount of harm to the palms by way of impoverishing the soil.

Note By Mr. W. H. Wright.

In reply to yours I am of opinion that Illuk grass can be got rid of by giving it successive weedings, the first to be a mamoty weeding 6 inches deep. After that, weed it by pulling it up with the hand, seven times successively as the blade grows. I have done this myself and have seen it done on several estates. The cost of the work will depend on the condition of the estate and the kind of soil in which the Illuk grasss grows. It should be easy to root it out after the third weeding.

Note by Mr. William Jardine.

Many thanks for sending me the interesting, well-written, and useful paper on the method adopted by the planters of Sumatra for effectually getting rid of that pest, the "Lalang-Lalang" of the Malays, and the "Illuk" of the Sinhalese. I have no doubt that, with the grass growing close and thick and 6 feet high, the method adopted in Sumatra would prove effectual; but it is rare to find such luxuriant growth in Ceylon. At any rate I have only occasionally come across a few patches. Usually the growth is thinner and not more than 4 feet high. Many a sleepless night has the thought of tow to get rid of this grass caused me, and I doubt not other planters who have had to do with it. I tried the method of pressing down and rolling the grass, and that checked its growth for a few months. I tried cutting it down with grass knives and thatching the ground with the grass, but as there was not enough of it to cover the ground thickly it was only a partial success.

There is a kind of "Illuk" that grows freely in the Chilaw and Puttalam districts. It rarely exceeds 3 feet in height and has a tendency to fall over. The blades are thick and flaccid, and the roots surely penetrate more than 8 inches. This kind might be effectually dug out for Rs. 25 an acre, provided a sufficient force of men could be got to do the work at the right time.

The writer of the article on "Lalang-Lalang" says that the work should be done before the grass blossoms. I cannot say in how many years it does blossom. Where I have seen it left for quite some years I have never seen it blossom. But if once interfered with, either by cutting down or burning, it at once springs up in blossom; and if this blossom is cut off, another follows within a month, and I think it would go on doing this till it exhausted itself and died.

A Simple and Inexpensive Method of Exterminating "Illuk" Over Large Areas on Coconut Plantations.

By Mr. Gerald Nicholas.

Practical coconut planters in Ceylon who have had to contend with this pernicious weed-grass know that *speedy and complete* eradication can only be effected at a cost that is prohibitive. There are but two effectual ways of accomplishing speedy extermination that the writer is acquainted with, and they are both equally expensive:—

1. To dig and turn the soil completely over the whole of the affected area for rather more than the actual depth the roots have penetrated, and then carefully to pick out by hand every bit of the root and destroy it by fire.

2. To pen herds of cattle for five or six consecutive nights on the illuk in enclosures so compact that the animals cover the ground with their droppings. The latter plan, however, can be carried out only where the coconut palms are so advanced in growth that they cannot be knocked about, or otherwise damaged, by the cattle. Either of these methods will cost from Rs. 40 to Rs. 50 per acre according to the character of the growth of the illuk. The second plan, however, would also considerably enrich the soil, so that a part of the cost would be covered by the manure.

Sickling the illuk with grass knives, or mowing it down with scythes, then ploughing the ground, or digging and turning it up with the mamoty to a depth of 6 or 8 inches, and finally thatching the surface with the weed grass or several layers of coconut husks are effectual remedies, and if they are not quite so quick in their operation, they are certainly less expensive than the two methods previously described.

But unless the ground is completely shaded by a heavy covering success is only partial. The writer has known illuk blades penetrate thin layers of coconut husk when the latter were not carefully laid down. But the difficulty is to get either coconut husk or the illuk grass in sufficient quantity near at hand, as the grass cut on the ground on which it grew seldom suffices to cover it to the required depth, and owing to their bulky nature the carriage of husks for a considerable distance is expensive. On a coconut plantation it is not absolutely necessary for the well-being of the palm that the whole surface of the ground should be perfectly bare of herbage.

When illuk has got a firm hold of the soil and a large area is involved, the simplest and cheapest plan of dealing with it is, in my opinion, to open lanes 10 feet wide along the rows of palms, thus :—

Rows of coconut.
10 ft. lane.

Spaces of Illuk 15 ft. wide.

Rows of Coconut.
10 ft. lane.

Spaces of Illuk 15 ft. wide.

Rows of Coconut.
10 ft. lane.

and to keep the lanes clean and free of illuk and other miscellaneous weeds by digging or weeding them as often as may be necessary, but the growth of ordinary grass herbage should be encouraged until a close sward is established. The best way to open lanes where the growth of illuk is strong, is to first sickle it down close to the roots, remove the grass and lay it on the intervening spaces, then dig and turn up the ground to the full depth of a mamoty. If Crotalaria is thickly sown in the lanes immediately after the fast digging it will shade the ground completely and help to suppress the growth of illuk, besides enriching the soil. The improvement effected by such a course of treatment on the condition of young palms which had been previously stunted in growth and almost killed out by illuk was simply marvellous. By the sixth month they begin to make vigorous growth, and in eighteen months they are often far and away finer and bigger plants than those of the same age growing in land free of illuk. By this time the illuk, also, will have disappeared along two-thirds of the lanes and given place to a close sward, and it may be confidently expected that by the end of the second year all the land (in one case over an area of 217 acres) will be absolutely free of illuk. As for the strips of illuk, between the lanes, it soon becomes apparent that con fining the weed grass to a space 15 feet wide has the effect of considerably weakening its growth, and it has been further noticed that a climbing plant such as *Kirimadu*, Sing. (*Ipomaea Cymosa*) or *Mikania scandens* or a low shrub such as *Pupula*., Sing. (*Vernonia Zeylanica)* is inimical to it, the tendrils of the climber putting down the blades of illuk and the shrub pressing upon it and gradually choking it out. The spread of such friendly weeds should be encouraged, all other "cheddy" growth among the illuk being rooted out; and in less than two years most of the illuk will be killed out.

The initial cost of opening 10 ft. lanes averaged in my experience Rs. 8 per acre, and subsequent digging or weeding, and rooting up "cheddy" in the strips of illuk between the lanes Rs. 1 per acre per month, or Rs. 12 per year. The total cost of exterminating illuk by these measures is therefore about Rs. 32 per acre. The writer has had quite 12 years' experience in the treatment of coconut plantations over-run with illuk, and after careful trial of various methods he is of opinion that a simple, less expensive, or better plan of exterminating illuk over large areas on coconut plantations can scarcely be devised than that just described.

At the meeting of the Board of Agriculture (March 5th, 1906) Dr. J. C. Willis, Director of the Botanic Gardens, said his experience of the grass in both the countries mentioned had showed him that the grass in Ceylon was hardly worth mentioning in comparison with what it was in parts of Malaya. It was no unusual thing there for one to look round from horizon to horizon and see nothing but thousands of acres over-grown with this grass, which grew in a way we never dreamed of in this country. One method of getting rid of it that had been discovered in the Straits was by mowing. With regular mowing, little by little, other grasses got a footing on the land, which was thus turned into decent pasturage. Referring to a certain estate in the Straits Dr. Willis said he was told that ten years ago it was a mass of illuk grass. It had been mowed regularly, however, with the result that the illuk grass had gradually given way to other grasses. Dr. Willis went on to advise the abolition of the custom of burning illuk, saying that burning did no harm to that grass and did much damage to everything else. If fire was kept away, and mowing resorted to, trees would grow up and the shade would grow over the illuk, causing it to die down.

"CHIPPING" AS A REMEDY.

A correspondent writing to the *Tropical Agriculturist* Supplement of April, 1907, says ;—I have always found the following plan cheap and effective. Provide young weeders with sharp-edged weeding currandies and let them chip the illuk down level with the ground, repeating this over and over again as soon as say 3 inches of growth appears. In three months or so all the roots below ground will die out. I have tried forking out the roots and other means of eradication, but found the chipping back process the cheapest and surest way. [The repeated cutting, as Mr. Bamber explains in his note on spraying, tends to exhaust the reserve food stored up in the thickened underground roots.]

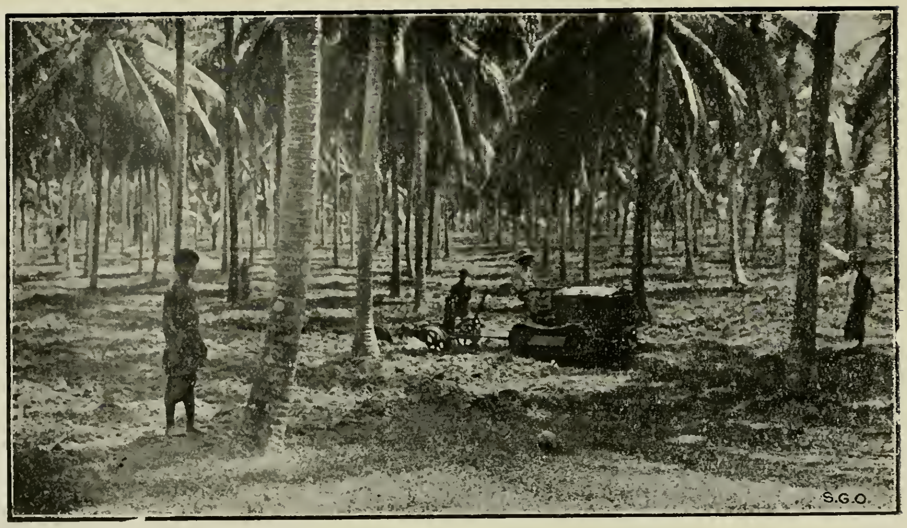
SPRAYING ILLUK.

The August, 1907, number of the *Tropical Agriculturist* contains a communication from Mr. M. Kelway Bamber, Government Agricultural Chemist, in which he states that he and Mr. J. B. Carruthers, late of Peradeniya, conducted experiments in the spraying of illuk with Arsenite of Soda, which are reported to have proved successful. The difficulty in this treatment is that the substance is very poisonous and care must be taken that cattle do not eat any of the treated grass. The method of preparation and treatment are as follows :—

2·88 lbs. washing soda are dissolved and boiled in 3 gallons of water ; 2 lbs. arsenic are slowly stirred in, the liquid being kept boiling till the arsenic is dissolved. This is then diluted to 20 gallons as a stock solution.

For use 2 pints of this are diluted with 5 gallons water and this is sprayed on the grass, or it can be put on by means of a cloth, one end of which dips in a trough on wheels containing the solution, the other trailing on the grass and kept spread out by means of a rod.

The grass can be first burnt off. When new shoots are 8 or 9 inches high the wet cloth is drawn over them and kills them in 48 hours. This must be repeated every time new shoots appear, the object being to exhaust the roots of all the starchy matter and so kill the plants entirely.



Ploughing with Tractor.

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ESTIMATE FOR OPENING AND WORKING 200-ACRE ESTATE FOR 10 YEARS.

WITH EXPLANATORY NOTES.

[For this revision of the estimate by Mr. Gerald Nicholas appearing in the old edition of "All about Coconuts" we are indebted to Mr. A. Karl Beven of Franklands, Veyangoda.]

This estimate gives full details of expenditure, year by year, for ten years from the first clearing of the land, allows interest on such annual expenditure at 8 per cent, and shows that the aggregate outlay is Rs. 115,910 plus interest Rs. 87,132, or a total of Rs. 203,042, which gives Rs. 1,015 per acre; or, deducting the receipts in nuts up to the 10th year, Rs. 760 per acre.

ESTIMATE OF COST OF PLANTING AND CULTIVATING 200 ACRES OF COCONUTS UP TO 10TH YEAR, SHOWING ALSO PROBABLE RECEIPTS FOR SAME PERIOD.

ANALYSIS OF ESTIMATED EXPENDITURE.

1ST YEAR.	Rs.	Int. 8 % Rs.	Total. Rs.
Value of Land, 200 acres at Rs. 150 ..	30,000		
18,200 Seed Nuts at Rs. 100 ...	1,820		
Transport to spot at Rs. 10 ...	182		
Preparing and Tending Nurseries ...	120		
Felling, Clearing, Fencing ...	4,500		
Drains, Roads, Culverts ...	500		
Lining 25 by 25, and Holing 3 by 3 by 3	1,260		
Filling in 24″ and Planting ...	350		
Weeding, 8 months ...	2,400		
Watching ...	360		
Buildings ...	1,000		
Tools and Implements ...	400		
Superintendence ...	3,000		
Contingencies	308		
Carred over Rs...	46,200	3,696	49,896

ANALYSIS OF ESTIMATED EXPENDITURE.

	Rs.	Int. 8 % Rs.	Total. Rs.
Brought forward Rs...	46,200	3,696	49,896
2ND YEAR.			
Fence ...	180		
Drains, Roads, Culverts ...	300		
Supplies add Supplying ...	120		
Beetles or Other Enemies ...	150		
Weeding ...	3,000		
Watching ...	360		
Buildings ...	150		
Superintendence ...	3,000		
Contingencies ...	240		
	7,500	4,592	12,092
3RD YEAR.			
Same as above with an additional Rs. 200 for Tools and Cost of Weeding less by Rs. 500. ...	7,200	5,535	12,735
4TH YEAR.			
Fence ...	80		
Drains, Roads, Culverts ...	200		
Beetles and Other Enemies ...	100		
Forking 5′ Circles Round Plants ...	420		
Weeding ...	2,000		
Watching ...	360		
Buildings ...	150		
Superintendence ...	3,000		
Contingencies ...	250		
	6,560	6,503	13,063
Carried over Rs...	67,460	20,326	87,786

ANALYSIS OF ESTIMATED EXPENDITURE.

	Rs.	Int. 8 % Rs.	Total. Rs.
Brought forward Rs...	67,460	20,326	87,786
5TH YEAR.			
Fence ...	80		
Drains, Roads, Culverts ...	200		
Beetles and Other Enemies ...	100		
Weeding ...	2,000		
Watchers ...	360		
Buildings ...	100		
Tools and Implements ...	150		
Superintendence ...	3,500		
Contingencies ...	250		
	6,740	7,562	14,302
6TH YEAR.			
Fence ...	80		
Drains, Roads, Culverts ...	100		
Beetles and Other Enemies ...	100		
Digging or Forking round Palms 7′ ...	560		
Weeding ...	1,200		
Watching ...	360		
Buildings ...	3,100		
Superintendence ...	3,500		
Contingencies ...	250		
	9,250	8,907	18,157
7TH YEAR.			
Fence ...	80		
Drains, Roads, Culverts ...	100		
Beetles and Other Enemies ...	80		
Ploughing @ Rs. 2 (Half Estate) ...	200		
Purchase and Keep of Stock ...	1,500		
Weeding ...	1,200		
Watching 3 @ Rs. 15 ...	540		
Buildings ...	100		
Tools and Implements ...	250		
Superintendence ...	3,500		
Contingencies ...	250		
	7,800	10,244	18,044
Carried over Rs...	91,250	47,039	138,289

ANALYSIS OF ESTIMATED EXPENDITURE.

	Rs.	Int, 8 % Rs.	Total. Rs.
Brought forward Rs...	91,250	47,039	138,289
8TH YEAR.			
Fence ...	80		
Drains, Roads, Culverts ...	100		
Beetles and Other Enemies ...	50		
Ploughing @ Rs. 21 (Half Estate) ...	200		
Keep of Stock ...	700		
Weeding and Clearing ...	1,000		
Watching ...	540		
Building ...	400		
Picking and Gathering Crop ...	200		
Tools and Implements ...	200		
Superintendence ...	3,500		
Contingencies ...	250		
	7,220	11,641	18,861
9TH YEAR.			
Fence ...	80		
Drains, Roads, Culverts ...	100		
Ploughing @ Rs. 1·50 (Half Estate) ...	150		
Keep of Stock ...	700		
Picking and Gathering Crop ...	250		
Weeding and Clearing ...	1,000		
Watching ...	540		
Buildings ...	200		
Tools and Implements ...	100		
Manure and Application ...	3,600		
Superintendence ...	3,500		
Contingencies ...	250		
	10,470	13,411	23,881
Carried over Rs...	108,940	72,091	181,031

ANALYSIS OF ESTIMATED EXPENDITURE.

	Rs.	Int. 8 % Rs.	Total Rs.
Brought forward Rs.	108,940	72,091	181,031
10TH YEAR.			
Fence ...	80		
Drains, Roads, Culverts ...	100		
Ploughing at Rs. 1·50 Half Estate ...	150		
Keep of Stock ...	700		
Picking and Gathering Crop ..	350		
Weeding and Clearing ...	1,000		
Watching ...	540		
Buildings ...	200		
Tools and Implements ...	100		
Superintendence ...	3,500		
Contingencies ...	250		
	6,970	15,041	22,011
Total Rs...	115,910	87,132	203,042
LESS RECEIPTS :—			
8th year (average 5): 70,000 nuts @ R65 Rs. 4,550			
9th year (average 15): 210,000 nuts @ R65 ,, 13,650			
10th year (average 30): 420,000 nuts @ R65 ,, 27,300	45,500	5,637	51,137
Nett Cost of Estate ...	...	Rs...	151,905

NOTES ON ESTIMATE.

It is assumed the soil is good, the climate favourable, and the land so situated as to admit of its being opened and worked at a reasonable cost.

Seed Nuts, Nurseries and Supplies.—The selection of seed nuts is a matter of primary importance. Attempts at economy in regard to the purchase of these are a great mistake and only result in loss. Be sure that the nuts come from healthy, matured, heavy-bearing trees. Nuts of medium size and globular, with thin husks, I would choose. An allowance of 30 % more seed nuts than the number of plants to the acre is necessary, namely 10 % for failures in the nurseries and 20 % for supplies in the first 3 years. Do not have the nurseries in too shady a spot. When the time arrives for planting out, remove alternate plants in the nursery, so that those which remain for supplies will have more space to develop.

Fence.—The timber on the land should provide materials for a fence which should not cost much to run up, and, with occasional repairs, ought to last about 2 years, but a good strong live fence is a desideratum and should be got up as early as possible. *Erandu* (*Jatropha curcas*) interspersed with *Erabadu* (*Erythrina indica*) and *Kapok* (*Eriodendron anfractuosum*), and also *Sapan* (*Caesalpina Sapan*) and Mauritius Hemp (*Furcrea gigantea*) would make a neat and efficient fence. *Kapok* would also give a profit by its yield of cotton.

Barbed wire fencing would be more costly, but more effective in keeping cattle off the estate. Once set down practically no upkeep, if quick-growing plants, such as *Lunumidella* (*Melia dubia*) or Kapok be put down, The wire can be nailed on to them, in perhaps the third year, when the posts show signs of decay.

Distance between the Trees.—25 ft. by 25 ft. is the proper distance. Anything more is a waste of valuable land, besides increasing the cost of cultivation, when carried on later, between the rows. The superfluous spaces afforded the palms cannot result in increase of individual yield, and, therefore, the crop per acre, with the fewer number of palms, must be considerably less. Another disadvantage is the ground would be more exposed to effects of drought.

Weeding.—should not be neglected, as apart from other disadvantages, it would only increase the eventual cost. In the 2nd, 3rd and 4th year I have allowed for 10 weedings a year. Thereafter 8. It is advisable to have clean circles round the plants. Say 6 feet radius. Between the rows encourage the growth of leguminous plants. I do not consider it necessary or advisable that the surface be clean weeded, although there are many in favour of it. When the time comes for ploughing no humus is added to the soil, and on undulating land it will be found that the wash is great and the rich surface soil is gradually carried away to the low-lying parts.

Buildings,—A sum of R1,000 is put down for temporary bungalow with wattle and daub walls and a thatched roof: also a set of coolie lines.

4th Year.

Digging Round Plants.—By the 4th year the holes will have filled up to a level with the surface, and the soil within the bare space round the plants might now be loosened to a depth of about 9 inches, and for this purpose a 12-inch three-pronged digging fork will generally be found the most serviceable.

5th Year.

Superintendence.—An increase of R500 is allowed.

Weeding.—should cost a great deal less in the fifth year and still less in subsequent years, but from the 7th year onwards there will be an increasing quantity of "droppings" from the trees, and provision is made for their disposal preparatory to burning or burying.

6th Year.

Buildings.—The building of a permanent bungalow might now be considered, and accordingly the moderate sum of R3,000 is allowed for the erection; but the cost will, of course, be in proportion to the size and style of the building. R100 are also put down for coolie lines.

7th Year.

Ploughing the whole surface might now advantageously supersede digging round the plants, one-half the estate being so treated every year, for it would be quite sufficient if the soil were ploughed in alternate years.

Stock.—Three or four pairs of draught bullocks or buffaloes would be needed for this, 9TH YEAR.

COST AND APPLICATION OF MANURE.—If it is desired to get the trees into full bearing earlier than they would if left to nature, recourse should be had to manure. This is a large subject and cannot be dealt with in a few lines. To be brief; no provision is made for the purchase of stock other than draught bulls or buffaloes. Once the plantation is well established and the plants above the reach of cattle, the advantages of having a herd are many. An inexpensive method of manuring and good results are obtained by tethering two head of cattle to each tree for 10 nights. At the end of this period spread out the droppings over a circle 12 to 14 ft. diameter, sprinkle 6 lbs. bone dust over it, and turn over to a depth of 9 inches. In my estimate I have put down in 9th year a manure mixture to cost Rs. 130 a ton on the estate—8 lb. per tree. This to be applied to the backward trees

TRENCHING.—Contour trenches, in sections 20 ft. × 5 ft. × 15 ft., are necessary where the ground is undulating—cut at right-angle to the slopes and embracing them. I have made no provision for trenches, but there may be a saving on roads, culverts or other items to meet the cost, as well as that of propping bunches.

RECEIPTS.—My estimate of crops is only under most favourable conditions. In many reputed districts for coconuts, it is nearer 15 years before appreciable returns can be expected. In the 20th year there should be no difficulty in harvesting 800,000 nuts and over, and, with liberal cultivation and manuring, a million obtained evantually.

[The question of growing catch crops, such as manioc, &c., during the first year or two, is one about which there is much difference of opinion. From one point of view it is not economic to allow the land lying between the rows of a newly planted estate to lie idle, and use should be made of it until the palms require the full feeding area—or at least as long as the catch crops will grow and yield satisfactorily without interference from the coconut roots below and fronds above. From the other point of view this is considered an objectionable practice as robbing the soil of fertility which should go to nourish the palms. Of course, if catch-cropping is practised any loss of fertility in consequence must be made good by manure. Mr, A. E. Rajapakse (whose estimate follows) thinks it possible to secure a nett return of Rs. 1,500 from the 200 acres by growing catch crops in the first year, after which he would discontinue growing them.]

Cletrac Tractor with Disc Harrow.

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ESTIMATE BY Mr. A. E. RAJAPAKSE.

N.B.—This is for land situated in the dry zone. The figures are based upon actual expenditure incurred.

Description of Works.	Cost Rs.	Int. 8 % Rs.	Total Rs.
1st Year.			
Value of land 200 acres at Rs. 100 ...	20,000		
18,000 selected nuts @ Rs. 120 ...	2,160		
Preparing and Tending Nurseries ...	250		
Felling and Clearing @ Rs. 25 ...	5,000		
Drains, Roads and Bridges ...	500		
Barbed Wire Fence ...	2,000		
Lining 27′ by 27′ ...	250		
Cutting Holes 3′ by 3′ by 3′ (12,000 Holes) @ 10 Cents ...	1,200		
Filling and Planting ...	750		
3 Weedings for 9 months ...	2,000		
2 Watchers @ Rs. 15 ...	360		
Tools, &c. ...	200		
A Cart and a Pair of Bulls with Upkeep	750		
Superintendence and Allowance ..	1,000		
Buildings ...	1,500		
Cangany @ Rs. 25 ...	300		
Contingencies ...	500		
	38,720	3,097	41,817
2nd Year.			
Fence ...	*nil*		
Drains, Roads and Bridges ..	500		
Supplies and Supplying ...	100		
Beetles and Other Enemies ...	180		
Weeding and Cultivating round Plants	2,400		
Upkeep of the Pair of Bulls and the Cart	300		
Buildings ...	100		
Watching ...	360		
Cangany ...	300		
Superintendence, &c. ...	1,000		
Tools ...	50		
Contingencies ...	500		
	5,790	3,808	9,598
Carried over Rs...	44,510	6,905	51,415

Description of Works.	Cost. Rs.	Int. 8 % Rs.	Total. Rs.
Brought forward Rs...	44,510	6,905	51,415
3rd Year.			
Same as 2nd Year ...	5,790	4,576	10,366
4th Year.			
Fence ...	25		
Drains, Roads and Bridges ...	500		
Weeding ...	2,000		
Digging and Forking round Plants ...	600		
Beetles and Other Enemies ...	180		
Buildings ...	100		
Uprooting of Stumps ...	1,000		
Upkeep of Cart ...	300		
Superintendence ...	1,000		
Cangany ...	300		
Tools ...	100		
Contingencies ...	500		
Watching ...	360		
	6,965	5,499	12,464
5th Year.			
Fence ...	50		
Drains, Roads, &c. ...	500		
Beetles and Other Enemies ...	180		
Ploughing and Weeding ...	2,000		
Uprooting Stumps ...	1,000		
Purchase and Keep of Stock ...	1,500		
Tools and Implements ...	250		
Superintendence, &c. ...	1,250		
Cangany ...	300		
Watching ...	360		
Upkeep of Cart ...	300		
Contingencies ...	500		
	8,190	6,595	14,785
Carried over Rs...	65,455	23,575	89,030

Description of Works.	Cost. Rs.	Int. 8 % Rs.	Total. Rs.
Brought forward...	65,455	23,575	89,030
6th Year.			
Fence ...	75		
Drains and Roads ...	500		
Ploughing, Weeding & Disc-harrowing...	2,000		
Buildings ...	3,000		
Beetles and Other Enemies ...	180		
Uprooting of Stumps ...	500		
Tools ...	500		
Upkeep of Stock ...	500		
Superintendence ...	1,250		
Cangany ...	300		
Watchers ...	360		
Contingencies ...	500		
	9,665	7,895	17,560
7th Year.			
Fence ...	75		
Drains and Roads ...	500		
Beetles and Other Enemies ...	180		
Ploughing, Weeding & Disc-harrowing...	2,000		
Buildings	100		
Watching ...	360		
Tools and Implements ...	50		
Upkeep of Stock ...	500		
Superintendence ...	1,250		
Cangany ...	300		
Contingencies ...	500		
	5,815	8,992	14,807
Carried over Rs...	80,935	40,462	121,397

Description of Works.	Cost. Rs.	Int. 8 % Rs.	Total. Rs.
Brought forward Rs...	80,935	40,462	121,397
8th Year.			
Fence ...	75		
Drains, Roads and Bridges ...	500		
Beetles and Other Enemies ...	180		
Ploughing, Weeding & Disc-harrowing...	2,000		
Upkeep of Stock ...	1,000		
Watching ...	420		
Buildings ...	300		
Picking and Gathering of Crop ...	300		
Superintendence ..	1,250		
Cangany ..	300		
Contingencies ...	500		
Tools ...	50		
	6,875	10,262	17,137
9th Year.			
Fence ...	75		
Drains, Roads and Bridges ...	500		
Beetles and Other Enemies ...	180		
Ploughing, Weeding & Disc-harrowing...	2,000		
Upkeep of Stock ...	1,000		
Picking and Gathering of Crop ...	350		
Buildings ...	200		
Tools and Implements ...	250		
Cost and Transport of Manure for ½ the Estate ...	5,000		
Application of Manure ...	500		
Watching ...	420		
Superintendence ...	1,500		
Cangany ...	360		
Contingencies ...	500		
	12,835	12,109	24,944
Carried over Rs...	100,645	62,833	163,478

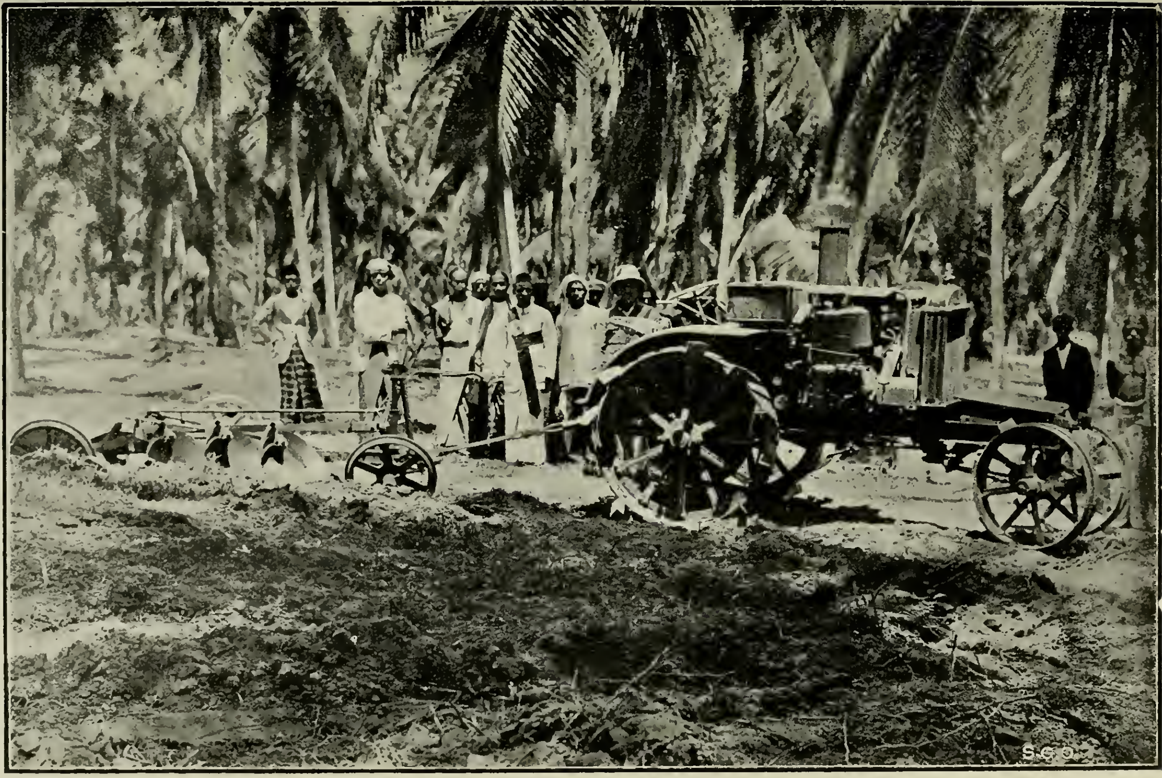
Description of Works.	Cost. Rs.	Int. 8 % Rs.	Total. Rs.
Brought forward Rs...	100,645	62,833	163,478
10th Year.			
Fence ...	100		
Drains, Roads and Bridges ...	500		
Beetles and Other Enemies ...	180		
Ploughing, Weeding & Disc-harrowing...	2,000		
Upkeep of Stock ...	1,000		
Picking and Gathering Crops ..	500		
Watching ...	420		
Buildings ...	200		
Tools and Implements ...	100		
Cost and Transport of Manure for ½ the Estate ...	5,000		
Application of Manure ...	500		
Superintendence ...	1,500		
Cangany ...	360		
Contingencies ...	500		
	12,860	14,107	26,967
Total Rs...	113,505	76,940	190,445
Less Receipts :—			
8th Year 130.000 nuts @ Rs. 60 ... Rs. 7,800			
9th Year 250,000 nuts @ Rs. 60 ... ,, 15,000			
10th Year 420,000 nuts @ Rs. 60 ... ,, 25,200	48,000	6,537	54,537
Net Cost of Estate ...	...	Rs...	135,908
—*i.e.*, Rs. 679 per acre.			

VALUATION OF COCONUT ESTATES.

When valuing coconut estates, the would-be purchaser or mortgagee naturally wishes to have all the available information about the estate to be purchased or taken on mortgage. Therefore full information must be obtained and given under the following heads :—

1. Situation of Estate.
2. Title to the Land.
3. Acreage and Particulars of Acreage.
4. Census of Trees, Plants, etc., *i.e.*, Trees is bearing, Trees with Stems and coming into bearing, Plants of all ages Vacancies.
5. Distance of Planting.
6. Lie of Land and Description of Soil.
7. Roads and Drains.
8. Boundaries, whether Natural or Wire-fenced.
9. Age and Condition of Trees.
10. Condition of Estate.
11. Crops and Prospects of Crops.
12. Buildings.
13. Supervising Staff.
14. Labour, whether Resident or Village.
15. Medical Aid. Distance from Dispensary or Hospital.
16. Approach Road to Estate.
17. Nearest Railway Station.
18. Rainfall.

When figures of crop are given, you has to test them to see whether they are approximately correct. Judging by the crops on the trees, you have to decide what the number of the nuts per tree is likely to be and then divide the number of nuts, as supplied to you, by the number of trees in bearing. By these means you could fairly find out whether the figures supplied are approximately correct. Ascertain the number of nuts per candy from the estate books if the figures are available; otherwise use your experience and discretion as to what it is likely to be, by the size of the nuts, &c. Divide the crop by the number of nuts per candy and you will get the number of candies per annum. Multiply that by the average price of a candy



SANDERSON TRACTOR.

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of copra. That will give you the gross annual income of the bearing portion of the estate. Subtract from the gross annual income the expenditure per annum on the bearing portion of the estate. If the figures are not available from the estate books, the figures of the working of coconut estates, similarly situated, will supply you with the information that is required.

The gross income per annum, less expenditure per annum, will give you the nett income per annum. The nett income, into 10 years' purchase equals value of the bearing portion of the estate. Add to this the value of non-bearing acreage and the acreage of the vacant land, and you have the value of the whole estate. When coconut estates are above the average, the value is about 12 years' purchase.

A. W. B.

Another well-known planter writes:—

The method usually adopted in valuing a coconut estate is to base your calculation on a 10 years' purchase.

On most estates run on modern lines figures are usually available to work on. Otherwise a census of the trees must be taken and the estimate of crop made by going carefully through the estate and estimating the nuts per tree by taking what one considers average bearing trees. In this case the number of trees is multiplied by the number of nuts per tree and crop for the year arrived at. By this means the estimate of crop is close enough for purposes of valuation.

For example, let us suppose that an estate of 100 acres yielding 3 candies per acre, costing Rs. 30 to produce, has to be valued. We proceed as follows:—

Take the price of copra as Rs. 60 per candy, and Rs. 30 as the cost per candy. Then the nett profit per acre per annum would be Rs. 30 and the valuation would be arrived at thus:—100 acres × 3 candies per annum × Rs. 30 profit per candy equal Rs. 9,000 per annum. At 10 years' purchase the estate would therefore be worth Rs. 90,000.

A. D.

EXTRACTS FROM A PAPER BY THE LATE MR. WILLIAM JARDINE.

(Written in 1905.)

The cultivation of the Coconut Palm is now so universal in all tropical countries that it is next to impossible to discover its original habits, and there is no authentic account as to when the first coconuts were drifted to the shores of Ceylon. Those who wish for information on this head, and are curious as to the traditions concerning the Coconut Palm, will find it all set forth in the introductory portion of Ferguson's "Coconut Planters' Manual." So far as Ceylon is concerned, the reliable information available points to the Dutch as the people who really began the systematic planting and cultivation of the palm; and once planted along the seaboard it has been regularly maintained by the dwellers on the land. The old idea that it would not thrive far from the influence of the sea breeze is exploded, as it grows well all over the low-country, where the soil and rainfall are suitable, and even in sheltered valleys at an elevation of 2,000 feet, as in the town of Badulla. We must also give up the poetic fancy that the coconut tree stretches out towards the sea because it loves the briny breeze. The truth is, that the tree is a lover of light, and will bend in any direction to reach it; and as there is no obstruction on the seashore it naturally bends in that direction and would do the same if the open space were inland. So sensitive is it to shade of the lightest that it instinctively bends away from it, and instances may be seen where the tree has grown almost horizontally till outside the influence of the shade, before it assumed its upward growth. For the success of a Coconut Plantation the essential is the right kind of soil; that secured, all else is easy and success assured; that missed, leads to constant trouble, increased expense, and often to failure and loss. It is marvellous how men will go on planting lands utterly unfit, though they have constantly before their eyes the failures of others on like soil. If a census could be taken of the acreage of all bad lands planted, which never have paid and never can pay, it would be scarcely credited. When land unsuited for the successful growth of coconut has unfortunately been purchased, and even gone as far as to be cleared, the cheapest thing for the purchaser is to let it revert to jungle. The loss of the purchase money would be as nothing compared to the constant drain should he decide to cultivate it.

DESCRIPTION OF LANDS.—The best soil is, of course, the alluvial deposit on the banks of rivers, where the land is periodically flooded for a few days; fortunate, indeed, is the possessor of such land. The next best is a deep sandy loam, and 75 per cent, of sand is not too much.

On such land the trees grow rapidly and come into bearing early and respond readily to manuring. After this comes a dark chocolate loam, either alone or mixed with quartz or large stones; or a brown soil also mixed with quartz and stones. These soils though they may be rich are, owing to their greater tenacity, not so good for the growth of coconuts, as the trees are slower in growth and take perhaps 12 to 15 years to come into good bearing. Avoid as you would your worst enemy, cabook, clay, and gravel soils, for they can never make successful or paying estates. Provided there is sufficient natural drainage, the flatter the land the better. Moderately steep land, if of good soil, is not to be despised though the cost of all works will be slightly enhanced.

Rainfall.—From 60 to 80 inches a year, well distributed, is what suits the coconut tree best, though it will thrive and bear well with 50 inches on deep free soil, where the roots can travel easily in search of water. Less than 50 inches is perhaps hardly sufficient even on the most suitable soils. It has been said that a rainfall of 100 inches and over sends the tree to leaf and diminishes fruit production. I have not found this so. I know lands receiving up to 160 inches a year which compare well with those receiving only 80. If the soil is good, the extra rainfall does not seem to do harm.

Nurseries.—Where any large extent of lands is to be planted it is not possible to get nuts from selected trees for sowing in a nursery, though this might be done for raising plants for supplies. When selecting from a heap fully ripe nuts should be chosen, the water in which gives a metallic ring when shaken; they should be of medium size, and smooth and globular as they can be got, as such nuts have generally thin husks and are borne on a short fruit-stalk, and the trees are good bearers. The site of a nursery should be level and not far from water as the nuts must be liberally watered during dry weather. Cut a trench say 4 feet wide and 8 inches deep; remove all the soil and put in the nuts touching each other, with the stalk end upwards; put in soil and fill in all interstices, ramming in the soil with a stick; water liberally and then put in more soil, leaving only two inches of the top of the nut exposed. I have found this method the most successful. A great deal has been written as to the best position in which to lay down nuts in a nursery. My observation is that it makes very little difference whether placed with the eye end upwards, on the side, or the eye end slightly elevated; they seem to grow well in all positions.

Lining.—The base lines should be laid with a lining instrument as bad lining remains as long as the estate lasts, a witness to the carelessness of the Superintendent. All distances, from 24 by 24 feet to 30 by 30 feet apart, have their advocates; I think 26 by 28 feet apart a good distance; the tree, except on the richest soils, have ample room to grow, and there is no unnecessary loss of space. I have not found that trees planted 30 by 30 feet apart bear any more nuts than those planted 26 by 26 feet; and the loss of 16 trees an acre is a serious matter; and this becomes very apparent when, in manuring, there are only 48 trees per acre from which to expect crops from. Never plant nearer than 24 by 24 feet, but too many of the ignorant villagers plant so close that it is impossible for the trees to bear till they are about 30 years old, when they are able, through the pliability of the stems, to sway out in various directions in search of light. This is one of the things the Ceylon Agricultural Association should give its attention to. In the interest of the people a law should be passed forbidding any one to plant coconut trees nearer than 24 by 24 feet apart; and I would even go further and prohibit their being planted under jaks, mangoes, bread-fruit, &c. The triangular method of planting, by which 90 trees can be got into an acre instead of 70, will, I have no doubt, recommend itself to the goiya, who has an insatiable desire to cram into an acre as many plants as he thinks he can get to grow, regardless as to whether they will bear. To me, one of the greatest recommendations of planting in squares is the extra space between every four trees which admits of more light and sun getting to the ground; a coconut tree can hardly have too much sun and light.

Holing.—Three feet cube should be the standard, a yard every way.

Planting.—Where plants have been raised by laying the nuts on their sides, fill the hole with 18 inches of good soil and put the nut on the surface, pressing it into the soil for about one inch, steadying the plant with a stick driven into the side of the hole and tying the stem to it. This will keep the eye or sprout free from contact with the soil, where it would be liable to the attacks of the white ant; when the plant is well rooted fill in to cover the nut. Where plants have been raised in a nursery, with the eye end up, fill the hole two-thirds, and when planting bury the nut to within one inch of the surface of the soil in the hole. In both cases there will remain about a foot of the hole to be gradually filled in by weeding and wash. It is not uncommon to see plants put at the bottom of a three-foot hole, and where the soil is at all hard, the plants, when six or seven years old, have a poorly developed stem and the hole be still two feet deep. This only shows what a hardy plant the coconut is, and what unkind treatment it will survive. There are some soils so retentive of moisure, where the water percolates so slowly, that the least depression retains it for weeks, even with a deep drain within a few feet of it. In such a case the only way plants can be raised is by filling the holes right to the surface, and when putting in the plants, burying the nut and four inches of the stem and filling in the soil again to the surface, so that no water can possibly lodge; in this way they grow well. Drains should be cut where found necessary. I am doubtful if it is advisable to drain and plant in really swampy land and old paddy fields; the cost is great to do it thoroughly, and the results doubtful, in my opinion.

Treatment of the Plants for the First Five Years.—The practices are many, from permitting the jungle to grow up for a few years and then cutting it down, then cleanweeding the whole surface. The latter is rare except where grown with cocoa or tea. The accepted method is to allow the grass to grow, keeping down weeds and jungle growth, and keeping a radius of from three to four feet round the plants clean weeded. I think if in the second year this radius were increased to six feet, it would bring on the plants much faster. I have in my mind's eye several patches up to ten acres, which were kept clean-weeded from the time of planting till the fifth year; now that the trees are ten to fifteen years old they show a growth of quite five years over the others planted at the same time, but having only a radius of three or four feet kept clean round each plant; they also came into bearing four to five years before the others. I should mention that the ground was not exposed to the full force of the sun, as cocoa in one instance and Liberian coffee in others were grown for four years. If catch crops like cotton or manihot were grown with the coconuts for four years, necessitating the ground being kept clean, I am convinced it would pay well to do it.

Ploughing.—Where the soil is light and free, ploughing could be done with benefit in alternate years, after the trees have attained their eighth year; but where soils are stiff and they are in the majority in some districts, we have neither the ploughing nor the cattle capable of doing the work effectually. The only other way to loosen the soil is to, say once in three years, dig it over about six inches deep with mamoties, burying all grass and weeds in the process; and where the soil is deficient in it, scattering broadcast about a ton of freshly-slaked lime per acre. If at the same time, the seeds of some nitrogen collecting plants were sown, it would materially lessen the cost of the work, as so much nitrogen would be added to the soil when the plants were cut down and buried. When a steam digger comes to be placed upon the market it will be a boon to Coconut Planters.

Propping.—This is an absolutely necessary work. from the time the tree begins to bear till the 15th or 20th year, according to the nature of the soil. Each bunch needing it is propped up with a forked stick finely pointed; the forked position is inserted between the nuts till it catches the fruit stalk. It is then slightly raised, so that the weight is partly lifted from the fruit stalk, and the sharp point inserted into the stem of the tree, the weight of the bunch keeping it in position. Why it should be necessary to support the fruit of the coconut, in its early years, in this way, I am unable to say; but it seems to indicate a weakness, due perhaps to something lacking in our soils. Can any of our numerous agricultural chemists say if there is any chemical that can be added to our manures, capable of toughening the fruit-stalk? Where jungle is scarce propping is rather costly.

MANURING.—Ceylon soils, as a rule, are poor, and to rest satisfied with the returns nature gives, is, in the case of coconuts, bad policy. If we want heavy crops we must put into the soil the manures necessary to produce them. When should I begin to manure? So soon as you see that your plants need it. If there is a child or an animal suffering from inanition you do not say: "Oh! you are too young to be fed up, it may do you harm, and it would be wrong to accustom you to nourishing diet." This is practically the argument of those who say you should not manure young coconut trees; but you at once treat the child or animal in a rational way and give it the food suited to its condition. So should you do to your plants. Some want assistance earlier than others; and when a person can afford to do it he should begin manuring before his trees show by scanty heads of leaves and reduced crops that they are lacking food. Manure half the estate each year, for I know of no manures except coarse bone dust which will last unexhausted longer than two years, and on no account should the trees be allowed to fall into a poorer condition than that in which they were maintained by the manure. There are many Agricultural Chemists now in Ceylon, so there can be no difficulty in ascertaining the right manures to apply. Without doubt cattle manure is the best, but much of that is not available, as pasture outside the estate is rarely to be had, and although the passing of herbage through the intestines of an animal makes it more readily available as food for plants, the grazing of cattle on an estate, and concentrating the droppings to one part, is after all only "robbing Peter to pay Paul." It adds nothing to the soil, but tends rather to exhaust it too soon. Many persons with the means have not the courage to spend money on artificial manures, fearing that their money may be lost. This timidity arises from ignorance, for those who have used artificial manures know that when the proper manures are used and judiciously applied, they always give remunerative returns. Again, ignorance makes many impatient and disheartened; they apply manure and expect to see results in crop within a year, forgetting, or not being aware, that it takes quite six months before artificial manure becomes to any extent available to the tree, and that it takes a year from the setting of a nut to its ripening, also that on poor lands the first application is almost all appropriated for the building up of the constitution of the tree and that it is not till after the second application that results in crop are seen. Others object: "If we begin to manure we must continue it": that certainly you must, and if the money invested in manure yields 25 to 50 per cent. I fancy most persons would desire to continue it; various nitrogen-collecting plants, through the praiseworthy efforts of the Royal Botanical Gardens' staff, are now being grown experimentally, and no doubt we shall soon have reliable information as to cost and results. It is necessary to remind owners that manuring does not only increase crops, but prolongs the life of the trees for probably from 20 to 30 years!

Enemies of the Coconut Plant: White Ants.—These are not very destructive except on old lands where no jungle has grown for many years; where they have decaying timber and roots to feed upon they rarely do much harm to plants. Many remedies have been proposed, but I have found the following effective:—Place half a quart of salt under the nut of the plant and keep it in its place by a stake driven into the ground, tying the stem of the plant to the stake; no earth should come in contact with the nut, and after the plant is thoroughly rooted earth may be gradually filled in; mild showery weather should be chosen for this. A very old and experienced hand recommends dipping each nut into a thick strong mixture of salt and cow dung; a pinch of corrosive sublimate added would be an improvement.

Wild Pigs.—Where these are numerous they are very destructive and capable of destroying almost every plant in a clearing within a week of planting out. The only remedy in such a case is six months before putting out the palms, to plant up the clearing with manihots and sweet potatoes; the pigs being fond of these will confine their attention mainly to them, and do the minimum of harm to the coconut plants. Where not so numerous a reward of Rs. 5 and the carcase will send a good many Shikaries on their tracks.

Porcupines.—These are very wary and destructive animals. The following plan, for their destruction, was tried with marked success on an estate near Ambalangoda. Take a few coconuts that have germinated sufficiently to largely develop the fuzz-ball inside the nut; split the nuts with a clean stroke of a sharp axe, and into the fuzz-ball mix about two tea-spoonfuls of "rough on rats"; close the halves together again and tie loosely with a piece of jungle creeper Leave these in the tracks of the animals; so long as there is the least taint of the human hand they will not be touched, but after the animals will feed on the nuts and die. Seventeen were killed in this way within a fortnight. This plan would also suit for the bandicoot rat.

Cattle—are most harmful to young plants, for if badly eaten down by them the plants must be replaced with others, as they will never thrive or grow into good trees. The only protection against cattle is a good fence, and to allow none into the estate till the plants are five years old.

Any one desirous of going for coconut cultivation would do well to carefully consider my remarks on soils, and also disabuse his mind of the very prevalent fallacy, mainly amongst Europeans, that coconut trees come into bearing in six years. This occurs only on the finest soils, and even then the bulk of the trees are not in bearing till the 8th year. On inferior soils it takes 10, 15 and even 20 years for the trees to bear anything appreciable. The "goiya" who plants his few dozen trees, and does not count the value of his labour, can afford to wait, but not the capitalist, who invests his money in the hope of quick returns. Under the most favourable conditions the cost of bringing an estate into bearing is considerable; what then must it be when expenditure and compound interest go on accumulating for 15 years. The cost of producing the estate is then far more than it can ever fetch in the market.

EXTRACTS FROM A PAPER BY MR. A. K. BEVEN OF FRANKLANDS, VEYANGODA.

SELECTION OF LAND.—Coconuts are supposed to grow anywhere and everywhere, but this is a mistaken idea. The object of most capitalists is to get as quick returns as possible from land at a minimum of expenditure. But the palm is not a product suited for acquiring rapid fortunes: those who can afford to wait will be rewarded for their patience. For the successful growth of coconuts an average temperature of 80 deg. is required; and an average and even distribution of 70 to 100 inches of annual rainfall is essential where the soil is heavy. In the Chilaw and Puttalam districts, a free soil and the presence of water near the surface enable the palm to thrive with a much scantier rainfall. In some of the higher districts, with an abundant rainfall, coconuts grow; but a low temperature and excessive moisture hinder the production of fruits. Next to rainfall and temperature attention must be directed to the nature of the soil. The best, of course, is to be found in alluvial flats and along the banks of the rivers, where the land is annually flooded for a few days. But land under these conditions is not plentiful. The next best soil is a sandy loam. There are many others on which the palm thrives: and the richer and deeper the soil the less will be the subsequent expenditure in maintaining its fertility. The only two soils on which the palm, unless heavy expenditure is to be faced, refuses to grow profitably are hard gravel and stiff clay. The latter is the worst to deal with, and one I would avoid altogether. Trees on the former, however, to my knowledge, have responded to cultivation and can and will yield profitable returns.

Buffaloes Ploughing.

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Seed Nuts.—The next subject to engage attention should be the selection of seed nuts. It is of paramount importance that the greatest care be taken that only the best nuts be got for seed. Time, trouble and expense should not be grudged, for a great deal of the future of the plantation depends on the trees from which the seed nuts have been chosen. I should choose nuts from trees ranging from 20 to 50 years of age. That is those in their very prime. The tree should present a vigorous growth and have large crowns carrying the bunches of fruit on well-set short stems. It is well to avoid those trees that show a tendency to drop their nuts, however large or numerous; and those with scanty or drooping fronds. There is a prejudice in favour of a large-sized nut, but I prefer those of a medium size, since one has to take a commercial view of the product. Where the nuts are exceptionally large, it follows that there would be fewer on a bunch than where the nuts are of medium size. The difference in numbers when acres are considered will be very considerable, as nuts are sold by the thousand, only very small ones being rejected. In weight, too, if you turn your nuts into copra there is a great advantage. Considering their numbers, with medium over large nuts, I would choose therefore medium-sized nuts, globular in shape and with a thin husk and a thick kernel for the nursery.

The Nursery.—The method of laying out the nursery is known to most of us. But I would emphasize the need of special precautions to avoid a site in which white ants are likely to show themselves, or one with too dense a shade. The latter causes the plants to be "spindley." These feel the shock when planted out in the open. There are two methods of laying the nuts in the nurseries; horizontally—the position they lie in when fallen from a tree—and vertically with the " eye " up. The latter system I do not favour, as the retention of water in the depression, at the stalk end, when the nut is in the upright position, is liable to cause rot, to which the germ, directly below it, may succumb. When laying the nuts on their sides, do not bury them deep. They should be only half-covered; and both now and when planting them out later *in situ* let the stalk end be kept slightly above ground. The husk toughens and offers some resistance to white ants; but if they are in the nursery they secure a lodgment and give no hope to the plant in the field. If the stalk end, which is the tender spot, is above ground, the mischief can be easily detected. It would be wise to reject those plants tardy in shooting out or springing up.

Lining.—Strict accuracy should be shown here, not because a plant out of line by a foot or two would suffer, but because the appearance of the field would be spoilt, and the field could not be conveniently ploughed and harrowed. I advocate the usually adopted distance 25 ft. x

25 ft. apart, and would avoid planting any closer, but in a very damp district 30 ft. x 30 ft. would perhaps be more suitable both to provide for the rapid spread of the fronds and to secure heat and sunlight for the soil.

HOLING.—This should be carefully attended to, and every effort should be made to give the plant a good start. Nothing less than 3 feet square and a depth of 3 feet should be provided. Coolies, when holing in undulating land, will persist in throwing all the earth on the lower side. It is well-known that the richest soil is on the surface. Care should, therefore, be taken that at least the first 12 to 15 inches of soil be dug out and heaped on the lower side of the hole; the remainder banked up in a semicircle on the upper side.

PLANTING OUT.—When the time comes for planting out, the plants should have at least four leaves—the hole should be filled up to within 12 to 15 inches of the surface with the richer soil and a basket of ashes, if available. A secondary advantage of the soil being banked up on the upper side is that it would prevent a rush of water into the hole and the consequent displacement of the plant. It is now one of the advantages of planting the nuts on their sides in the nursery comes in. When planted out, to prevent the plants toppling over through wind or rush of water, two short stakes should be driven in cross wise over the nut and these keep it firmly in its place. Where there is excessive moisture, it is necessary to cut drains between the rows to carry off the water that may accumulate and stagnate, and also from the holes that are liable to fill. Avoid what one sees frequently done—the dumping down of plants in deep holes, in which sufficient soil has not been put in. The roots should be cut with a sharp knife before the plant is put down, and they should not have to fight their way into hard soil.

WHITE ANTS AND RATS.—In the first stages of growth and until the plants have taken a hold of the soil and are independent of the nourishment they derive from the kernel and the husk, the chief difficulty that besets the planter is the destruction caused by white ants. An application of salt is beneficial, and so is the planting of an aloe seedling by the stem of the plant. The sprinkling of a handful or two of fresh jak or lunumidella saw-dust is also effective. But, perhaps, the easiest and surest remedy is the application of a solution of corrosive sublimate on the husk—say a teaspoonful to a bottle of water.

During the first five years, the wary bandicoot rat and porcupine prove yet more serious enemies. The damage done by them is all the greater, because they do not appear on the field until the plant is, to a certain extent, advanced in growth. The porcupine prefers to make a meal off the plant just when it shows a stem above ground. My experience of the bandicoot, waiting until the plants are 4 or 5 years of age to begin their destruction, may be exceptional, but in a field of 7¼ acres, no less than 150 plants were destroyed within a few weeks. The field was under cinnamon at the time.

Protection against Cattle.—It will not be out of place to urge the necessity for taking steps to protect plants, during the first five years of their existence, from the attacks of cattle. They do a tremendous amount of damage—the growth of plants eaten down by them is seriously retarded; and such plants will seldom thrive and develop into good trees. Badly attacked plants should be rooted up and replaced if possible by plants of the same age as those in the field. The advantages of cattle on a plantation are great, but it is not advisable to bring them on to the land until after the plants are free from the danger of being attacked. No pains should be spared to protect plants during the first 5 years against the bandicoot, the porcupine and cattle, for it is of paramount necessity that plants should start to grow under the most favourable conditions.

Weeding and Green Manuring.—The plants themselves need practically only the clean-weeding of a circle of say 5 feet in diameter. The application of wood ashes proves beneficial as well as a mulch of green manure. Between the rows of plants I would only cut down the brushwood; and in order not to expose the ground to the full force of the sun, the growth of some leguminous plants offers a double advantage in enriching the soil as well. A great object should be to maintain the richness of the soil, remembering that the roots of the palms are wide-spreading and surface feeding; and when the trees grow up they will require all there is to be had. The future welfare of the tree will be greatly helped by conserving the richness of the soil. Green manures can always be grown with advantage. There are soils which will not be impoverished, to the detriment of the palm in later years, by the growth of catch crops, but care should be taken to choose such as are not too exhausting.

The systematic application of manures will not be necessary before the palm reaches the bearing stage, nor even in the first few years of bearing. The advantages of applying some manure to stimulate those plants that are backward are obvious. They need a helping hand and timely help should secure uniformity in the plantation. I shall not touch further on the all-important subject of manuring and on the great benefits to both trees and crop from the application of suitable manures. It is a large subject and I prefer to leave it to some other member to deal with it.

Trenching.—A regular system of trenching begun early would greatly benefit the trees. On steep land, countour trenching before planting would conserve soil moisture. In the earlier years, it would be sufficient on ordinary flat or undulating land to have narrow trenches, say 2 feet wide and 18 inches deep between the rows of trees to hold up water and to prevent wash in the portions of the land that require them. But when the trees have developed, it would be advisable to have contour trenches, embracing every little rise in the land and throughout the undulating section. Even where the surface is fairly covered over with grass, and the slope is hardly appreciable, a trench often reveals, after an average shower, an immense amount of moisture that would otherwise have run to waste; perhaps carried out of the land altogether. It is not only the water but the soil also that is often lost to the estate.

The first object in trenching should be to conserve as much moisture as possible on the higher portions. Then, the wider the trenches lower down, the greater the superficial area of soil reached and the greater its porosity. It is usual to have trenches cut in section say 20 ft. long, 5 ft. wide, and 12 to 15 inches deep, the soil being banked up on the lower side. The advantage of having trenches cut in sections, with the firm ground 2 ft. between, is that where they do not run at right-angles to the slope, they prevent all the water rushing to the lower end to accumulate there and probably burst the bund. It is to meet these two contingencies that the sections are of use, each section holding the water that come from above it, to the benefit of the plants above and below. The bottom of the trenches should be as level as possible. If the trenches be gradually packed with husk, fallen branches and all rubbish that can be collected, and finally receive a top-dressing of earth, the benefit will soon be realised.

A similar system of trenches carried on in alternate lines will help to cover the whole estate by degrees with a net-work of receptacles for moisture and manures within easy reach of every tree. Slowly but surely the entire surface soil will thereby be worked. Nor should the cost of those trenches be heavy, at least not to the practical planter who refuses to be guided by the contract rates which are paid by Government generally in their P.W.D., Railway, and Irrigation Works. I believe the rate is somewhere about 75 cts. to a rupee a cube. Now, I have had cut tens of thousands of feet of these trenches and have found a cooly able to cut three trenches, each 20 ft. x 5 ft. x 12 in., or 20 ft. x 4½ ft. x 15 in., in a day in a medium soil. The cost works out at only 12 cts. a cube. Task work is welcomed by the men, as the better workers find no difficulty in completing their trenches and striking work at 3 and 4 o'clock in the afternoon.

Vacancies.—These should be promptly filled up, and if uniformity is to be preserved, it is well to have advanced plants in the nursery to take the place of the lost ones; but vacancies mean so much space wasted and income lost. Where the plantation has grown beyond the reach of cattle, and they are allowed on it, it is necessary to protect the supplies from destruction by them. Fencing with dead sticks is expensive in that it has to be frequently renewed. The method I have found most successful is to have a hedge of the much-abused lantana round the plant, planted in a circle a couple of feet away from the hole. It is quick growing, and may be protected by thorns so as to keep cattle off it until a stout hedge is formed. It can be trimmed down to the height of the growing plant and during drought it has the advantage of affording shelter and conserving moisture, while the prunings enrich the soil. The cost of trimming the hedge once in six months is small. In a stiff soil the lateral roots thrown out by the lantana open up the soil. It grows on the surface and can usually be rooted up by hand, the roots loosening the soil. Finally, when the coconut plants are beyond the reach of cattle, the hedge is rooted up and buried in the plant-hole; or it is burnt after a week's exposure, and much potash, in which the lantana is very rich, is added to the soil. The vigorous and perfectly developed plants, which flourish within this live hedge, falsify the theory that the lantana impoverishes the soil to the detriment of the plant. When saplings are planted in older plantations whose trees have taken possession of the land, it will be of advantage to cut a narrow drain outside the coconut-hole and say 5 feet away from the plant, all round it to a depth of 15 to 18 inches. This would help in checking the roots of the trees immediately round from interfering with the growth of the young plant.

[The section on pests and diseases are omitted.]

In Conclusion.—The results of scientific research are now being applied practically to almost every field of human knowledge. Agriculture is now exalted to a science. The cultivation of coconuts has long been purely experimental. While we would welcome all that scientific methods can do to improve the cultivation of this great staple product of the Island, we must remember it is practical experience which can alone test and use intelligently the theories of scientists.

MEMO BY Mr. A. E. RAJAPAKSE MUDALIYAR.

Clearing.—Felling and burning the jungle should be done early so as to have the land ready for planting a month or so before the rainy season. All standing trees should be cut as low as possible to assist lining and planting in regular rows.

Lining.—The lines should be perfectly straight. Trees planted in straight lines not only add to the appearance of the estate, but greatly facilitate the use of modern mechanical appliances as well as the allotment of tasks.

Distance.—The distance which is considered most suitable in good soils is 27 x 27 feet (60 trees to an acre), and in gravelly and poor soils 25 x 25 feet (70 trees to an acre).

Direct sun-light is absolutely necessary for assimilative work in the leaves, and growth and production depend on the amount of assimilative work done by the tree. Therefore trees should be so planted as to prevent the leaves of one overlapping those of another. Trees planted 24 x 24 feet in good soils do not bear well till they are about 20 years old when the leaves begin to droop along the trunks and let in more light.

Holing.—Holes should be 3 x 3 feet by 2½ feet deep. A wooden frame 3 feet square, with diagonal bars and a hole at the intersection of the diagonals, for the peg to pass through, should be used to mark the position of the hole. The difficulty of locating the right spot to plant after the hole is cut could be met by adopting a simple device. This consists of a bar about 6 feet long with a hole in the middle and two holes at either end equidistant from it. This bar should be slipped on the peg, so that it passes through the middle hole, and two smaller pegs are driven into the ground passing through the holes at the ends. Thus there would be three pegs in a straight line at fixed distances from one another. Though the main peg is removed by cutting the hole its position could very easily be locatted by replacing the bar in position, so that in planting out the only thing to do is to place the bar in position and fix the plant vertically under the middle hole. Holes should be partly filled with surface soil mixed with ashes, and planted at depths varying from 18 inches, on high land, which does not require trenching, to one foot and even less on low land, where trenches are necessary.

Seed-Nuts.—Great care should be taken in the selection of seed-nuts. They should be collected from the best trees on an estate. The trees should be from 20 to 40 years old, healthy, heavy bearing, drought-resisting, possessing short bunch-stalks, yielding good all-round nuts, etc.

There is a variety of green round nut and a long red nut amongs the common varieties found in the Island, which have been found to be the best for planting. The nuts should be perfectly dry for planting.

Nursery.—The nuts should be placed in the nursery with their tops up. Though there is a difference of opinion on this point, this plan has been adopted for the last 30 years with good results. Late germinaters and unhealthy plants should be rejected when planting out.

Planting Out.—The young plant is able to live on the kernel and water within the nut for about 12 months from time of germination. Therefore it is not necessary to wait for the rainy season to plant. Plants on germination, or a month or two after, but before roots are produced, could be taken up and planted out a month or so before the rains without fear of loss. If the soil in the hole is dry at the time of planting it should be moistened with a potful of water after the plant is set in the soil and covered with a layer of dry earth to arrest evaporation.

The field should be drained before the rainy season to enable the surplus water to escape, if not a large percentage of plants will be killed by stagnant water.

Catch Crops.—If the coconuts are to come into bearing as fast as possible and fine healthy trees are to be established it is better that no catch-crops should be grown. But, on the other hand, if it is essential that some income should be obtained from the land to help to carry on the planting, one crop of cassava or other short-lived product, readily saleable at a profit, may be grown in the first year only. Before doing so it should be determined whether the labour conditions would permit of such a crop being grown without interfering with the work of the estate. Also if the profits of the catch crop would compensate for the loss of plant-food from the soil. If no catch crops are to be grown, Crotalaria or other leguminous plant suitable to the district should be sown just after firing. This crop will not only feed on the available plant-food and reserve it for the use of the permanent crop, but will check the growth of weeds. The green crop should be cut from time to time and used for mulching round the plants. About 6 feet round the plants should be cultivated twice a year immediately after every rainy season, till the end of the 3rd year. Then if the trees are sufficiently grown, the whole land would be cultivated and all stumps uprooted. This cultivation should be repeated once a year till a plough could be put on the land.

After Treatment.—To make coconut estates pay it is necessary to manure them. If cattle manure is not available for the purpose a full mixture to supply the following ingredients:—Nitrogen, phosphoric acid and potash—should be applied. My experience is that organic manures are preferable to chemical or inorganic manures. The following is an all-round suitable mixture:—

4 lbs. ground nut cake or castor cake
4 lbs. fish manure.
6 lbs. bone meal.
2 lbs. sulphate of potash.
16 lbs. to a tree to be applied once in two years.

After or just before manuring the plantation should be ploughed or forked deep.

This treatment is sufficient for two years for wet districts with a rainfall from 75 to 100, but another shallow ploughing a year after could be done with advantage. In dry districts where the rainfall is from 50 to 75 or less, an animal ploughing is essential and disc-harrowing during the dry months. In rainy weather grain crops of the leguminous order should be grown. It should be borne in mind that the cultivation of coconuts is a *business,* and the owner of the land is the manufacturer or producer of copra. His capital is the stock of plant-food in his soil and his machinery is his trees. His aim should be to produce copra at the smallest expenditure of labour and plant-food. His capital is a limited one, which is liable to be exhausted if not replenished from time to time to make good the exhaustion due to the removal of copra. It must be remembered that 2/3 of a pound of copra is oil and the other 1/3 is poonac. The soil does not so much suffer by the removal of oil as by the removal of poonac. If therefore poonac can be purchased at a cheap rate it would be wise to use as much of it as possible in manuring the land.

Coconut husks, leaves, etc., if removed off the land should be returned to it or sold at a price to enable some fertilizers to be used in place of them. If they be returned to the land the soil will not only get back what it has lost but also what has been taken up from the atmosphere. The failure of some coconut estates during drought is due to the depletion of organic matter in the soil caused by the continuous removal of leaves, husks, &c.

Coconut husks should be used for mulching round the trees. If husks have to be sold the equivalent of fibre dust should taken back to the estate and ploughed in.

Picking.—Perfectly ripe nuts only should be picked. This could be done by picking two bunches only once in two months. Allowing ripe nuts to drop is to be recommended, though this is not always a practicable course for many reasons.

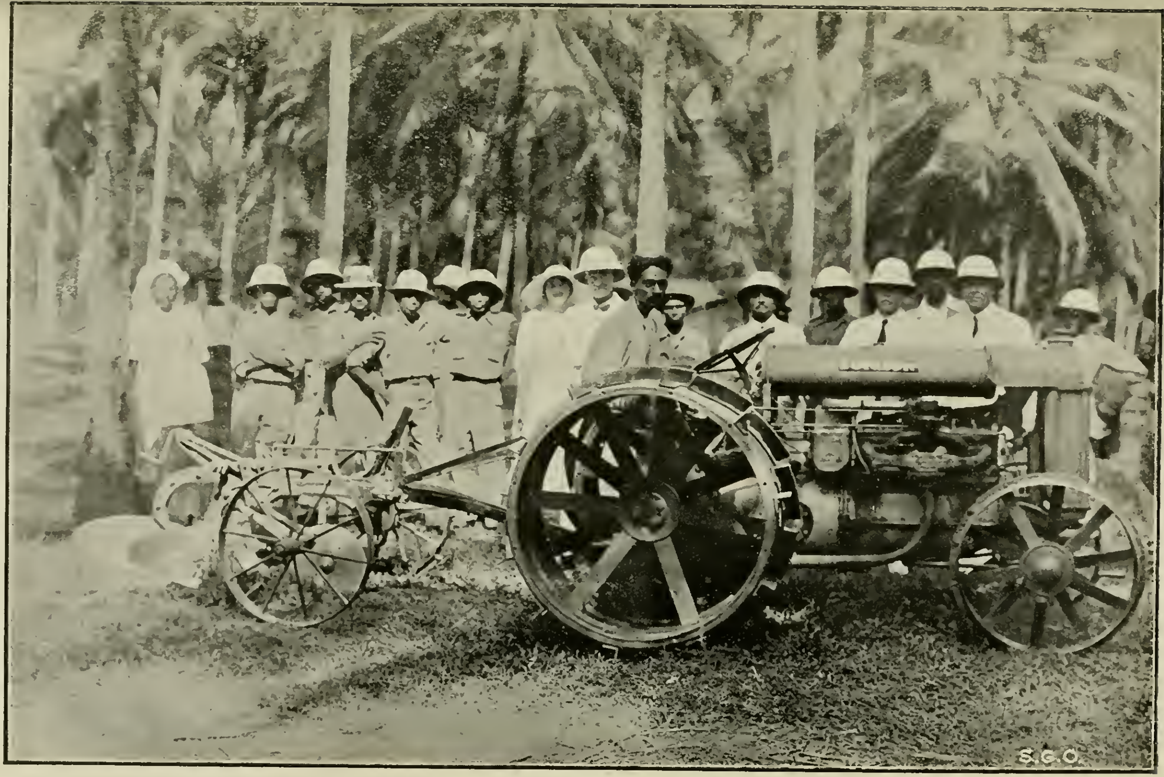
Copra.—The preparation of copra is effected either by sun-drying or by artificial heat. Sun-dried copra is superior to kiln-dried copra. It is possible, to some extent, to prepare sun-dried copra during a large part of the year if the curing be done in the following periods :—

The January crop—in March (dry month).

March and May crops in July.

July crop in September.

September and November crops in January.



FORDSON TRACTOR.

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Coconuts could be kept in husk for about 4 months without deterioration. Sun dried copra could be prepared by about 6 to 8 exposures: kiln-dried by 8 to 10 firings (2 a day)—6 with double lines of shells and the rest with single lines. The kiln should be open in front with holes at the back for free circulation of air. The drying stand should be from 6 feet 6 inches to 7 feet in height. Firing should be done very carefully—double rows of shells to every 4 feet for wet coconuts in shell, and single lines of shells after separation has taken place.

Copra dries according to the maturity of the nuts, the less matured taking a longer time. Copra that is found to have dried sufficiently should not be subjected to further heat especially in the kiln. Coolies, for the sake of convenience, do not sort out the dry from the undried but keep the heat going till all the copra is dried. This should not be permitted.

YIELD.—The average yield on a well-cultivated estate is about 50 nuts per tree, though in some estates as much as 75 nuts are sometimes obtained. On cultivated estates between 900 and 1,200 nuts go to make a candy of copra.

EXTRACTS FROM A PAPER BY MR. M. KELWAY BAMBER, GOVERNMENT AGRICULTURAL CHEMIST.

Before dealing with the treatment and manuring of the coconut palm it is perhaps advisable to briefly consider the various types of soil and the climatic conditions under which it thrives. In most tropical countries the palm is found to grow most luxuriantly near the sea coast where the contour of the land is generally flat, and where it is exposed to the effect of salt sea-breezes during some period of the year. It grows best within a few degrees north and south of the equator In several countries, including Ceylon, its growth has extended inland many miles from the sea, and it is now grown over large areas at elevations up to 1,600 ft. on soil totally different, both physically and and chemically, to those found on the sea coast. In the Maldives and South Sea Coral Island the coconut thrives on almost pure coral lime; while in Ceylon, it is generally grown on sands varying from pure white, as seen in and around Colombo and Batticaloa, to dark grey reddish sands of the Chilaw and other districts. Further inland it is also frequently grown on alluvial banks of rivers where it does well, and is also grown on cabooky soils which form the rising ground in most of the low-country plantations. In the Malay States the palm flourishes on deep alluvial soil varying from coarse sands to finely divided siliceous silts almost of the consistency of clay, and of exceptional richness in plant food and with a rainfall of 65 to 80 inches. Some of these soils contain from 8 to 55 times as much nitrogen as Ceylon sandy soils and 10 to 60 times more potash. In some instances the growth is even more rapid when there is a layer of jungle mould over the silt deposits. In the West Indies, Brazil and Central America it grows chiefly along the coast; and in the former, healthy palms are said to average 100 nuts annually.

The climate of the coconut districts varies in different parts of the island. From Colombo to Chilaw and thence to Puttalam the rainfall gradually decreases from 72·5 inches in Colombo to 45·2 inches in Puttalam. The heaviest rainfall is in the North-East monsoon from October to December, with a fair amount in April and May, the rest of the year being more or less dry, though rain falls every month. From Colombo to Galle the rainfall is generally heavier (82 to 90 inches) and better distributed throughout the year. Inland at Veyangoda and Kurunegala the rainfall is about the same as in Colombo and is fairly well distributed. In Jaffna, the rainfall is only 49 inches the greater part of this falling between October and December, June to September being practically dry. In Batticaloa the average is about 62 inches with a long dry period from February to September and a wet N.-E. from October to January. The sandy soils of Ceylon are usually found near the sea coast, but they also occur in the low-lying portions of slightly undulating estates for many miles inland, and are formed by the breaking down of the cabooky soils, the finer clay being washed away to the rivers and sea, and the sand collecting when the downward flow of water is temporarily checked. The cinnamon soils, consisting of almost pure white sand, are the poorest, and contain little available plant food; and although coconuts will grow in them, they will hardly yield remunerative crops until heavily cultivated and manured. The yellow grey and reddish sands are usually a little richer in plant food, but even these may be classed as poor from a chemical point of view; and it is remarkable, in many instances, how good yields are obtainable from such soils. They consist of 93 per cent of sand and only contain 0·311 per cent of plant food altogether. Some of these soils are too poor even to grow grass for grazing purposes, and it is only by the enormous root development of the coconut palm through a large area that it can obtain sufficient nutriment for a healthy leaf growth and fruit production. The Maldive coral soils consist of about 90 per cent carbonate of lime and are particularly rich in phosphoric acid, and in some cases in potash. It has been estimated by Lepine and others that a thirty-year old coconut palm forms 2,240 pounds, or one ton, of organic matter during that period of growth, and absorbs from the soil from 228 pounds to 320 pounds of ash or mineral matter, consisting chiefly of potash salts, phosphate of lime and other lime salts, with a small proportion of sodium chloride and silica. The average composition of the ash of the whole tree is approximately, salt

22·77, potash salts 132·00, phosphate of lime 92·00, carbonate and sulphate of lime 61·50 lb. and silica 13·20 lbs. The greater proportion (or about 56 per cent.) of the potash and phosphate of lime is to be found in the leaves. Most of this is returned to the soil when the leaves drop off, and it shows the importance of utilising the mineral matter in the fallen leaves to the best advantage. A young palm about five years old was analysed at my Laboratory and the analyses of the various parts were very similar to those made by others. A feature of the analysis was the large amount of silica in the leaves, root and stem, especially the two former, the silica amounting to 36 and 56 per cent, respectively. On carefully burning a portion of the leaf a skeleton of every cell was obtained consisting chiefly of this silica. This shows that the roots of the coconut palm are able to attack the silica of the sandy soils more than most other plants. Lime is an important constituent both in the leaves and stem, and to a less extent the root, while potash is chiefly in the leaves and stem and phosphoric acid fairly evenly distributed throughout. Another constituent that is generally present in fairly large amount is sulphuric acid, so that the Calcium Sulphate in superphosphates and the sulphuric acid in sulphate of potash no doubt add to the value of these manures. Much of the potash, but little of the phosphate of lime, is to be found in the immature fallen nuts and there again the advisability of utilizing them as manure either before or after burning is indicated. The amount of mineral matter estimated to be removed from the soil by one acre of coconut palms annually at 62 palms per acre is said to be salt 52 lb., potash salts 321, phosphate of lime 194, carbonate and sulphate of lime 140, Magnesia 2, silica 28, equal to 737 lb. The leaves and fallen fruits remove most, viz.—370 and 250 lb. respectively, while the trunk utilises 70 lb. and the remainder 47 lb. These figures show the importance of including a good proportion of lime, potash and phosphoric acid in a manure mixture even for the growth of the palm, especially, if the soils are deficient in these constituents. But it must be remembered at the same time that the coconut palm roots penetrate through several feet of soil, so that a comparatively poor analysis may still mean a very large amount of plant food. A foot of sandy soil over one acre weighs about 4,200,000 lb. and this increases with greater depth by about 7 per cent per foot, so that at 4 ft. it would weigh over 5,000,000 lb. and the total 4 ft. of soil about 18,480,000 lb :—

1st foot	...	4,200,000 lb.
2nd ,,	...	4,480,000 ,,
3rd ,,	...	4,760,000 ,,
4th ,,	...	5,040,000 ,,
	Total...	18,480,000 lb.

Taking an average poor sandy soil as containing 0·22 per cent. lime, 0·014 per cent potash, 0·03 per cent phosphoric acid and 0·04 per cent nitrogen, such a soil would contain to a depth of 4 ft. (and many roots go much deeper) the following amounts of essential plant constituents, though not in readily available form :—

Lime	... ...	40,656 lb.
Potash	... ...	2,5'7 ,,
Phosphoric acid	... ...	5,800 ,,
Nitrogen	... ...	7,400 ,,

Were all these constituents available, no manuring would, of course, be required, but they can only be released from their insoluble combinations by gradual decomposition with the aid of air, moisture and dissolved gases, chiefly carbonic acid. At the same time there would only be sufficient potash for about 16 years, and phosphoric acid for about 65 years, were it not for the return of the leaf ash to the soil annually. But apart from the composition of the palm itself the question of its remunerative cropping has to be considered. Several comparative analyses of the nut and the husk have been made by Lepine, Bachoffen, Rideau and others, and the following may perhaps be taken as an approximate average:—

Husk	... .	53·0 per cent
Shell	... ...	12·6 ,,
Copra	... ...	18·5 ,,
Water	... ...	13·5 ,,

The chief ash constituents of the husk, amounting to 1·63 per cent. are Salt 46 per cent., Potash 30·7 per cent., Lime 4·14 per cent , Phos. Acid 1·92 and Silica 8·2 per cent. The large amount of salt and potash in the husk is noticeable and would point to their value as manure. Copra ash amounts to 1·70 to 2 per cent. of the weight of dried copra and consists chiefly of phosphate of potash, potassium chloride, sodium chloride, and a small amount of lime, while sulphuric acid is unusually high. A candy of copra would contain about 10 lb. of ash consisting of 5·27 lb. of potash, 2·03 lb. of phosphoric acid, 0·87 lb. of sulphuric acid, 0·50 lb. of salt, so that an average crop of 50 nuts per palm, giving say 3 candies of copra per acre, would remove from the estate nearly 16 lb. of phosphoric acid and about 11·7 lb. of nitrogen, the nitrogen content of copra being about 0·7 per cent.

To replace this in manure would require an application of a mixture some-what as follows applied every other year :—

Sulphate of potash	... ...	32 lb.
Bone meal	... ...	27 ,,
Groundnut cake	... ..	167 ,,
		226 lb.

—or say 3 1/5 lb. per palm.

To apply such a small quantity to large or old plants would, however, be absurd and there would be little visible effect on the palms. It has been found in practice that at least 4 or 5 times this amount, or say 12 lb. to 16 lb. per palm is required to render manuring profitable. It is very evident, however, that manuring as carried out at present must gradually and steadily result in an accumulation of plant food in the soil if full use is made of the dropping fronds, immature nuts, etc. This again, however, depends on the character of the soil and the type of manure applied, and increase in reserve food would, as a rule, be more marked in retentive loamy soils or the common cabooky soils than in the deep sands which have little retentive power either for moisture or the soluble constituents of manure. The question of the use of soluble or insoluble manures on the latter class of soils is an important one, and experiments are being conducted to prove their respective values. It must be remembered that the root system of the coconut palm is different from ordinary trees, consisting as it does of a thick carrot-shaped bole at the foot of the stem from which as many as 2,000 roots start and penetrate the soil in every direction, the roots themselves branching at nearly right angles at varying distances from the stem or bole. Most of the roots, if uninjured, run for many feet and absorption of the soluble plant food takes place at the extremities of the main root or the smaller branches. The tip of the root, unlike many other roots, is devoid of fine hairs through which absorption usually takes place; but the extremity, for about half to one inch, consists of soft and easily injured tissue with a central group of fibrovascular bundles: behind this soft extremity the tissue rapidly becomes tough and fibrous. When cut through, the cut surface dries and shrivels, and new rootlets spring at right angles to the original, so that any temporary injury arising from ploughing or cutting circular trenches round the palms, when applying manure, is soon remedied. The idea that the cutting of the roots by digging or ploughing is harmful, is, I think, a mistaken one, though it should not be done at the beginning of the dry weather. By occasional disturbance of the surface soil the roots are driven downwards, so that the palms are less affected by drought.

The wide dissemination of the roots throughout the soil would seem to point to the advisability of applying a soluble manure over a fairly wide area, commencing at some distance from the trunk, which when dissolved by the rain would soak into the soil around the root extremities, and be carried downwards and upwards through the soil as the weather was wet or fine.

As in sandy soils there is little retentiveness for chemical salts and at the same time the formation of leaf and flower stalks is practically continuous throughout the year, it would also appear desirable to apply small quantities at frequent intervals in order to obtain the best return for the manure, rather than larger application every second year. On the other hand the good effect of tying cattle to the trees an occasional fortnight in the year, would tend to show that the soluble salts are retained and the effect is more prolonged than the nature of the soil would lead one to expect, the beneficial result being chiefly due to the urine and soluble matters in the manure which soak into the soil.

That the coconut palm appreciates a continuous supply of readily available plant food is shown from the manner in which they flourish and crop heavily close to cooly lines or cooly houses.

So far the general practice has been to apply a practically insoluble mixture (except for the potash salts) consisting of castor or groundnut cake, bone meal or basic slag, and kainit and other potash salts frequently with 20 to 30 lb. of cattle manure in addition when available. Such a manure is applied every second year.

The results generally are satisfactory and have resulted in generally increased yields, especially after the second application, showing that insoluble phosphates, etc., can be easily utilised by the coconut palm. Mr. Rajapakse's results on one estate show an increase from 38,670 nuts in 1900 to 161,648 nuts in 1907. Still it remains to be seen whether frequent small applications of concentrated soluble manures would not give more rapid and equally satisfactory result than a large application of an insoluble manure every two years. The result so far obtained at Peradeniya on old palms rather point to this conclusion. A good deal of the first application of manures goes rather to increase the general vigour of the palm than to increase the crop, and for this reason it is advisable to make the first mixture rather more nitrogenous, though if a good proportion of phosphates are also given the crop should also improve.

Manuring is usually done by digging circular shallow trenches round the palms, forking the manure into the trench and covering with soil. The distance of the trench from the palm varies, some putting the manure at 3 to 4 feet or even closer, and others up to 10 to 12 feet.

It is generally believed that most absorbent rootlets are to be found where the drip of rain water from the leaves would fall on the soil. In the case of the coconut palm much of the rain that falls on the top upright leaves is directed inwards to the crown and runs down the stem. As a constant supply of moisture is essential for the solution of the manure, and most of the absorption is from the root extremities about 8 feet to 12 feet would be the best distance for large well-grown palms. For young palms and those of stunted growth a closer application is advisable, from 3 to 4 feet, gradually increasing the distance as the palms increase in vigour and the spread of leaf becomes greater. An experiment with a 7-year old palm with a large proportion of upright leaves showed that 97 per cent. of the rain ran down the stem, 9·3 per cent. from 2 feet and 2·7 per cent. from 8 to 12 feet from the stem.

For the improvement of a backward estate which has been more or less neglected for years, it is advisable before manuring thoroughly to plough or cultivate the whole soil, or large circles round the palms, burning all refuse, dead leaves, etc., and spreading the ash over the loosened soil. A few months later, when the palms have begun to form fresh rootlets, manure should be applied in six-inch deep trenches at 3 to 6 feet from the stems and forked in with any decaying weeds, cheddy or available organic matter, and the trench filled with soil.

All coconut husks and newly-fallen leaves should be laid over this forked area to retain moisture round the manure and so encourage root growth into it.

On most estates the amount of organic matter available for mulching purposes is comparatively small, and humus can only be added in quantity by growing a green manure. For this purpose there are several suitable plants including two or three varieties of Tephrosia and Crotalaria. The Tephrosias commonly found in the low-country and grown on several estates are *Tephrosia purpurea* (Pila) with straight and narrow pods, and another variety with curved hairy pods, also a creeping variety which is to be found in the North-Central Province. Either of these grow freely, forming small bushy plants about 18 in. high, the leaves being very rich in nitrogen containing about 2·5 per cent on the dry material. As a rule the seed can be collected with very little trouble and expense. An important variety is *Tephrosia candida*, which is larger and more robust, giving as much as 40 to 50 tons of green material annually for 3 or 4 years. It grows well on rubber and tea estates, and is now being tried on the sandy and cabooky soils of coconut estates. *Crotalaria striata* and *incana*, also *Cajanus indicus* or the Pigeon-pea are also very useful, the latter supplying a certain amount of fodder for cattle and an edible grain.

Such green manures should be sown in from 2 to 5 feet wide rows between the palms, and when 4 to 5 feet high, the plants should be cut across at 15 in. and the material mulched over the forked ring where the manure is to be applied and dug in with the manure. The leguminous green manures average 0·86 per cent. of nitrogen on the fresh plant, a ton containing 19½ lb. of nitrogen. Many tons can be grown per acre.

A well-grown green manure should supply far more nitrogen than the palms require annually; but while growing they absorb a large amount of mineral matter, especially lime, potash and phosphoric acid, from the soil and therefore are competing with the palms. This is given back when the green material decays and reverts to humus, but it is advisable to apply additional phosphoric acid and potash when a green manure is being grown. They should also be cut across early in the dry season and the material mulched to prevent too much moisture being absorbed or evaporated from the soil.

The effect of green manures is permanently to improve the soil conditions for bacterial growth, and to enhance the effect of artifical manures by increasing the humus and water retaining power of the soil. On sloping soils they also greatly assist in preventing wash of surface soil.

Good drainage is essential for all soils, but the presence of ample moisture is of more importance even than manure, as no amount of the latter can counteract the immediate and after effects of a long drought. It is estimated that a well-grown palm transpires through the leaves about 2,235 gallons or practically 10 tons annually; allowing for 70 palms per acre, this equals about 700 tons, or the equivalent of 7 inches of rainfall per acre. Every planter knows the heavy fall of immature nuts that succeeds a drought, especially after the first shower of rain, and the loss in crop that results.

Any practical means of preventing this loss by irrigation, dry farming and increasing the humus would materially increase the yields per acre. Irrigation is, in many cases, out of the question, but much may be done by dry farming and increasing the humus. In Peradeniya experiments, ploughing the soil twice annually had a very marked effect on the old palms and the younger palms were also greatly benefited by stirring the soil monthly with a disc harrow. At Maha-illuppalama in the dry zone the effect is even more marked, the growth of the palm being very fine as the rerults of the cultivation with disc harrows. These latter experiments have demonstrated the value of irrigable land in the North-Central Province for coconut cultivation and shows that far less water is required than for paddy, when a thorough system of surface cultivation is adopted.

In all the districts where rainfall is deficient stirring the surface soi. should be done at the beginning of the dry weather to form a loose mulch, which will prevent evaporation of subsoil moisture. This together with mulching of the manured rings will greatly assist the palm in withstanding drought, but the treatment must be continued over several years.

Much useful work has already been done in the manuring of coconuts by private owners and others, and the manure merchants have greatly assisted proprietors by excellent booklets published on the composition and value of certain manures, and the result of manuring already obtained. It is unnecessary to enumerate all the manures that are now available for coconut cultivation, as most of them are well known, but a few words as to their properties and suitability for various soils may be advisable.

The chief phosphatic manures employed are bones, steamed or ground, basic slag and superphosphates. Steamed and ordinary bones contain at least 3 per cent. nitrogen and 22 per cent. phosphoric acid, equal to 48 per cent. phosphate of lime. They decompose slowly in the soil, but the successful results obtained from their use show that coconut roots attack them rapidly. There is no fear of loss of phosphoric acid by their use.

Basic slag has no nitrogen, but contains 15·20 per cent. of free lime and 16 to 20 per cent. of phosphoric acid in a form easily available to the palms.

It can be used with advantage in soils poor in lime and phosphoric acid, especially in conjunction with green manuring. On pure sands without green manures, the lime would be better applied as ground coral lime.

Superphosphate consists of bone or other phosphates which have been treated with sulphuric acid to render the phosphoric acid soluble. Ordinary superphosphate contains no nitrogen, but 18 per cent. of phosphoric acid and a good proportion of sulphate of lime, which, as I have said, may be of special value to the growth of the palm. It is suitable for application to all the soils; but when poor in lime, they should receive an application of ground or slaked coral lime previous to the manuring.

Of the potash salts, the muriate contains 58 per cent. pure potash compared with 50 per cent. in the sulphate, both costing the same. For soils poor in sulphuric acid, and most of them are, the sulphate is probably better. It is slowly soluble in water and after rain would soon be diffused throughout the soil.

Kainit is another potash salt frequently employed. It contains only 12 per cent. potash but a considerable amount of salt and some magnesium salts. These are very hygroscopic and are thought to assist in absorption of atmospheric moisture during a dry period. A pound of potash costs 50 per cent. more than the potash in the muriate or sulphate.

If mixed with basic slag as is commonly done, it should be applied at once, or kept in a dry place; otherwise the slag will set like cement and be rendered useless.

Nitrogenous manures consist of the organic manures such as cakes, blood, and fish and for this reason are valuable on soils poor in humus. The nitrogen is insoluble in water, but as the manures decompose, it is gradually converted into ammonia and nitric acid which combines with lime and can then be absorbed by the roots, chiefly as nitrate of lime.

The cost of nitrogen per pound varies and has risen considerably in recent years. It now costs 75 cents per lb. in nitrolim and sulphate of ammonia, but from one rupee and over in cakes.

Blood meals contain from 11 to 12½ per cent of nitrogen and are more rapidly decomposed than cakes, but the pound of nitrogen now costs Rs. 1·12 compared with Rs. 1·30 in castor cake.

The nitrates are all very soluble in water and have to be used with caution. They should not be applied during or just before the wet season; otherwise some loss is bound to result, but a certain amount can frequently be employed in mixtures with advantage. The cheapest source of nitrogen available at present is in nitrolim, which is a manure formed from the nitrogen of the air. It contains from 20 to 24 per cent. of free lime and 18 per cent. of nitrogen, and has a strongly alkaline reaction like basic slag, making it very suitable for acid soils. It has been very successfully employed for tea and rubber. For coconuts there is no reason why it should not be equally valuable especially on estates where green manuring is carried out systematically. It cannot be used in mixtures containing blood meal or ammonia salts, unless added just before application.

I have not gone into the details of various mixtures suitable for manures, as so much depends on the soil, local climatic conditions and the condition of the palms, when manuring is to be undertaken. Manuring may not always be necessary. and in some cases would be distinctly wasteful unless efficient drainage and cultivation of the soil is done prior to the application.

The main points to be borne in mind when manuring coconuts are first to apply a manure suitable to the soil requirements, and of a composition that will encourage a healthy and vigorous leaf and root development. Then when this is accomplished to apply a manure richer in potash and phosphoric acid to further encourage fruit production and of a superior quality. Thirdly to apply the manure at sufficiently short intervals to insure continuous growth and minimise the effect of drought on yield and quality of the nut. Samples of copra from manured and unmanured palms have been shown me which clearly demonstrate the beneficial effects of manure on the appearance and thickness of the meat and no doubt oil contents.

No trees respond more to proper manuring than the coconut palm, especially in the younger stages, but even palms of 70 to 80 years of age will respond as shown by the result of the Peradeniya experiments which have now been conducted for three and half years.

The chief difficulty to be overcome in the improvement of such old palms, of which there must be many thousands of acres in Ceylon, is to enable them to retain the large proportion of nuts, which form as the result of the manuring or cultivation, but which fall at all stages from an inch in diameter to nearly half-grown, but chiefly in the younger stages. The average yield of ripe nuts from the manured and unmanured plots when the experiments began were :—

			1911	1912	1913
Manured	...	...	26·8	33 0	30·0
Unmanured	...	...	27·4	24·2	23·0

while the immature nuts were for the same period :—

			1911	1912	1913
Manured	...	...	23·5	41·6	49·0
Unmanured	...	...	36·3	42·4	45·7

Had it been possible for the palms to retain these nuts, or even half of them, the result would have been very satisfactory. It is probable that careful supporting of the flowering stalks would have saved many.

An encouraging feature in these experiments, especially for the smaller cultivators who cannot easily afford expensive manures, is that ploughing or digging or the growth of leguminous plants with the aid of the cheaper mineral manures such as basic slag and potash, or mulching with any weeds or cheddy, all have a good effect on the palms, and increase the yield considerably. Such treatment is within the reach of every one, and should well repay the extra trouble and slight expense incurred.

Mr. Petch has shown that on coconut trees examined at Peradeniya the fertilisation of one inflorescence by another on the same tree would only be possible when a new inflorescence appears within 30 days of the former one and that this only occurs in May, September and October, which are usually the most active growing periods in Ceylon and the tropics generally. The duration of the period that the female flowers are opening depends on the number on the inflorescence, 2 or 3 opening daily, but the individual female flower is only receptive for 24 hours or less, from 3 to 4 weeks after the opening of the inflorescence. It is possible that the larger crops in May-July are due to this overlapping and fertilisation on the same tree, but more probably to the increased vegetative activity at that period of the year.

A badly yieding tree, however, can be made to yield more heavily by cultivation and manuring, though whether the effect is to increase the number of female flowers on the newly forming inflorescence, or to cause more rapid floral production, within the 30 days necessary for fertilisation on the same tree, or the prevention of falling-off of immature nuts has still to be determined.

Little is yet known as to the effect of any of the principal manuring constituents, such as nitrogen, lime, potash and phosphoric acid on the formation of a larger proportion of female flowers on each flowering stalk, or whether moisture alone or in conjunction with one or more of these is the chief cause. The actual formation of the enbryo leaves and flowers in the growing apex of the palm must take place some months before they actually appear, and it is of importance to ascertain what are the determining factors.

The manuring experiments which are being carried out in different coconut districts should enable this and several other questions to be solved, but careful records for several years must be kept before definite conclusions can be drawn, except on points of actual manuring for crop, which should be available in 3 or 4 years.

Much has already been learned by practical experience from manuring experiments on a large scale conducted by Mr. A. E. Rajapakse and others and the thanks of all coconut planters are due to these gentlemen who have allowed their experiences to be published for the benefit of the community.

If similar data of the practical experience of coconut planters were collected and the results condensed for publication in their annual report, I am sure that the Agricultural Department would gladly assist in making the deductions.

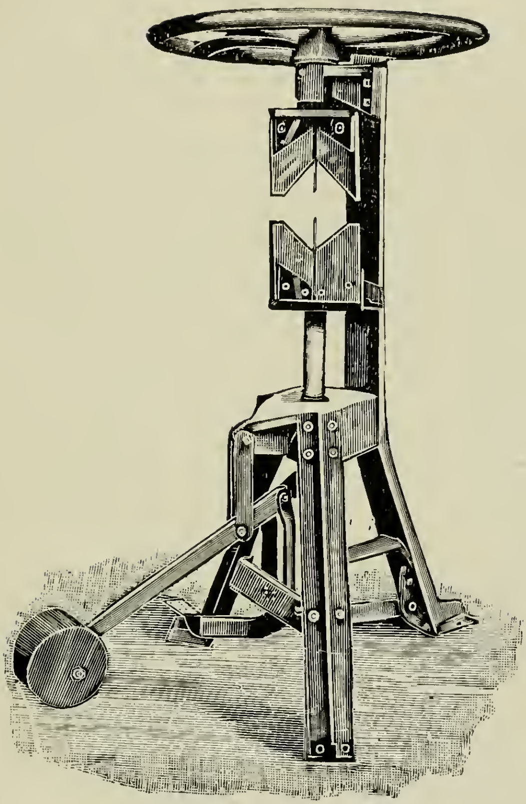
In starting any new experiments, it is important that each is made to determine one point only, and that dates, number of trees, climatic conditions and all factors likely to affect the result are carefully recorded.

EXTRACTS FROM A BROCHURE ON "THE PROPER CULTIVATION OF COCONUTS."

ISSUED BY THE COLOMBO COMMERCIAL COMPANY, LIMITED.

There are few crops which respond so readily to manuring and cultivation as coconuts, and every owner of coconut land should study the question of increasing his crop by the use of up-to-date methods. There are probably very few, if any, coconut estates in Ceylon which have reached anything like the state of efficiency in yield per acre that the modern tea estate has been brought to, and the number of estates which have made no progress at all towards a maximum yield is very great. The scientific cultivation of coconuts is, in fact, only just beginning, and those who will reap the greatest benefit from it will be those who are first in the field.

It is rather remarkable that the majority of coconut lands are situated in districts where the conditions of climate make good methods of cultivation essential for success, and yet we find that these estates are for the most part left entirely uncultivated. Even where cultivation is practised, it is done by haphazard methods which fall far short of perfection, and the results of which are a poor recompense for the labour involved. The contrast between the appearance of an average tea estate and that of the vast majority of coconut estates is very striking even to the casual observer. On the one hand we see neatness and order, a well organised and busy labour force, well-tilled land kept free from weeds, and healthy bushes giving their maximum yield; while on the other hand it is only too apparent that the coconut planter believes in leaving his estate alone. The trees are irregularly planted, and badly cared for. Many are scraggy and almost barren. The fronds shew ample evidence of the attacks of beetles, while many are drooping and discoloured, and worst of all, a thick carpet of grass is everywhere allowed to grow, and the surface of the soil is untouched by mammotie or fork from one year's end to another. The photograph on the opposite page shews a typical uncultivated coconut estate in Ceylon. Weeds and grass are growing in profusion, and the picture is a good example of what an estate should not look like. Were the tea planter to neglect his estate in the way that is usual with coconut planters the tea-planting industry would soon cease to exist, and although at the present time a profit can be made from coconuts without cultivation, yet modern methods will be adopted as time goes on and those who lag behind will find their profits disappear through the competition of their more intelligent and painstaking neighbours.



Husking Machine.

The nut is placed upright in the space and pinned down before the wheel is turned to make the sharp angular knives revolve and tear out the husk.

To face page 102.

In countries where fruit growing forms a regular industry cultivation of the fruit orchards is as much a matter of course as the ploughing of fields is to the farmer who grows crops of wheat and rice, or the planter who cultivates tobacco and cotton. In growing coconuts, or any other crop, the object is to obtain the greatest profit per acre. This means that the crop must be increased to the point at which a further increase costs more to produce than the extra crop fetches in the market. The main question then is, by what means can we increase our coconut crop.

Probably the first answer to this question that would occur to most people is "By the application of manure," and that is indeed an important means of increasing the crop. If manure be applied to any land it will increase the growth of whatever crop is on that land, and if there be several crops the benefit of the manure will be split up amongst them, those benefitting most whose roots come most completely into contact with it. This is a simple and common sense argument, and yet it is one which is very generally lost sight of, and manure is often applied in such a manner that the crop which it is intended to benefit is the very last which it reaches. Consideration of this brings us to a second very important operation which is itself a means of increasing our crop, and that is cultivation or tillage of the soil. It cannot be too much insisted on that manuring can only be carried out profitably if it is accompanied by cultivation.

The need for cultivation is, as has been already mentioned, particularly pressing in the coconut planting districts which are, for the most part, liable to long periods of drought, and where the soil is by nature unretentive of moisture. For the conservation of soil moisture is one of the chief aims of systematic cultivation, and the fact that the coconut tree needs abundance of moisture is seen by the heavy crops carried by trees whose roots have penetrated to the neighbourhood of wells. Such trees often shew a remarkable contrast to their neighbours whose roots do not extend so far, and the difference is entirely due to their best supply of moisture.

The Importance of Soil Moisture.

In spite of the heavy damage and loss of money often caused to coconut estates by drought the very great importance of the effect of the moisture in the soil on the crop is not generally recognised. This is partly due to the widespread root-systems which the trees possess, enabling them to draw moisture from a wide area and from great depths and to continue to live, although perhaps not to flourish, when the land appears everywhere dry and parched and when shallow-rooted plants like grass have long since died. But when we consider that not only can the roots absorb no food unless this food is dissolved in water, but also that there is a continual movement of water, called the transpiration current, from the roots to the leaves, where it is lost by evaporation, and further that if this transpiration current be not maintained the leaves droop and die, we begin to realise what a tremendous drain on the soil moisture growing crops are and how important it is to supply them with enough moisture.

This transpiration current has no visible effect because the water evaporated at the surface of the leaves goes off in the form of invisible vapour, and this accounts for the common failure to recognise that such a current exists.

The vigour of the transpiration current varies with different plants, they do not all transpire the same amount of water, but consideration of a few of the figures arrived at by similar experiments will convince one that in all cases the quantities of water withdrawn from the soil by this means are enormous.

For instance, measurements of the water transpired by a sun-flower plant 3½ feet high shew that 2 lbs. are transpired in 12 hours. An average crop of cabbages transpires 3 or 4 tons of water per acre every day. An average wheat crop transpires 750 tons of water per acre during its period of growth, while a single oak tree accounts for over 700 tons in a year. Of special importance is the figure of 3½ lbs. of water transpired by every square foot of grass land per day. Assuming that the grass were growing all the year round, the amount transpired by an acre in each year would reach the enormous total of over 24,000 tons.

With these figures before us, the importance of soil moisture and the necessity for husbanding it to the utmost becomes apparent, and every agriculturist should make himself acquainted with the various methods for preventing waste of water from his land.

How to Prevent Waste of Soil Moisture.

Before we can discuss this question we must understand how soils lose water by other means than by the transpiration of living plants just described. For practical purposes we may take it that all the water in a soil is derived from rain which falls on its surface. Part of this rain soaks into the soil and part runs off the surface without penetrating. If the surface is soft nearly all the rain soaks in, but very little penetrates through a hard surface. Since the water which runs off the surface is wasted we see already how we can prevent some waste by keeping the surface of the ground soft

The rain which soaks into the ground sinks down through the small spaces between the soil particles until it either reaches the underground water level, or runs into a drain and is carried away. As the surface of the ground dries after rain the moisture in the lower layers rises to the top in the same manner as oil rises in a lamp-wick by the capillary action of the very small holes, or pores, with which it is crowded. This suckling up of the water from below will go on until the whole of the water in the soil has reached the surface and dried off into the air, and we have then a condition of drought. If we can break the connections between the tiny pores of the soil, we can stop this upward flow of water. This breakage is very easily brought about by cultivation. All that is needed is that the surface layer of soil should be kept in a loose and granular condition so that there are large air spaces between the particles. The water cannot rise through large air spaces, with the result that although the loose surface becomes dry the rise of water from the soil below is stopped and no more water is lost by evaporation. Many people believe that by keeping the surface of the ground hard and well stamped down the soil moisture is prevented from escaping, as though stamping the ground were equivalent to locking the door of the soil, but the truth is just the opposite. By pressing the earth hard, the particles are brought very close together, the tiny pores in each lump are made to join those in the next and a continuous channel of small pores is made for the water to rise in and reach the surface, and once it reaches the surface the sun and wind soon dry it off and it is lost. It is only by separating the soil particles and thus breaking the channels leading to the surface that the escape of moisture is prevented.

Now we see that a loose surface does good in two ways. It allows rain water to soak easily into the soil instead of running off at the surface and it prevents this rain water being sucked up again and lost by drying in the sun and wind.

Other methods of preventing evaporation of soil moisture are also practised. By spreading a layer of any loose material, such as straw, leaves, prunings, etc., we get the same effect as if we have a layer of loose earth. The moisture rises to the surface of the ground, but cannot rise through the large air spaces of the straw or other loose material, and so is not lost by evaporation. This practice is known as mulching, and although at times very useful it is not so effective as a layer of loose earth.

Coconut husks can be usefully employed as a mulch round newly planted trees. Young trees are more sensitive than old ones to lack of moisture owing to their less extensive root development, and it is a good plan to cover the ground around them to a distance of 3 or 4 feet with husks placed close together. They must, however, be carefully laid so as to cover the ground completely, and any grass or weeds which grow up between them must be at once removed.

Any method which shades the surface of the ground reduces the amount of evaporation, and for this reason shade crops are often grown to protect the surface of the ground until the roots of the main crop have grown to some depth and are not so dependent on the moisture near the surface. In considering the use of shade crops, however, one important fact is very often lost sight of, and that is the loss of water which results from the transpiration of these crops. We have already seen what enormous quantities of water are transpired by growing crops, and although they shade the ground and lessen evaporation from the surface directly beneath them it must never be forgotten that they are at the same time pumping large quantities of water out of the soil, often from a considerable distance, and may be more than undoing by this means the good they do by their shade. If, however, the action of these shade crops be properly understood they can often be usefully employed. The principle which should govern their use is that they should not be allowed to grow continuously, and never throughout the dry season. A crop of low spreading habit should be chosen giving the maximum amount of shade to the surface of the ground. It should be planted during the rains and should be a quick-growing crop, which reaches maturity in a few weeks. Soon after the end of the rainy season or as soon as a good cover is obtained it should be cut or up-rooted and allowed to lie as a mulch on the surface of the ground all through the dry weather. At the beginning of the next rainy season it should be dug into the ground as completely as possible, and a fresh crop planted for the following dry weather. Unless this procedure can be followed, and strictly followed, it is much better to leave such crops alone and rely on cultivation to prevent loss of moisture.

Remember that a cut crop makes a good mulch, but a growing one a bad mulch.

This brings us to the question of the effects of allowing grass to grow around coconut or other fruit trees.

The Evil Effects of Grass.

It has already been noted that growing grass causes a loss of water from the soil corresponding to many thousands of tons per annum from every acre. If the grass is grown for the sake of its own crop, as in land kept for pasture, this loss is unavoidable, and must simply be reckoned with as the requirement of a grass crop for moisture. But, if there is another crop upon the land, as in the case of a coconut estate, the great disadvantage of such a waste of soil moisture is at once apparent. The coconut tree needs abundance of moisture, and is usually planted on sandy lands, which are liable to long periods of drought. Under these circumstances, the practice of allowing a grass crop to pump thousands of tons of useful water out of the soil is the height of folly.

Besides the injury growing grass causes by abstracting large quantities of water from the soil, serious harm is done in another way. It has been found that some substance is formed by the roots of growing grass which is astually poisonous to plant life. This subject is being investigated at the Duke of Bedford's Experimental Fruit Farm in Herefordshire, England, and many interesting results have already been published. The conclusion come to by the experimenters is that growing grass round a tree is nearly the worst treatment to which it can be subjected.

The trees on the plot where the grass was allowed to grow lost their leaves and looked very unhealthy compared with those which were kept clean-weeded. In another experiment a clear space was kept within six feet around each tree, grass being allowed to grow outside of this space. It was found that as soon as the roots grew long enough to reach to the growing grass the tree began to shew signs of injury and could only be restored to health by removing the grass as the roots extended. This result proves that it is not sufficient to keep a clean space around each tree; the whole surface must be kept free from grass so that the extending roots may nowhere come across a grassed area. The impossibility of applying manures to the trees when they are surrounded by grass is a further objection to its being allowed to grow. Manure applied under these conditions acts mainly as a fertiliser for the grass, and only a small portion of it reaches the roots of the coconut tree. Even if a trench is dug for the manure and is kept free from grass this manure loses a great deal of its value by being applied in such a small space, for it comes into contact with only a few of the roots of the tree.

From every point of view, then, the coconut planter should look upon grass round his trees as his greatest enemy; it steals moisture, steals manure and poisons the land.

The common objection to clean cultivation is that the grass is required for cattle feeding. A little reflection will shew how short-sighted this policy is. The coconut crop is much more valuable than the grass crop, and therefore the attention of the owner should be directed first of all towards obtaining the maximum yield of coconuts. We have seen that this maximum yield cannot be obtained if grass is allowed to grow on the land, and it is certainly not sound business to sacrifice valuable coconuts for the sake of much less valuable grass. The large number of useless cattle which are kept on coconut estates is one of the chief obstacles in the way of progress in this important branch of agriculture. It is altogether wrong to look upon coconut land as pasture ground for cattle, more especially for cattle which serve no useful purpose. No more cattle should be kept on an estate than are needed to work it, and this number does not exceed, for carting purposes, two pairs of bulls for every hundred acres of land in bearing. If modern methods of cultivation by means of ploughs or harrows are employed we may add one extra pair, giving a total of 6 head of cattle as ample for all requirements. If these are allowed to feed on the grass growing around the trees, they will probably need as much as 20 acres to support them, whereas if they were grazed on good pasture land they would get all the grass they need from 6 acres, while if their grass feed were supplemented by poonac, even a less acreage of pasture would suffice for their support. On an estate of 100 acres, therefore, not more than 6 acres of good pasture land are required, and this land should be set aside and cultivated for this purpose. There is no need to cut down the coconut trees; all that is required is to cultivate these 6 acres to give a maximum grass crop, the coconuts being considered a secondary crop and left to take care of themselves, while the remaining 94 acres are kept entirely free from grass and cultivated for a maximum crop of coconuts.

Before considering the subject of manuring, mention may be made of one other method by which loss of soil water can be diminished. The capacity of the soil for holding moisture can be increased by increasing the amount of organic matter it contains. By organic matter is meant chiefly the decaying remains of vegetation such as accumulate in the soil of a jungle. Soils which are rich in this material hold much more moisture after rain than do open sandy soils, and by digging quantities of vegetable matter into sandy soils they are gradually made more able to hold the water which falls on them as rain instead of allowing it to sink through them beyond the reach of roots. Cattle manure acts in much the same way, and does much to improve the water-holding capacity of sandy soils.

The Use of Manure.

The purpose of manuring is to supply the growing crop with the food it requires. This food is present in all soils, but, as everyone knows, soils vary in quality. Some are rich and bear heavy crops, others are poor and produce meagre stunted vegetation; and when this poorness is due to lack of plant-food they can be improved by applications of manure.

The plant-foods which it is necessary to apply as manure are only three in number, namely Nitrogen, Phosphoric Acid, and Potash, but these three substances can be used in a great many different forms.

That is to say, there are a great many different manures which can be used and they contain different quantities of these foods. Just as soils are of different qualities so are manures, some are rich and some are poor, and it is important to realise that the value of a manure depends very largely on the amount of plant-food it contains. For instance, 100 lbs. of castor cake contain 5 lbs. of nitrogen, while 100 lbs. of sulphate of ammonia contain 20 lbs. and for this reason sulphate of ammonia is much more valuable as a manure than castor cake.

When buying a mixed manure, a common mistake is to consider only the price per ton and to imagine that 10 lbs. of a mixture which cost Rs. 80 per ton, will be of the same value as a fertiliser as 10 lbs. of another mixture which costs Rs. 120 per ton. The real state of matters is that 15 lbs. would be required of the cheap mixture to supply the same amount of plant food as 10 lbs. of the more expensive one, and that more money would have to be spent on rail freight, and other transport charges, because a larger quantity of manure would have to be handled. Generally speaking, a rich manure at a high price per ton is the cheapest in the end, because less of it has to be used. It is the cost per tree which should be looked at, not the cost per ton.

It is not proposed to discuss the theory of the action of manure in this pamphlet, and it will be sufficient for our purpose to state in general terms that the effect of nitrogen is to encourage the growth of the green parts of a plant, that is, the leaves and young shoots; phosphoric acid is chiefly concerned with the production of fruit and seeds; while potash is necessary for the growth of the woody portions, such as stem and bark. All three are required if a healthy tree is to be produced, but different trees require them in different proportions. Sometimes the soil is rich enough to supply the tree with all that it requires, but often one or other has to be added in the form of manure to bring the food in the soil to the proportions needed by the tree.

The proportions which are best for the coconut tree vary, therefore to some extent according to the richness of the soil, but in most cases the differences in soils are so slight that one general coconut mixture is suitable for all.

The following are good proportions for a general coconut mixture:—

Every 100 lbs. of mixture should contain

4½ lbs. nitrogen.
7 lbs. phosphoric acid.
5½ lbs. potash.

The choice of ingredients to be used in making up the mixture depends on many things, and a full discussion of them would be a lengthy matter. It will be enough here to note that the mixture should not be made entirely of rich artificial manures, but should contain some slow-acting bulky material such as poonac or fish. Bone meal or steamed bone meal is a good ingredient on most soils and supplies a large amount of phosphoric acid, while nitrate of potash or soda acts quickly and is a good stimulant for sickly trees. A judicious mixture of materials such as these arranged so that 100 lbs. of the mixture contain the quantities stated above can be safely used as a good all-round coconut manure. The quantity to be applied per tree is a question on which a good deal of misunderstanding exists. There seems to be a very general idea that 15 lbs. per tree is the proper dose for full grown trees, but after what has been said on the variation in the richness of different manures it will be seen that it is quite incorrect to say that 15 lbs. should be applied in every case. It depends on the richness of the mixture. 15 lbs. of castor cake would do very little good, while 15 lbs. of sulphate of ammonia might do a great deal of harm.

If the proportions stated on the previous page are used, then 10 lbs. per tree should be applied to trees in bearing, but this is only correct for those proportions. For young trees the dose should be less, starting with about half a pound the first year after planting, and increasing gradually year by year up to 10 lbs.

The Use of Cattle Manure.

As was mentioned before, cattle manure is of great value in sandy soils for increasing their power of holding moisture after rain. It is in this improvement in the texture of the soil that the value of cattle manure chiefly lies. It also supplies nitrogen, phosphoric acid, and potash, but the quantities it contains are small compared with other manures, and it consists mainly of a large bulk of decaying organic matter which adds to a sandy soil just what it lacks in this respect.

Cattle manure is of universal application, and there are few soils, in Ceylon at least, which would not be benefitted by it. Its action as a fertiliser tends towards promoting leaf growth, for it contains more nitrogen than it does phosphoric acid or potash, and for this reason it should not be used in large quantities if the soil is rich. Too much nitrogen delays the ripening of the fruit.

In the case of most sandy coconut soils, however, it would be almost impossible to apply too much cattle manure, and the difficulty generally is that sufficient cannot be got. Where more is needed than can be obtained it is much better to apply what you have in heavy doses to a small number of trees than to spread it over the whole estate. The driest and sandiest parts of the soil need it most, and the trees with yellowish drooping leaves will respond to it best. It should be applied at the rate of not less than 10 baskets per tree, and even 20 baskets would not be too much in many cases. By choosing the worst parts of the estate, and the most needy trees and continuing with them for a year or two they will be gradually improved, and the applications of cattle manure can afterwards be extended to other portions until the whole estate is brought into good condition. The improvement will be much more marked and more rapid in this way than if small doses of the cattle manure were given to all the trees.

The Storing of Cattle Manure.

After the proofs which have been given above of the injury done to trees by growing grass it should not be necessary to add much on the subject of tethering cattle to coconut trees. This is only done on slovenly, ill-kept estates, and when the grass is removed the practice cannot be continued. It is at best a wasteful way of applying manure. In a tropical climate a very large proportion of the manure is lost if it is left to lie on the surface, and what little does find its way into the soil comes in contact with only a very few roots. If it is to be economically used it should be collected and stored until sufficient is obtained to enable it to be applied in heavy doses as described above.

It should be kept under cover on a cement or hard mud floor, well pressed down whenever a fresh lot is added to the heap, and covered from time to time by a layer of dry earth. This is a cheap and effective way of preventing loss, and the manure can readily be dug out as required.

The Use of Wood Ashes.

Wood ashes make a very useful addition to cattle manure, but like the latter, can seldom be obtained in large enough quanties for application to the whole estate. Their value lies chiefly in the potash they contain, but they also contain a little phosphoric acid and so are well suited to supplement cattle manure. When wood ashes can be had they should be mixed with cattle manure at the rate of about 2 parts of ashes to 1 part of manure at the time of application, or they may be added to the heap in the manure shed from time to time before the layer of dry earth is placed upon it, and the mixture dug out as required.

The Use of Lime.

Lime is what is called an indirect fertiliser. It is not itself a plant food, but it brings about chemical changes in the soil by which plant-food is produced. Potash in particular is formed in this way and the effect of liming is often the same as if potash salts had been applied.

Lime has also a good effect on the texture of sandy soils. It cements the small particles together and makes the soil less open and porous and therefore not so apt to lose all its moisture after rain. Its action is slow and the treatment is only required at intervals of several years. All sandy coconut lands should, however, be limed at least once in five years.

Lime can be bought in two forms, quicklime and slaked lime. As a general rule slaked lime is to be preferred for coconuts. The question of the proper amount per acre is quite different in this case from the case of fertilisers. The lime is wanted not as a fertiliser but as an improver of the soil texture and the dose is to be reckoned in tons per acre rather than pounds. At least one half ton per acre of slaked lime should be given for the first dose. Later doses may be modified according to results.

The Use of Salt.

There is a common belief that because the coconut tree thrives on the sea-coast it needs salt to make it produce its best crops. This seems probable, but is nevertheless untrue. The good growth of coconut near the sea-shore is the result of their need of abundance of light and air and is not due to any need for common salt. Common salt is not a plant-food, but like lime it has an indirect fertilising action. It has the power of setting free potash from its compounds in the soil that a plant can make use of it, but it is not the common salt that the plant feeds on. The coconut tree is able to live in a soil containing larger quantities of common salt than would be healthy for many other plants, but the salt is not in any way a necessity. Just as good crops are got from trees growing far inland and far from the influence of the salt of the sea as are got from trees on the coast, and moreover it is only those few trees whose roots extend below high-water mark that come into contact with salt water at all. The direction of flow of soil water is from the land to the sea and not vice-versa, and the influence of the saltness of the sea extends only a short way inland.

On certain soils rich in potash minerals, applications of common salt may give profitable returns, but it is not to be recommended for general use. Long continued applications have a bad effect on the texture of the soil and by exhausting it of its natural store of potash they leave it in the end in worse condition than it was before treatment.

The Use of Kainit.

Kainit is often recommended as a fertiliser for coconuts because of the common salt which it contains, but from the above paragraph it will be clear that the common salt is only of use indirectly. Kainit is an impure salt of potash and its value depends chiefly on the amount of potash it contains. At present it is sold under a guarantee of 12 per cent. of potash, and at a price of Rs. 60 per ton. Sulphate of potash contains 50 per cent. of potash and is sold at Rs. 185/- per ton, and is therefore really cheaper than Kainit. For suppose we wished to apply 10 lbs. of potash to our soil, we would have to use 83 lbs. 5¼ ozs. of Kainit which would cost Rs. 2.23 whereas by using sulphate of potash we would only require 20 lbs. costing Rs. 1.65.

Kainit has an additional value, however, as a safeguard against insect pests and fungus. A liberal dressing of Kainit applied to germinating nuts or young coconut plants which are attacked by white ants, for instance, is often an effectual cure. For this purpose it should be applied at the rate of not less than half a pound per plant.

How to Apply Manure.

When it is remembered that the coconut tree absorbs food by means of its roots and that the absorbent roots are the youngest portions, there will be no difficulty in understanding the best method of applying manure. The object of the application is to bring the manure into contact with as many of the young feeding roots as possible. These roots extend practically equally in all directions round the stem, and cover a larger and larger area as the tree grows older. When the tree is just planted, or in its first year, the roots extended only a little way, and if manure is applied it need only be put in a circle measuring about one foot or eighteen inches in width round the plant. As the tree increases in size its roots reach farther and farther out from the tree, and the circle must be increased in size year by year. After two or three years the oldest portions of root near the stem become thick, woody, and non-absorbent, and when that stage is reached the manure need not be applied close to the stem. The application should then begin about one foot from the stem and continue in a circular band as far out as the roots art found to penetrate. Later on it will be noticed that the roots from one row of trees have extended so far that they are intermingled with those from the next row, and that therefore the whole planted area is penetrated by roots, and when this occurs, it is obvious that the manure must be applied over the whole planted area and not merely round each tree. This is best done by broadcasting the mixture between the rows so that it falls evenly over the whole space, but not within two feet of the stems. If the direction is changed at each manuring, first up and down the rows and next time across them, the whole area will be evenly fertilised, the roots will grow symmetrically and the tree will be strong and healthy.

After the manure has been broadcasted it must be dug into the soil with mammotie, fork or plough. It need not be deeply buried. If the whole surface is gone over with a mammotie or fork the manure will be quite sufficiently covered.

It will now be seen that the common plan of applying manure in a circular trench around each tree is open to many objections. It provides for only very poor distribution of the manure, for it only brings it into contact with a very limited number of roots, many of which are not feeding roots; in cutting the trenching, a great number of the oldest roots are severed, and, while new roots will be produced near the cut, yet the main root growth will not be encouraged and the tree will have to depend largely on these new roots for the absorption of its food. This means it will feed from a restricted area and be more liable to suffer from drought than a tree which has a vigorous root system extending to a great distance. It is, indeed, a slovenly method which is only upheld by those who are too indolent to do more than the minimum of work on their estate. Manure should be applied towards the end of the rainy season, before the rains have entirely ceased, and if broad-casted, this should be done when there is no wind. The early morning is generally a suitable time. Trees should be manured every year, and the same remarks as have been applied to the subject of cattle manure apply also to general manuring. It is much better to manure a few trees well than the whole estate badly. If money is scarce and the whole estate cannot be manured with its proper dose do not spread the manure over all the trees in small quantities. Apply the proper dose to part of the estate even if it be only to one acre to begin with. Persevere with this one acre until the profit from the extra crop enables more manure to be bought and a larger area to be treated. In this way you enhance the value of your property year by year, whereas by haphazard and inadequate doses applied to all the trees and at irregular intervals, the same money might be spent and only a small increase in crop obtained.

Soil Analysis as a Guide to Manuring.

A good deal of useful information can often be obtained by soil analysis. Some soils are less suited to bone meal than to basic slag, for instance; others respond better to sulphate of ammonia than to nitrate of soda or potash; while others, again, having a big reserve store of potash, may give their best returns after applications of lime or of kainit. Points such as these are important and can only be settled by chemical examination, and it is advisable, before starting manuring, to submit a sample of the soil for analysis.

Select portions of the estate at different spots where the soil is uniform in appearance and represents a fairly large area. At each point dig a hole 18 inches deep and having one vertical face. From this face, cut a slice of soil from top to bottom and place it in a box or sack. Mix all the slices together thoroughly and send a portion of about 10 lbs. for anlysis.

The Uses of Cultivation.

It has been pointed out that one of the main objects of cultivation is the preservation of soil moisture and it is also evident that manuring can only be properly done and the manure brought into contact with all the roots when the whole area is cultivated and not merely a circle round each tree. Another important result of cultivation is that air is by this means allowed to enter the soil freely. Air is necessary for the growth of the multitudes of bacteria which exist in the soil and which perform many duties in the way of bringing different plant foods into the condition in which they can be used. The nitrifying bacteria, for instance, produce nitrates from other nitrogen compounds, and until these compounds are converted into nitrates few plants can use them. These nitrifying organisms can only live in presence of air, and a well aerated soil contains many more than a compact and badly cultivated soil. It has been found in laboratory experiments that 25 times as much nitrate is formed in soils which have been stirred as in those left undisturbed. Besides this, air is directly necessary to growing roots. A good example of the need of roots for air is seen on turning out the soil from a flower-pot in which ferns or other plants have been growing for some time; a felted mass of roots is found lining the inside surface of the pot, having grown there in profusion as the result of the air which enters through the pores of the earthenware. Plants cannot be grown in pure clay, the soil particles are so fine and become so closely compacted that no air can enter, the roots cannot develop and the plants soon wither and die.

It is evident, however, that the amount of cultivation which a soil needs depends on its texture. Thus the pure clay just mentioned could be made to support plant life if it were possible to keep it constantly stirred, while lighter soils would succeed with much less stirring; and so, in general, heavy clay soils need more cultivation than light sandy soils. A good deal of attention is being paid at the present time in Ceylon to what is called dry-farming. By this is meant the cultivation, without irrigation, of lands where the rainfall is insufficient to support heavy crops without special methods. The principles of dry-farming are neither more or less than the principles which should govern all farming, namely the proper conservation of soil moisture by cultivation so that the maximum amount is available for the crop at the time when it is most needed.

A soil to be in the best condition should resemble a moist sponge. It should be able to draw up moisture from great depths by capillary attraction to the region where the growing roots are, and should be covered by a layer of loose surface soil which prevents that moisture from being lost by evaporation.

In the case of heavy, or even moderately heavy soils the matter is comparatively simple, and the danger of over-cultivation is not great; but in very loose, sandy soils, such as are often planted with coconuts near the seashore, the case is different. Such soils suffer more from rain water draining out of them beyond the reach of the roots than by surface evaporation. They are often so coarse-grained as to have little power of holding moisture or of drawing it up from below by capillary action, and injudicious cultivation in these cases may do harm. It must not be thought that cultivation during dry weather is for any other purpose than preventing surface evaporation; it is not at this time for aerating the soil nor for promoting the decomposition of the soil minerals, it is purely and simply to preserve that loose layer of surface soil which is essential to the prevention of loss of moisture. That being so, it need only be done when the surface shews signs of becoming hard, and it should only be done to the least depth which is found to produce good results and always to the same depth, not deeper one time than another.

If the soil needs aerating, or if the decomposition of its minerals or organic matter needs hastening, this should be done by deep cultivation at the beginning of the rainy season, never during dry weather. In heavy clay soils this deep cultivation is necessary, but sandy soils are usually very well aerated and seldom need deep cultivation, and it is very important that the dry weather cultivation of these should be shallow, not more than 3 inches deep. It should be done immediately the dry weather sets in, and should only be repeated when the surface shews signs of becoming hard. This is also true of clay soils, and all other soils. The surface must be kept loose all through the dry season, but in sandy soils it will remain so much longer without attention than it will in more compact soils. Although the soil in sandy estates should not be disturbed during the dry season more often than is necessary to keep the surface loose, this must not be taken to mean that grass or weeds should be allowed to grow. It is during the dry weather that these do the greatest harm, and the estate must be kept free from them at all times.

Mechanical Cultivators.

One striking difference between tropical agriculture and that of temperate climates is that in the former the land is permanently covered by the crop, whereas in the latter the crops are for the most part annual crops which are cleared from the land each year. The permanent nature of tropical crops makes it less easy to make use of machines for carrying out the operations of cultivation than is the case in countries where the fields are harvested and freshly planted every year. Land under coconuts, however, gives less trouble in the use of such machines than any other permanent crop in the tropics. It is nearly always level land, or only gently undulating; it is very seldom rocky; the trees are sufficiently wide apart to make it easy to drive a cultivator between them; there are no low-hanging branches to get in the way; and finally, should any part of the cultivator come into accidental contact with a tree in passing, practically no damage is done, certainly much less than would follow a similar bruise to a rubber tree, for instance. There is no doubt that it is only a matter of time until mechanical cultivators are used as freely on coconut estates in the tropics as they are at present on fruit orchards in California and elsewhere, and there is no object in delaying their introduction. By their use the labour on the estate is reduced to a minimum, while the efficiency of the cultivation is very greatly increased. Many forms of cultivator are to be had, and many of them are very suitable for use under coconuts. For loose sandy soils, the lightest disc harrow should be used, while for clayey soils a heavier grub harrow or even a plough would be more useful. One requirement which they must fulfil is that they must be easily adjustable to work at different depths. With one of these machines in use, the general system of working the estate should be as follows:—

When the ground softens with the first rains the cultivator should be set to work at a depth of about 6 inches and driven between the rows of trees, up one row and down the next. Afterwards it must be run in the same way across the rows, so that no part of the ground is left untouched, and at this operation it should be driven as close to the trees as possible. This opens up the grounds and allows rain water to soak in easily.

Towards the end of the rains, when only light showers may be expected, the manure should be put out. From the amount to be applied per tree and the number of trees per acre the dose per acre is calculated and that quantity spread broadcast on the surface up and down and across the rows, but it should not be scattered nearer than 2 feet from the stems of full-grown trees. After the application the cultivator is again run over the ground, working to the same depth as before.

Of course if the land is such that it becomes swampy during the rains and remains so for some time afterwards, the application of manure must be delayed until it has dried sufficiently. Manure should not be put out on wet swampy land.

If lime is to be applied it should be done in exactly the same way a week before the application of manure.

The ground should now be left until the dry weather sets in, but should be regularly weeded by hand as often as is necessary. During the dry weather, the amount of cultivations to be given depends on the texture of the soil. Very loose soils like the sandy lands of many coconut estates may be injured by being disturbed during dry weather, for there is so little capillary action in coarse-grained sands that water does not readily rise in them from below. In such cases disturbance of the surface soil is not required to break the capillary connection with the subsoil, because that connection is already largely broken by the coarseness of the particles, and there is a danger that any stirring of the surface dries it out more completely and admits the sun's rays and the drying action of wind to the lower layers also where the moisture is most needed.

But, just as soon as the surface shews signs of becoming hard and compact then cultivation is needed and the cultivator should be run over the ground whenever these signs appear. It should be set to work to a depth of not more than 3 inches and need not be driven across the rows each time, but up and down the first time and across the second, up and down the third, and so on. In the case of clay soils this may have to be done four or five times during the dry season, while in sandy soils once or twice may be sufficient. There should be no difficulty in deciding on the amount of dry weather cultivation which is necessary when it is remembered that we want the water to rise from the depths of the soil to the level of the roots of our coconut trees and for that purpose the soil at these levels should be fairly compact and fine-grained, but we do not want it to rise above the level of the roots, and for that purpose the surface must be kept loose so that the capillary connection is broken.

If no mechanical cultivators are used, the same system of cultivation must be carried out by hand. The ground must be well mammotied at the beginning of the rains, the manure put out towards the end by broadcasting, and the whole area gone over again with mammoties or digging forks to cover the manure. As often as is necessary to keep the surface loose during the dry weather a very light forking must be carried out, and all weeds and grass must be systematically uprooted as soon as they appear.

Conclusion.

There is no doubt that surprising results will be got before long from well cultivated and manured estates. When we see occasional trees in native gardens, which are unwittingly manured by the owner's household refuse and the dung of his domestic animals, bearing crops of 300 or 400 nuts we begin to realise that the possibilities before this branch of agriculture are enormous. There is no reason why crops of 200 or more nuts per tree should not be obtained over large areas. It has often been demonstrated that the tree is capable of bearing such crops and it only needs care and the application of up-to-date and common-sense methods of cultivation and manuring to ensure success.

Remember that grass-grown estates will never give the highest yields, and do not sacrifice your crop for the sake of third-rate pasture for useless cattle. Clean-weed the whole estate and manure every year.

Coconut Picking.

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CHAPTERS BY "TRENT VALE."

SOME OF THE SPECIAL FEATURES AND REQUIREMENTS OF THE COCONUT PALM.

THE ROOTS.

The roots of plants perform two functions. Firstly, they fix the plant in the soil and provide a support upon which the stem, branches and foliage are raised, and secondly, they absorb from the soil nitrogen and the mineral plant-foods which form an essential part of the diet of plants.

So far as these functions themselves are concerned the roots of the coconut palm do not differ from those of any other ordinarily cultivated plant, but as regards the manner in which these functions are carried out the coconut palm is in a class entirely by itself.

Consider first the purely mechanical function performed by roots, the fixing of the plant to the soil. The roots of ordinarily cultivated plants, such as rice, tea, grass, rubber and so forth, develop either upon the "tap" or the "fibrous" system; that is to say the roots grow down into the soil either in the form of one or more large main stems which give off secondary and tertiary branches at varying intervals, or else the roots grow out from the base of the plant in a more or less dense mass of fine fibres. The coconut palm develops its roots upon neither of these systems. From the base of the palm radiate, in the case of a full-grown healthy specimen, several thousands of long strand-like roots which are remarkably uniform in diameter, being a little thicker than a pencil and not quite so thick as one's little finger. These roots develop outwards from the palm in almost straight lines, shewing very little tendency to twist or turn in any other direction. They never go very deep into the soil; in ordinary land the huge majority of them will be found within the first two feet of soil. The length to which they ultimately develop is largely governed by the nature of the soil and the amount of cultivation which is carried out. In heavy "Cabooky" land these roots may not be more than twelve to fifteen feet in length, while in lighter soil they may easily reach outwards for a distance of twenty-five feet.

These long main roots may bear as many as twenty branches or they may have none at all. As a general rule the branch-roots are not more than three or four feet in length and they possess a marked tendency to grow out at right angles from the parent roots. The branch-roots may themselves bear smaller branches not more than a few inches in length and these again sometimes give off still tinier shoots, the number and extent of these sub-divisions being greater in firm soil than in light sands.

The construction of all these roots is the same. On the outside is a hard and rigid shell, called the hypodermis, whilst down the centre of every root runs an exceedingly strong pith in the form of a cable. The rigid hypodermis is admirably suited to withstand a bending strain.: whilst the cable-like pith will resist an immense tension. These two devices, in conjunction with the fact that all sub-divisions of the roots grow out at wide angles to the branch which bears them, constitute a most perfect form of anchorage which enables the palm to stand up against the fiercest storms to which it may be subjected.

So much for the mechanical functions performed by the roots: now for that which is concerned with the absorption of nitrogen and mineral plant foods.

The outstanding difference between the roots of the coconut palm and those of other crops is that the former bear no root-hairs. At the extremity of each sub-division of the roots of the coconut palm is a dark coloured conical object known as a "root cap" which is composed of tough woody fibres and is for the purpose of protecting the tender growth-point of the root as it forces its way through the soil. Immediately behind the root cap, for a distance of not more than two inches in the case of the main roots and of only a fraction of an inch in the case of the root-branches, is an area of soft tissue through which the plant-food is absorbed. Behind this area of soft tissue and right back to the base of the palm the long strands of roots are sheathed in their casing of hypodermis which is quite impervious to weather. At frequent intervals along the root-strands are found curious small white projections which are special breathing organs for the purpose of admitting air into the roots, but no plant-food whatever can gain entrance to the palm except through the soft-walled tissue at the extremity of each main strand and of each sub-division.

These facts relating to the structure and growth of the roots of the coconut palm are of the utmost importance to us when we come to consider the questions of cultivation and manuring.

In Ceylon the most usual number of palms grown per acre is in the neighbourhood of seventy, that is to say the palms are about twenty-four feet apart. Now from the fact that the roots of each palm extend outwards for a distance of fifteen to twenty-five feet it follows that the entire area of the soil of an estate of full-grown palms is enmeshed in a network of roots. And from the fact that the primary roots give off secondary and tertiary branches at some distance from the parent palm it follows that the soil midway between the palms will contain more roots, and more feeding extremities, than are to be found in any other position.

Obviously, therefore, it is this central area of soil midway between two rows of palms which should receive most attention in the shape of cultivation and manuring. On those estates which are kept clean-weeded the whole area of the land is cultivated at frequent intervals with the result that air is admitted to all portions of the roots and the solubility of the mineral plant-food is thereby increased uniformly throughout the estate. But where it is impracticable, owing to the lie of the land or the nature of the soil, to keep an estate clean-weeded, it is, far more often than not, just that area around the base of each palm, which necessarily contains the fewest root-extremities, which is cultivated and manured.

In other words air and plant-food are admitted to those portions of the roots which can make least use of them.

Now no planter should ever make a drastic change in his methods of planting until he has conclusively proved to himself that the change will be for the better. To those planters, therefore, who are in the habit of cultivating a small circle of land around each palm, the following suggestion is offered:—

Select a small area, say four rows of palms, on one of your estates. Plough up the land for a width of about eight or ten feet down the middle of each row and carry out all cultivations and apply all the manure to these central strips of land. Compare the crops obtained from the palms around which the soil has been cultivated in circles, and prove to your own satisfaction whether the new system is not better than the old.

How the Palm Feeds.

The coconut palm, like other plants, possesses two sets of organs through which it takes in food, namely, the roots and the leaves.

Considering first the method by which the roots absorb food, one of the most important points we have to remember is that only those food-stuffs which are dissolved in water can enter the roots of the palm. No solid particles of soil or of manure, no matter how minute they may be, can possibly effect an entrance into the roots. Every atom of food taken up from the soil has first to be dissolved in water before it can be consumed.

Moreover it must be remembered that water enters the palms through the roots only. Not a single drop of water can possibly find its way into the palm through the leaves, the crown, the cabbage, or indeed any portion of the palm except the roots.

The absorption of water through the roots of the palm is carried on most satisfactorily when the following conditions are fulfilled:—(1) a certain degree of warmth of the surrounding soil; (2) an adequate supply of fresh air; and (3) a suitable supply of water.

In the coconut-growing districts of Ceylon it is seldom indeed that the temperature of the soil ever falls below that point at which the absorption of water is checked, though this may occur occasionally in the case of badly-drained or water-logged areas. Neither is the temperature of the soil ever likely to rise too high. So far as concerns the soil temperature, therefore, Ceylon coconut planters are particularly fortunately situated; the natural conditions being favourable and satisfactory, the planter is not called upon to endeavour to modify them in any way.

But the same can by no means be said of the other two essential conditions, an adequate supply of air and of water.

In the absence of a proper supply of air the roots of the palms are unable to breathe, with the result that poisonous compounds are formed within them and the palms become unhealthy.

While all ordinary land plants require to breathe through their roots the coconut palm is one of the very few which actually develops special organs designed solely for the purpose of enabling its roots to breathe. These organs take the form of small, hard white projections which appear at irregular intervals along the root strands. The very fact that the palm puts forth these special breathing organs is sufficient indication of the necessity for an adequate supply of air to the roots.

While every planter in the world is perfectly well aware that a supply of water is essential to all forms of animal and vegetable life, the huge quantity of water required for the perfect development and growth of the coconut palm may possibly come as something of a surprise to those who have not made a special study of the subject. A very fair idea of what the requirements of the palm really amount to can be formed by a consideration of the fact that more than half the total weight of a fully grown palm, including the roots, stem, branches and leaves, is made up of nothing more nor less than water. In other words, suppose the total weight of the palm amounts to 2,000 lbs., then approximately 1,200 lbs. are composed purely and simply of water. Moreover, for every single pound of dry matter of which the palm is composed some 400 to 500 pounds of water require to be absorbed into the roots, passed up the stem and finally evaporated off into the atmosphere from the surface of the leaves! These elementary facts are in themselves sufficiently impressive to bring it home to all of us that by far the most important duty the coconut planter has to perform is that of ensuring an adequate and constant supply of water to the palms.

The water which enters the roots of the palm is not pure; it contains dissolved within it small quantities of nitrogen and mineral plant-food, such as phosphoric acid, iron, magnesium, etc., extracted from the soil. But the water which is evaporated off from the leaves of the palm is perfectly pure.

Nothing but absolutely pure water is allowed to escape from the surface of the leaves. All the various salts which entered the roots dissolved in the water are thus retained in the palm, and that is how the palm feeds.

It has frequently been shown by chemical analysis that the top few feet of all ordinary soils contain many thousands of pounds of all the different food-stuffs necessary to plants, more than sufficient for the requirements of a very large number of crops, and yet it is a matter of common experience that additional food-stuffs in the form of manure have to be applied to the soil before satisfactory crop growth can be assured. The explanation of this is that the huge bulk of the plant-food contained in the soil is in an insoluble condition. It cannot be dissolved in water and therefore the plant is incapable of absorbing it.

Now there are a variety of ways by which we can help to render soluble the plant-food contained in the soil, the most important of which is by means of cultivation.

By cultivation we admit air into the soil and we break down the lumps of earth and so expose a larger surface to the action of the air. What that action is may not be generally appreciated, but it can be very simply illustrated by considering the action of air upon a piece of iron, such as a knife blade or a plough-share. Even a few hours' exposure to the damp air is sufficient to cover such pieces of iron with a coating of rust, which means that the oxygen of the air has combined with the iron to form an entirely different substance, rust, or iron oxide as it is called by the chemist.

Every particle of soil exposed to the air is subjected to this same action of "rusting" or "oxidation," and by this means large quantities of insoluble plant-food are oxidised into different substances which can be dissolved in water and which are therefore of use to the palm.

Various natural agencies are also at work assisting to render soluble the plant-food in the soil, one of the most important of which is a gas called carbon-dioxide. This gas is brought down from the atmosphere dissolved in rainwater; it is also exuded from the root of plants as a result of their breathing process and it is given off from decaying vegetable matter in the soil. When dissolved in water it has the effect of making it a much more powerful solvent than pure water, and in this way larger quantities of plant-food are taken into solution.

THE FUNCTION OF THE LEAVES.

Three separate and distinct functions are carried out by the leaves of the coconut palm, viz., Transpiration, Respiration and Carbon Absorption.

Transpiration is concerned with getting rid of the huge quantities of water absorbed by the roots. This is effected by evaporating the water from the surface of the leaves into the atmosphere in the form of vapour or steam.

The water absorbed by the roots contains dissolved in it various substances which are essential for the nutrition of the palm; and between the root-ends, where the water enters, and the leaves, where the bulk of it escapes into the air, there is a continuous upward movement of a stream of water through the roots, stem and branches of the palm, and by this means the substances dissolved in the water are carried up to the leaves where they are left and utilized, only pure water being allowed to escape in the process of transpiration.

The practical importance of this process lies in the fact that the speed of transpiration governs the amount of plant-food absorbed by the roots. If transpiration is checked then the upward flow of water stops and the roots cease to absorb plant-food, whereas if transpiration is encouraged and hastened then the upwards flow of water moves more quickly and the roots absorb water and plant-food more vigorously.

The chief factors which affect transpiration are the following:—

1. The intensity of the light to which the palm is exposed.

2. The dampness of the surrounding atmosphere.

3. The amount of water in the soil and the quantity and nature of the substances dissolved in it.

The brighter the light to which the palm is exposed the greater will be the transpiration. It has been estimated that transpiration is at least a hundred times as great in bright sunshine as it is in the dark.

Even a light haze obscuring the sun will reduce transpiration by as much as twenty-five per cent., while a cloud heavy enough to conceal the sun will cut it down to about a quarter of what it is in direct sunlight.

All shade has, of course, the same effect. It makes no difference whether it comes from a cloud or a mountain or some shade tree or from another palm which is planted too close. Every leaf or part of a leaf which is in the shade has its transpiration cut down to about a quarter of what it might be, and therefore it gets only a quarter of the food it might get from the soil.

The palm itself does its best to obtain for each of its leaves the maximum amount of direct sunlight. Although to a casual observer the leaves may appear to be without any regular arrangement upon the palm, careful inspection shews that they are distributed on the stem in a very definite order. They radiate outwards from the stem like the spokes of a wheel at perfectly regular intervals, the obvious design being that each leaf should shade those below it to the least possible extent.

This is the experience of the low yield of nuts obtained from those estates on which the palms are planted too closely. The soil may be fertile, the cultivation good and the water supply abundant, and in spite of all these favourable conditions the yield in nuts will be small and will remain small so long as the palms continue to shade each other.

2. When the atmosphere is saturated with moisture as on a close damp day, transpiration is almost entirely stopped. The air being already thoroughly soaked it refuses to take up additional moisture from the vegetation.

On the other hand a dry atmosphere leads to a very considerable transpiration, which frequently becomes excessive, particularly in the case of young and delicate plants which have not had time to develop large root systems. Such plants as these require to be protected by shade so as to check transpiration, otherwise they very soon wilt and die.

3. A decrease in the amount of water in the soil reduces transpiration. Up to a certain point transpiration increases with an increase in the amount of water, but as soon as the soil becomes in any way water-logged the process is very severely checked.

Transpiration is also checked when the soil-water contains excessively large amounts of substances dissolved in it. It has also been found that plants which have taken up large quantities of common salt transpire less than those which have no access to this substance; and that while potash, soda and ammonia increase transpiration, acids tends to decrease it.

Respiration or breathing is carried on by all ordinary plants and is as necessary for their existence as it is for the existence of animals.

In ordinary practice those parts of a plant which are above ground obtain sufficient oxygen for all their requirements, but the roots of plants are often seriously injured through want of a suitable supply of fresh air in the soil. The unhealthy appearance of over-watered pot plants and of crops growing in badly-drained ground is primarily due to insufficient supply of oxygen to their roots.

Carbon Absorption

The leaves of plants absorb carbon from the atmosphere in the form of carbon dioxide gas, the carbon being retained in the leaves while the oxygen is released and passed back into the air.

This process of carbon-fixation can only be carried on in the presence of light. It ceases altogether during the night and in shady places is carried on so very slowly that the amount of carbon extracted from the atmosphere is often insufficient to supply the proper needs of the plant.

Similar partial starvation due to want of light occurs among thickly planted crops and in the inner boughs of trees bearing an excess of leaves, and in all cases of over-crowded plants. With an increased intensity of light carbon-fixation increases proportionately up to a maximum which for most plants is not attained until they are exposed to direct sunlight.

To Combat Drought.

In common with every other form of life the cocoanut palm demands a certain amount of water to enable it to live. If the water supply is entirely withheld the palm will die, whilst if the supply is cut down to a point below its normal requirements the palm will very soon begin to show signs of distress.

The roots are the first part of the cocoanut palm to be affected by drought.

When water is present in the soil there is at the extremity of each rootlet, a space between the root cap and the hard outer covering of the root, and through this portion is absorbed the solutions of nitrogen and mineral plant-food taken from the soil. In the largest roots this space is about two inches in length, while in the smallest it is only a fraction of an inch. As the roots extends in length it is followed by an equal extension of the hard hypodermis, and so the length of the absorbing area in each root is kept constant. But when the supply of water in the soil is reduced the roots cease to grow in length, whilst the hypodermis continues to extend towards the root cap. The absorbing area is thus reduced from day by day until, if the drought continues, it is entirely covered by the hypodermis and in its state no absorption whatever can take place.

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In this condition the root is valueless as an absorbing organ, but this does the palm no actual harm because an active root could absorb no water from a soil dry enough to bring about this condition. Of course, if every single one of the roots ceased to absorb the palm would naturally die, but this seldom if ever happens. The roots of a full-grown cocoanut palm spread out for a distance of fifteen to twenty-five feet in every direction, while some of them penetrate downwards for as much as four and five feet, and the soil would have to be extraordinarily dry if a few of these roots could not find a little moisture somewhere. Young supplies, however, up to three or four years old, which have a much more restricted root system, are frequently killed by the effect of prolonged drought upon absorbing areas of their roots.

The leaves of the palm are affected next by drought. The older leaves drop and hang down close to the stem, many of them wither and fall to the ground and no new ones are put forth.

Finally the nuts themselves are affected. Immature nuts in large numbers fall to the ground, whilst those which are retained on the palms remain small and shew no signs of development.

The soils most adversely affected by drought are the thin sands and the reason for this is because of the coarseness of the grains of rock of which they are composed. When rain fall upon sandy soil it meets with little resistance in its passage down the subsoil with the result that only a very small amount of water is retained in the upper layers of the soil where the roots of the palms can get at it. Moreover sandy soils have only a very small power of lifting water up from the subsoil by capillarity or, to use a more homely word, by soaking.

Capillarity is a difficult word with a very simple meaning and it is very important in connection with the supply of water to soils that it must be clearly understood.

If we spill a blob of ink on to a sheet of paper we can remove the greater portion of it by touching it with the edge of a piece of blotting paper. The ink runs up into the blotting paper under the influence of the force known as capillarity. Similarly, if we lower a lump of sugar on to the surface of a cup of tea the liquid will run up into the sugar and spread itself over the surface of each tiny grain of which the lump is composed.

Now suppose we had three lumps of sugar, one composed of very small fine grains, one composed of very large coarse grains, and the third made up of medium sized grains. If we lowered these one by one on to the surface of a cup of tea we should find that the liquid took a very long time to creep up to the top of the first lump, which was made up of very small grains, because it would have such a large number of grains to cover. When we came to experiment with the second lump, composed of very coarse grains, we should find that the tea would run quickly for a short distance up into the sugar, but then it would stop and it is doubtful if it would ever reach the top because large grains have so little lifting power. Finally, when we came to try the third lump we should find the tea moving easily and freely right up to the top of the sugar.

Exactly the same thing happens in the case of soils. The coarse grained lump of sugar represents sandy soils in which the particles of earth are large and coarse; the fine grained lump represents clay soils in which the particles are exceedingly minute; and the third lump represents medium loam soils. This is the explanation of the fact that sands suffer most when subjected to drought, heavy clay suffer nearly as badly, whilst the types of soil which are least affected by lack of rain are the medium loams.

Another force which acts upon the water in soils and which robs the palms to the most serious extent is that known as evaporation. This force is so familiar to us all that is scarcely requires explanation. It is under the influence of evaporation that the water which is brought up to the surface of the soil by capillarity is converted into vapour and passed into the atmosphere.

Now a brief consideration of the above notes will be sufficient to incidate to us that there are two main directions in which we can proceed to combat drought.

The first is, of course, by making good the natural deficiency in the water supply. If the seasons do not provide our palms with sufficient rain we must ourselves do what we can to augment the supply of moisture by irrigation or by any other means open to us.

Palms judiciously irrigated have nothing whatever to fear from drought, no matter how severe or how protracted the drought may be. If our estate is fortunately situated as regards the slope of the land and the supply of water, we have at once a means to hand by which we can defy the most arid of seasons. It is, of course, true that only a small proportion of Ceylon cocoanut estates are so situated as to permit of irrigation, but where it is possible to adopt this policy it should invariably be carried out.

Where irrigation is impossible we can water the palms by means of pumps or buckets and hand labour. This may seem an entirely hopeless and impracticable proposition to apply to an estate of a thousand acres, but as a matter of fact it is not nearly so difficult as it appears at first sight. In a very large proportion of the Ceylon coconut districts there is a permanent water table from six to eight feet below the surface of the soil. Immediately over this water table, particularly on the east coast side, there is a layer of extremely hard coral about two feet thick. Where such conditions as these prevail it is easily possible to break through the coral and open water-holes at intervals all over our estate. Once these holes are opened half a dozen small hand pumps and a few hundred feet of flexible tubing will work wonders in the way of saving our crops. This suggestion is open to all kinds of objections, but to a very large extent the objections are specious. The expense, the time and the trouble will all be amply repaid by the saving of many thousands of nuts and by obviating the set-back which the palms invariably suffer when subjected to a period of excessive drought from the effects of which it sometimes takes them several years to recover. When it is really impracticable to water the entire estate it is frequently a comparatively easy matter to water a portion of it, and it is obviously better to save half the crop than allow the whole to be destroyed. That this system is actually being carried out by a few of the more go-ahead planters is sufficient proof that it offers no insurmountable difficulties.

Another very useful system carried out in some districts is as follows:—A porous clay vessel of about two gallons capacity is buried up to its lip alongside each palm and filled with water. The water seeps through the sides of the "chatties" and so provides a certain amount of moisture to the palms, not nearly sufficient to satisfy their normal requirements, it's true, but still a little is better than none. (It might here be mentioned that the normal requirements of a full grown healthy palm are from 8 to 10 gallons of water per day.) The chatties themselves cost little and the labour required to replenish them is not very great.

The second direction in which we can proceed to combat drought is by preventing as far as possible the loss of the water which is already in soil. This we can do by suitable methods of cultivation and manuring, and while seeking the best system to adopt it must be borne in mind that our object is to encourage the process of capillarity, by which water is brought up from the subsoil, and at the same time to prevent evaporation, by which water is lost into the atmosphere.

Most of the salts which are used as artificial manures and are soluble in water increase capillarity in soils, hence an applcation of salt, nitrate of soda, or, to a lesser extent, kainit, will lift more moisture from the subsoil and thus maintain the top layer of soil in a moister condition. On the other hand solutions of those organic manures which contain a little oil decrease capillarity and bring about the burning of soils which is sometimes seen when such organic manures are applied late in the season and dry hot weather succeeds.

The judicious use of certain artificial manures is therefore indicated as our best means of encouraging the upward movement of water from the subsoil. But this upward movement must not be allowed to proceed too far. If the subsoil water is permitted to mount right up to the surface it will very soon be evaporated and lost into the atmosphere.

By far the best means of preventing evaporation is the constant stirring of the top two inches of soil by cultivation. This can be done cheaply and expeditiously by using the lightest of harrows since it is entirely unnecessary to cultivate or stir the lower layers of soil. All that is required is a mulch of loose earth to act as a kind of blanket separating the soil-moisture from the hot dry atmosphere. During periods of drought every head of draught-cattle on the estate should be employed all day and every day in drawing light harrows over the land and so keeping the top inch or two of soil loose and free. The benefits to be derived from this method of conserving the moisture in the soil can scarcely be exaggerated.

This system is, of course, applicable only to those estates which are kept clean weeded. Where grass is grown between the palms little can be done to save the soil moisture. The circles of bare earth around each palm should be constantly stirred by hand labour, and, if the grass between the palms is long, it should be cut and the hay left lying on the surface to shade the grass and so prevent, as far as possible, loss of moisture through transpiration. This shade should be supplemented wherever possible by means of leaves and husks spread out over the grass.

Generally speaking the soils and climate of Ceylon are peculiarly favourable to the growth of the coconut palm, but from time to time seasonal conditions are such that the palm will not flourish at its best. It is at such times as these that the skilful intervention of the experienced planter will make all the difference between a bad harvest and a good one.

Manuring.

Manures are generally made up of a mixture of three ingredients:— Nitrogen, Phosphoric Acid and Potash, and each of these ingredients has its own special action and effect upon the crop.

The principal effect of nitrogen upon the crop is to develop to a very marked degree the vegetative portions of the plant, *i.e.* the roots, stems and leaves.

It encourages deep rooting and the development of masses of fine feeding roots, for which reason its effects are lasting and permanent, since after the nitrogen has been completely absorbed the plant is left with a bigger and more active root system and consequently draws upon a larger area of soil for its food and water.

"A deficiency of nitrogen is seen in a general stunting of the whole development of the plant," says Sir A. D. Hall who also observes that: "On most cultivated soils upon which cropping is continued and manure withheld to a point when there begins to be a serious falling off in the yield through lack of plant food it is the want of available nitrogen rather than of phosphoric acid and potash which determines the yield. In other words the soil is much more rapidly exhausted of its available nitrogen than of its available phosphoric acid and potash."

Nitrogen starvation is manifested by a yellowing of the foliage, absence of growth and a poor, starved appearance generally. To plants in this unhappy condition an application of nitrogen has the immediate effect of changing the colour of the leaves to a rich dark green and encouraging the growth and development of all portions of the plant.

Phosphoric acid, like nitrogen, stimulates the development of roots, particularly in the case of young plants, but its principal effect upon the crop is to increase the flowering and fruiting tendencies and to hasten maturity.

The principal effect of potash upon plants is to assist in the process of extracting carbon from the carbon dioxide of the atmosphere. It also assists in the formation of fruit, particularly of those which contain sour juices.

Potash tends to prolong the life of plants and has a distinct effect in hardening the woody tissues of plants.

From a careful comparison of the effects of the three principal manurial substances it is obvious that the most important of the three, from the planter's point of view, is nitrogen.

In the first place, ordinary soils are more deficient in nitrogen than in any other kind of plant-food. Secondly, crops give a bigger return in response to an application of nitrogen than to any other form of manure. Thirdly, nitrogen is the most expensive substance applied to the soil as manure, for which reason it is obviously necessary to exercise the greatest care and judgment in the selection of the best form of nitrogen to apply.

Nitrogen can be applied in many different forms. Nitrate of Soda, Sulphate of Ammonia Dried Blood, Crushed Fish, Oil Cake, all supply this most important plant-food. The question at once arises therefore as to which form will give the best return.

Now there are three aspects to this question which must be most carefully considered in order to arrive at an absolutely reliable answer:—

First, there is the scientific aspect. In other words, what light has been thrown upon this question by scientific research? Secondly, what are the special peculiarities of Ceylon soils; and thirdly, what are the special requirements of the Coconut palm?

As regards scientific research this question has been the subject of most careful and accurate scientific investigation for scores of years past. Dr. J. G. Lipman and A. W. Blair have recently completed twenty years' work on this very point and their report read as follows:—

"Twenty years continuous investigation shew that Nitrate of Soda is the most effective in crop production, that is, the crop is able to utilise or win back a larger percentage of nitrogen in this form than in any other form. The average amount of nitrogen recovered in the crop, over twenty years, was:—

Nitrate of Soda	62·42%
Sulphate of Ammonia	47·48%
Dried Blood	36·89%
Farm Yard Manure	32·69%
Fish Manure	36·36%

Such is the result of twenty years' scientific experience. A searching, competitive examination carried out by trained observers who were animated solely by the desire to assist the world's agriculturists by answering this vitally important question.

Covering as it does a period of a fifth of a century this one investigation alone might be taken as definite and conclusive It would appear unnecessary to look for further proof in support of a fact already so well and truly established. Yet volumes of further proof are actually in existence.

Dr. E. B. Voorhees carried out experiments at the New Jersey Experimental Station over a period of ten consecutive years in order to determine what percentage of the nitrogen in the various manures was actually recovered in the crop. He reports as follows:—

Manure.		Nitrogen recovered in Crop.
Nitrate Nitrogen	(As in Nitrate of Soda) ...	62%
Ammonia ,,	(As in Ammonium Sulphate) ...	43%
Organic ,,	(As in Dried Blood) ...	40%

Thus was the twenty-year investigation of Lipman and Blair confirmed in every particular by the ten-year trial of Voorhees. But this is still by no means all.

Dr. Paul Wagner, working on this same problem in Darmstadt and other places in Germany, obtained the following results:—

MANURE.		NITROGEN RECOVERED IN CROP.
Nitrate Nitrogen.	(As in Nitrate of Soda) ...	62%
Ammonia ,,	(As in Ammonium Sulphate) ...	44%
Organic ,,	(As in Dried Blood) ...	40%

Here is a different scientist in a different country obtaining exactly the same results as Lipman, Blair and Voorhees. And it would be very easy to go on piling up proof after proof in further substantiation of the results already recorded, but let it suffice to quote one more:—

Dr. G. Smets of Liege, Belgium, taking Nitrate of Soda as a basis, established, after many years' investigation, the following comparative table shewing the relative amounts of nitrogen taken up by the crop from the different manures:—

Nitrate of Soda ...	100	Green Manure ...	65
Sulphate of Ammonia ...	75	Fish Manure ...	60
Nitrolim	69	Bone Meal	60
Dried Blood ...	65	Farm Yard Manure ...	40
Horn Shavings ...	65	Wool Waste ...	25
Oil Cake	65	Leather Waste ...	12

So much for the scientific aspect of this question! In every single investigation ever carried out Nitrate of Soda has invariably occupied the first and foremost position.

It should be observed that the above trials were carried out by scientists of such world-wide renown and unassailable integrity that it would be sheer folly to attempt to question their finding, more particularly as each result is confirmed by the independent researches of the others.

Moreover the trials were carried out on a multitude of different crops, in many different countries and under widely varying conditions. Each fertiliser was treated in exactly the same way, each had exactly the same chance of being absorbed by the roots of the crop or of being washed out of the soil by rain, and in every single instance Nitrate of Soda proved itself to be approximately 25 per cent. superior to the next best fertiliser!

* * * * *

Special soils demands special treatment. The chief peculiarities of Ceylon soils demanding special attention are lack of nitrogen and acidity.

The sickly pale green and yellow discolouration of the foliage together with the shrivelled appearance of the cabbage over many acres of Ceylon coconuts provide strong indications of nitrogen-starvation which can be only too readily confirmed by the chemical analysis of the soil.

That this deficiency can best be remedied by an application of Nitrate of Soda is proved beyond all question by the results of the scientific investigations given above.

The usual method of counteracting soil acidity is to apply lime, and it is probable that this substance would prove beneficial to many Ceylon estates. But on no account should a large dressing of lime be applied without first trying its effects on a small area of land. A far safer and more prudent method of procedure is to select manures of a non-acid or alkaline nature which will themselves neutralise soil acidity.

Nitrate of Soda is admirably suited to fulfill this purpose. Being an alkaline substance it has a marked effect in neutralising soil acidity and in so doing it sweetens the soil and makes it a more wholesome medium for the healthy development of roots.

* * * * *

As regards the special requirements of the Coconut palm it should be observed that it is the natural fruit of the palm which is harvested. Therefore, that mixture of manures which produces the largest yield of nuts and at the same time promotes the healthy development of the palm is obviously the best fitted to meet the special requirements of the crop.

Now Nitrate of Soda has been used in Ceylon for many years past to the extent of some thousands of tons per annum and a very large number of trials with Nitrate of Soda on Coconut have been carried out. The success of these trials can be seen by reference to the various text books written on the subject.

During the last few years a further series of scientific trials was commenced with a view to determining the exact nature and extent of the influence of Nitrate of Soda on Coconuts.

In 1919 the first of these trials was commenced on an estate in the Kurunegala district, A. S. Long Price, Esq., the well-known authority on Coconuts, very kindly undertaking to supervise the trial and to have accurate records kept.

A field of evenly grown palms, eight acres in extent, was selected and divided into two portions, A. and B., on each of which there were 231 palms in full bearing.

The object of the trials was simply to determine the effect on the yield of nuts brought about by the addition of a small quantity of Nitrate of Soda to the ordinary estate mixture.

The two blocks were manured as follows:—

		Block A. (Lbs. per palm)		Block B. (Lbs. per palm)
Crushed Fish	...	4·5	...	4·5
Bone Meal	...	3·0	...	3·0
Steamed Bone Meal	...	2·0	...	2·0
Superphospate	...	0·5	...	0·5
Nitrate of Potash	...	0·5	...	0·5
Nitrate of Soda	...	—	...	1·5
Total	...	10·5		12·0

The following is a certificated statement of the yields:—

1920.	1st picking	...	1,548 nuts.	1,717 nuts.
	2nd ,,	...	2,316 ,,	2,714 ,,
	3rd ,,	...	4,184 ,,	4,649 ,,
	4th ,,	...	4,865 ,,	4,871 ,,
	5th ,,	...	2,692 ,,	3,477 ,,
	6th ,,	...	2,161 ,,	2,192 ,,
1921.	1st ,,	...	1,214 ,,	1,557 ,,
	2nd ,,	...	2,188 ,,	2,874 ,,
	Total	...	21,168 nuts	24,051 nuts

Increase due to Nitrate of Soda:—2,883 nuts, or more than 12 nuts per palm.

It should be noted that this estate has been for years past in a very high state of cultivation—over this eight-acre field the yield averages more than 80 nuts per palm per annum, a fact which makes the magnificent performance of the Nitrate of Soda still more striking.

It is a common fallacy amongst many Coconut Planters that an application of manure to Coconuts will not increase the yield for considerably over a year, because it takes from twelve to fourteen months for the nuts to mature.

No greater mistake could be made.

In the case of every single trial carried out with Nitrate of Soda on Coconuts the yield has been increased in three to six months. A moment's consideration will shew how this is brought.

Lakhs of rupees are lost annually in Ceylon through the premature fall of young immature Coconuts. The fall of these nuts is caused by the weakness of the slender stalk which holds them to the spike; they are shaken off by the wind and pushed off by their more robust neighbours. Now one of the principal effects of nitrogen on plants is to strengthen and invigorate the vegetative portions, an effect which is easily noted in the increased development of root, stem, foliage and fruit which invariably follows an application of nitrogen.

Plants take up nitrogen from the soil in the form of Nitrates; from which it follows that the nitrogen in such manures as Sulphate of Ammonia, Crushed Fish, Bone Meal, etc., has first to be converted into Nitrates before being of any use to the crop.

In the case of Nitrate of Soda, the nitrogen is already in the form of Nitrates, no conversion is required: it is absorbed by the plant immediately after its application.

When applied to Coconuts its immediate effect is to invigorate all parts of the palm, including the vitally important stalks which hold the nuts to the spikes, and the nuts are thus retained on the palm instead of falling to the ground.

The simplest possible kind of trial will enable any planter to prove for himself the importance of this action of Nitrate of Soda. All he has to do is to select two acres of evenly grown palms, remove any young nuts which have alread fallen, apply a pound and a half of Nitrate of Soda to each palm on one acre, leaving the other acre undressed, and observe the results.

The diminution in the fall of immature nuts on the blocks to which Nitrate of Soda has been applied has been noted and remarked upon by the Superintendents of every single estate where trials have been carried out.

For the purpose of confirming the results of the trial detailed above an exactly similar trial was carried out in the Batticaloa district. In this case the block treated with Nitrate of Soda has yielded exactly ten per cent. more than the other. In addition to which the Superintendent reports:—"The block treated with Nitrate of Soda shewed a decided difference in colour and the heads looked greener and healthier than on the other block. Also I have noticed a difference in the falling off of immature nuts; the Nitrate of Soda block has hardly dropped a nut."

With a view to demonstrating the effect of Nitrate of Soda in bringing on young palms a further series of trials was commenced on an estate in Jaela. In this case it is not possible to quote figures because none of the palms have yet come into bearing. The following reports from the Colombo Agents and the Estate Proprietor, however, speak for themselves:—

From the Colombo Agents:—"The blocks treated with Nitrate of Soda is doing very well indeed. It is as good as any block with four any other plots even where a greater amount of ordinary mixture was applied."

From the Estate Proprietor:—"The block treated with Nitrate of Soda is doing very well indeed. It is as good as any block with four times the normal application of manure. The plot without Nitrate of Soda is not doing well."

* * * * •

The following mixture has been designed, in consultation with several leading Planters and Visiting Agents, to meet the special requirements of Ceylon soils and the Coconut palm:—

Manure.	Nitrogen.	Phosphoric Acid.	Potash.
300 lbs. Steamed Bone Meal, containing	9 lbs.	66 lbs.	0 lbs.
100 „ Fish Guano „	8 „	9 „	0 „
150 „ Nitrate of Soda „	25 „	0 „	0 „
50 „ Muriate of Potash „	0 „	0 „	25 „
600 „	42 „	75 „	25 „

Steamed Bone Meal supplies a large amount of readily available Phosphoric Acid together with a small proportion of Organic Nitrogen which gradually becomes converted into Nitrates in which form it is readily taken up by the plant.

Fish Guano shares with the true guanos the property of continuing to yield up nitrogen to the plant throughout the whole growing season. It also contains a valuable proportion of Phosphoric Acid.

Nitrate of Soda supplies the bulk of the nitrogen in the form which both the world's Scientists and Ceylon Planters have found to be the best.

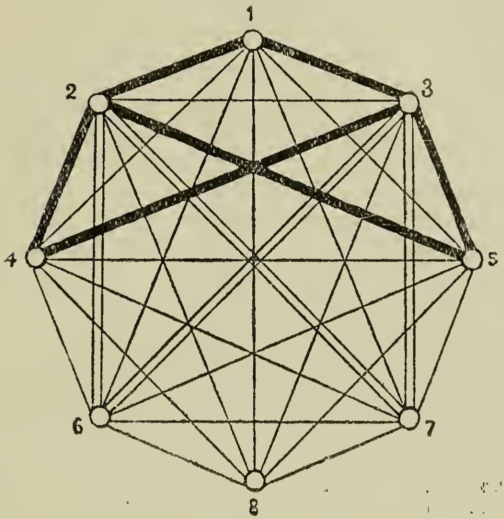
Muriate of Potash is a salt which meets the potash demands of the crop. A small amount only is included in the mixture because it will be supplemented by the action of the soda in the Nitrate of Soda which liberates potash from the soil compounds, thus rendering large dressings of this salt unnecessary.

The Composition of Fertilisers.

Fertiliser.	Nitrogen. (Per cent.)	Phosphoric Acid. (Per cent.)	Potash (Per cent.)
Animal Meal	7/8	7/8	5/6
Castor Cake	4/5	—	...
Groundnut Cake	7	—	—
Crushed Fish	4	4	—
Fish Guano	7/8	8/9	
Bone Meal	3	22	—
Steamed Bone Meal	3	22	—
Blood Meal	11	—	—
Nitrate of Soda	15½	—	—
Sulphate of Ammonia	20	—	—
Nitrate of Potash	10	—	33
Nitrolim	18	—	—
Superphosphate	—	18	—
Basic Slag	—	15/18	—
Ephos Phosphate	—	30	—
Muriate of Potash	—	—	50/55
Sulphate of Potash	—	—	48/50
Sylvinite	—	—	20/22

Dr. GEEHENS'S CHART.

Showing which Fertilisers may be mixed.



1. Superphosphate
2. Lime
3. Basic Slag
4. Sulphate of Ammonia
5. Farm-yard Manure and Guano
6. Potash Salts
7. Kainit
8. Nitrate of Soda

Many of the manures in ordinary use, such as Basic Slag, Superphosphate, Sulphate of Ammonia, etc., consist of powerful chemical substances which are liable to react with one another with a consequent loss of valuable ingredients, unless certain rules are carefully observed when making up mixtures.

These rules are graphically set forth in Dr. Geehens's chart, in which each numbered corner represents a particular kind of manure, an index below the chart shewing which manure corresponds to each number.

Those manures which ought never to be included in the same mixture are connected by heavy black lines, those which may be mixed just before application to the soil are connected by double lines, and those which can be mixed together at any time without fear of loss are joined by a single thin line.

A study of the chart will reveal the fact that all the "danger" lines, that is to say the heavy black ones and the double lines, radiate from two corners, viz., those numbered 2 and 3, and the index shows that these numbers represent Lime and Basic Slag.

Considering corner No. 2 first, it will be seen that a heavy black line connects Lime with Sulphate of Ammonia, No. 4, thus indicating that these two substances should not be mixed together. The reason for this is that lime attacks sulphate of ammonia and liberates ammonia in the form of a gas which escapes into the air. The valuable ammonia is thus lost and the manure rendered correspondingly useless.

The same action takes place when Lime is added to Farm Yard Manure or to Guano. Ammonia gas is set free and escapes into the air.

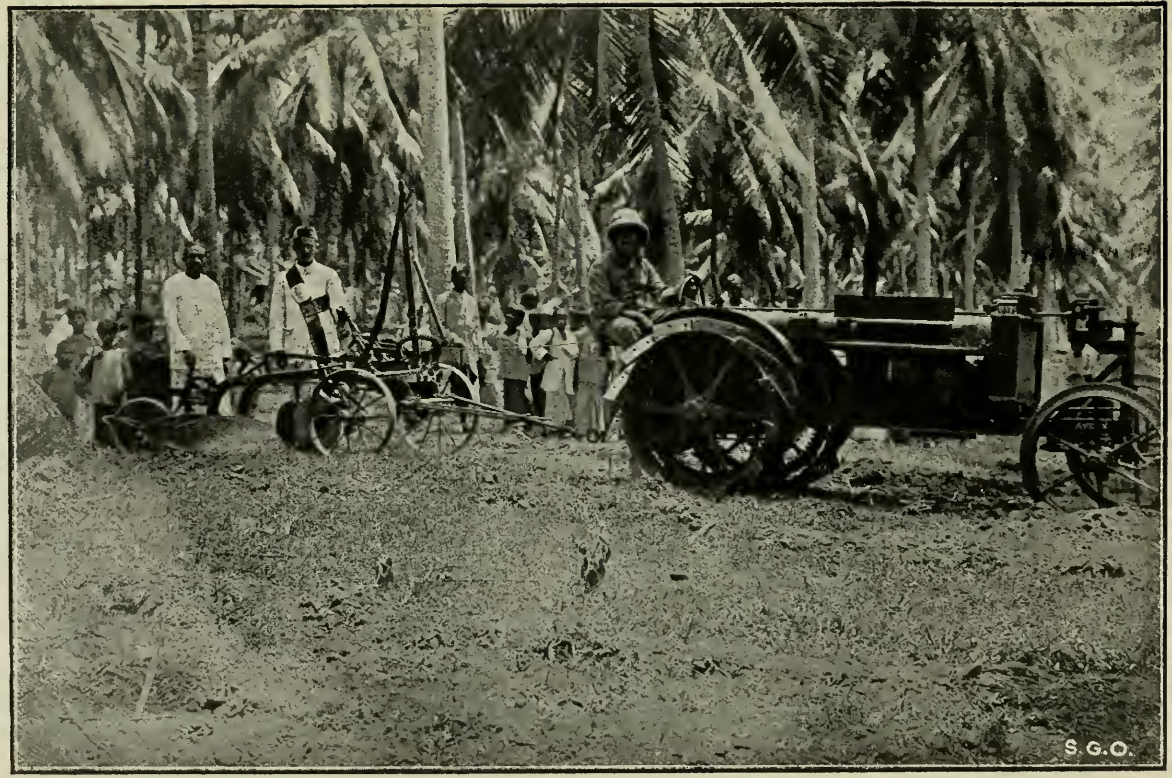
A different reason is responsible for Lime being connected by a heavy black line to Superphosphate, No. 1. Superphosphate is a substance in which insoluble phosphates have been rendered soluble by treatment with an acid. If lime is added to superphosphate it causes the phosphates to revert to the insoluble form, with the result that the manure is not nearly so valuable or so potent as it should be.

So much for the black lines radiating from No. 2; now for the double lines.

No. 2 is connected by double lines with Potash Salts, No. 6, and with Kainit, No 7, the reason being that if lime is added to these substances the potash is gradually converted into potassium carbonate which is very hygroscopic. The result is that the mixture becomes a sticky messy paste most difficult to handle and impossible to spread evenly in the soil.

Now consider the other corner from which "danger" lines radiate, No. 3, Basic Slag. This manure contains a large proportion of free lime and therefore exactly the same precautions have to be taken with basic slag as with lime. The heavy black lines radiate from No. 3, to the same corners as from No. 2, the double lines also run to the same corners, and the reasons necessitating these precautions are exactly the same as those explained above in connection with lime.

So you see it's really quite simple after all! And if, when devising your mixtures, you follow the rules laid down in the chart you may be perfectly confident that you will suffer no loss of valuable ingredients, neither will your mixtures deteriorate by becoming sticky and difficult to handle.



Avery Tractor

To face page 149.

THE TREATMENT OF COCONUTS.

EXTRACT FROM A LECTURE BY MR J. E. P. RAJAPAKSE.

(Delivered in 1923.)

Of all the cultivated products of this Island the most useful and reliable one to invest in is Coconuts. It is grown with very great success in the Western and North-Western Provinces and also in a few other provinces with fair success. A great part of the wealth of the permanent population of this Island is invested in it. It produces not only the exportable articles as Copra, Desiccated Coconuts, Oil, Poonac, Fibre, Fresh Nuts, etc , but also a hundred other things useful to man and beast. It cannot be imagined what this Island would be without this useful tree.

In the olden days, as the demand for coconut products was not very great, the value of a thousand nuts was from Rs. 15 to 20; today it is from Rs. 60 to 80.

Formerly the coconut was planted in lands best suited for its growth, in alluvial soils bordering rivers and oyas and in sandy soils along the sea coast. These estates, though carelessly p'anted, without piying much attention to distance, quality of seed-nuts, depth of holes, etc , were very successful and bore heay crops. Some of the lands being by rivers were fertilized by silt deposits from floods. Further, tying cattle to the trees was practicable then owing to the presence, in the viciniy of estates, of large tracts of land, belonging to Government and others, suitable for grazing cattle. With the extension of cultivation these lands are no longer available for pasture; and cattle grazing has to be restricted to planted areas As sufficient cattle for manuring could not be supported on plantations alone the use of artificial fertilizers is being resorted to now.

Fresh lands with ideal coconut soil and a rainfall of 75 inches or over are exhausted now. If cultivation is to be extended it must be on cinnamon lands in the Colombo and and Negombo Districts, or in drier districts with a rainfall from 50 to 75 inches. Large areas of cinnamon land are being turned into coconut plantations. Generally these lands are white sandy soils, the whiteness being due to depletion of organic matter by the continual removal of everything that had been produced by the cinnamon. Both the Manning Coconut Trial Ground at Negombo and my experimental plots at Alexandra Estate, which are conducted under the guidance of the Department of Agriculture, are on land of this description. Careful manurial experiments conducted at Manning Coconut Trial Ground have demonstrated that these soils are most deficient in potash and next in phosphoric acid, a fair quantity of nitrogen being available. The Alexandra Estate experiments demonstrate that coconuts could not be successfully grown on these lands by cultivation alone, however intensive it may be. The application of a full compost is essential from the commencement, while mulching the manured area with coconut husks or fibre dust greatly improves growth. The poverty of these soils is due to the absence of organic matter; therefore under no circumstances should any production of the soil be burnt and every effort should be made to add as much as foreign organic matter to the soil as possible.

Forest lands in the drier districts are available for planting coconuts, but owing to the absence of roads, scarcity of labour, prevalence of malaria, etc., the cost of opening such lands is prohibitive. During the last ten years very little land has been opened up in Coconut.

Seed Nuts.

From a scientific point of view the selection of good seeds is very important, therefore seed nuts should be selected with the greatest care. Nuts should be selected from healthy, drought-resisting palms 20 to 40 years old, bearing heavy bunches with shorts stalks. There are several varieties of coconuts. 19 more or less distinct varieties have been identified and experiments are being carried out both by the Department of Agriculture at Peradeniya and by me at Alexandra Estate, with plants from these varieties Owing to cross-fertilization these plants are not true to the parent, but the progeny of certain varieties are distinctly superior to others.

Nurseries.

The ground of the nursery should be well prepared by digging deep and removing all roots, stumps, etc. It should be then divided into beds about 6 feet wide, to enable one to walk through the nursery later for weeding, watering, etc. The nuts should be placed about a foot apart with their tops pointing upwards and then covered round with earth exposing only the top. There is a difference of opinion as to the best position the nuts should be placed. Some think it should be placed horizontally as it is the natural position, but experience has proved the upright position to be better and more convenient for planting. The plants which fail to do well in the nursery should be rejected. If this had been done in the olden days there would not be so many sickly trees on estates.

Felling, Burning, Etc.

Felling should be started just after the rains to enable early planting. All the trees should be cut as low as possible and the larger branches lopped off the fallen trees so as to cover the ground more evenly to ensure a good burn. The unburnt sticks should be piled up and burnt in the holes just after cutting, while larger logs may be reserved to obtain ashes later. The lining should be perfectly straight. This could be done economically by using two Surveyor's chains. Straight lines not only add to the appearance of the estate but greatly facilitate the use of labour-saving implements and allotment of tasks. A well-lined estate will remain for a century or more as a monument of the good work done by a planter. The distance of planting varies according to the nature of the soil. 27 by 27 or even 28 by 28 is most suitable for rich virgin soil, while for gravelly soils and cinnamon land 25 by 25 is considered sufficient. 24 by 24 has proved too close even for these soils as direct sunlight is absolutely necessary for assimilative work in the leaves, and growth and production depends on the amount of assimilative work done by the tree. Therefore trees should be so planted as to prevent the leaves of one overlapping those of another.

Holes.

Holes should be 3 by 3 feet by 2½ feet deep. A wooden frame 3 feet square, with diagonal bars and a hole at the intersection of the diagonal for the peg to pass through, should be used to mark the position of the hole. The difficulty of locating the right spot to plant after the hole is cut could be met by adopting a simple device. This consists of a bar 5 feet long with a hole in the middle and two holes at either end equidistant from it. This bar should be slipped on the peg, so that it passes through the middle hole, and two smaller pegs driven into the ground passing through the holes at the ends. Thus there would be three pegs in a straight line at fixed distances from one another. Though the main peg is removed by cutting the hole, its position could very easily be located by replacing the bar in position, so that in planting out the only thing to do is to place the bar in position and fix the plant vertically under the middle hole. Holes should be partly filled with surface soil mixed with ashes, and planted at depths varying from 18 inches, on high land, which does not require trenching, to one foot and even less on low land, where trenches are necessary.

Preparation of Land.

In new soils the under drainage being defective and the subsoil impervious to moisture, water collects on the surface and stagnates in the holes either killing the young plants or retarding their growth.

Therefore the natural water courses should be deepened and feeder drains parallel to the lines opened to drain out the surplus rain water. If this is not done satisfactorily it is not possible to plant sufficiently deep owing to stagnant water. But deep plantation is absolutely essential as coconut plantations invariably suffer from droughts and their ill-effects are greatest if the main root system is on the surface. Deep planting trains the roots on to a lower strata, thus enabling the surface to be used as a soil mulch, when necessary. If all the planting has to be done with the rains there is not sufficient time to adequately drain the land and a large percentage of the plants would be killed by stagnant water. Therefore only those portions, which have been drained, are planted up when the rains come. By experiments carried out at the Manning Trial Ground it has been proved that a just germinated coconut plant could live on the food in the nut for about a year without even water. Therefore if sufficiently small plants are used, much loss is not incurred even if the rains are missed and planting is carried well into the subsequent dry season. With this extra time available draining could be attended to leisurely and adequate provision made for the next rains. If the soil is very dry and water available, pouring a pot of water round the plant and covering up the wet soil with dry earth to stop evaporation is beneficial. This will help the plant to give out roots faster. If no rain has fallen watering may be repeated about a month later with advantage.

Young Stage

On a new clearing the quantity of plant food immediately available is much in excess of the requirements of the young plant. This surplus may be either converted into ready money by growing catch crops, if this proves remunerative, or reserved for future use by growing and returning to the soil any legume which suits the climatic conditions. The young plants will not need much plant food till about the third year, therefore it is not necessary to do much cultivation to liberate plant food till then. The soil immediately round the plants must, however, be kept frequently cultivated. This will keep down weeds, oxidise the soil, and act as a soil mulch at the same time. The vegetable matter growing in the middle of the squares may be periodically weeded and mulched round the palms with advantage. If the plantation is in a dry district with clearly defined periods of drought, the soil of the whole area should be stirred to arrest evaporation at the expiry of the rains. After the third year in order to enable ploughing and disc harrowing, it is essential to remove all the stumps. To perform this economically the use of a "Jack" is of great service.

Manuring

Manuring is the most important and expensive item in the cultivation of coconuts. Without it a remunerative income for an indefinite time cannot be obtained. An experiment carried out at Manning Coconut Trial Ground shows the total produce (including fallings) from ½ an acre to be about 3½ tons annually. If all this is removed, as is done on some estates, it will amount in ten years to 70 tons per acre. No land, however fertile, can stand a drain like this. An experiment is being carried out at the Manning Trial Ground to ascertain if a land's fertility would be maintained if oil only is removed and everything else (including poonac) be returned to the soil. But even here crops are not maintained and there is a gradual decline :—

RESULTS FROM 35 TREES (½ ACRE)

YEAR.		NUTS.		WEIGHT OF COPRA.
1917	...	2,165	...	1,015 lbs.
1918	...	2,164	...	943 ,,
1919	...	2,068	...	919 ,,
1920	...	2,052	...	910 ,,
1921	...	2,047	...	912 ,,
1922	...	2,017	...	869 ,,

It is therefore obvious that if we expect the land to continue to give good yields, something must be added to it in the shape of manure.

Of all manures cattle manure and wood ashes are the best if they are available in sufficient quantities. But as they are not, they have to be supplemented with artificial manures. There are some who are averse to the application of artificial manures on sentimental grounds. But the manures largely used in manuring coconuts are not artificial. Castor cake, fish refuse, bones, etc., are products of the soil and there could not be any harm in returning them to the soil to fertilize it. Although manuring, beyond all doubt, yields improved results, it has been ascertained by long experience that these results can be further improved upon by judicious cultivation. The old practice was to cultivate once in two years just after the rainy season during which manuring was done. But cultivation is so beneficial that former advocates of the two years' system now favour annual cultivation. The results of the cultivation experiments at Alexandra Estate show that given the same quantity of manure, the improvement is directly proportional to the amount of cultivation, the gradient of improvement with each degree of cultivation being very evident :—

	Plot.		Cultivated.		Annual Cost of Cultivation.		No. of Palms Flowered 1-1-1923.
MANURED WITH FULL COMPOST.	12	...	No	...	Nil	...	15
	11	...	Once in 2 Years	...	Rs. 4 (½ Share)	...	19
	9	...	Yearly	...	Rs. 6/–	...	24
	8	...	Twice a Year	...	Rs. 12/–	...	30
	10	...	Subsoiled and cultivated in alternative Years	...	Rs. 12/– (average)	...	32
	7	...	Monthly	..	Rs. 20/–	...	37

But cultivation, like all good things, can be overdone as witnessed in the intensive cultivation boom. During the intensive cultivation craze an elaborate series of cultivation experiments were started by me in July, 1917, to determine if (1) intensive cultivation could replace manuring, (2) if manuring and intensive cultivation combined give better results than either by itself. It was soon apparent that on cinnamon soil cultivation without manuring was useless, though as an adjunct to manuring cultivation improves results. In rich alluvial soils intensive cultivation will yield good results, but the strain on the soil is so great that there is a limit to its period of success. There are two contrary policies in treating coconut plantations. One aiming at the conservation of humus in the soil by applying organic manures, cultivating the soil about once a year, and growing green crops. The other intensive cultivation, not allowing any vegetation to grow, and burning all the fallings to clear a way for the free working of improved mechanical appliances, coupled with the use of indirect manures as lime and salt. The former is practised by those who intend to keep their lands and hand them down to posterity, the latter by lessees and others whose object is to get everything out of a land as quickly as possible.

A method of cultivation suggested to me by the Department of Agriculture, which in my opinion gives very favourable results on sandy soils, is subsoiling. Subsoiling consists in turning the soil to a depth of about 12 or 15 inches with the object of occasionally breaking up the strata just underneath the usually cultivated soil. This may be performed once in two or four years and on sandy soils the cost is not exorbitant. As some of the larger roots are cut, subsoiling should be performed in alternate squares, thus leaving half a tree's roots untouched. The unworked squares could be taken up after one or two years, when the trees have had ample time to throw out new roots before the remaining half are cut. Subsoiling greatly increases the tilth of a soil, but as it is practicable only when the soil is wet, it is unsuited for clay lands as these would be only hardened by handling during wet weather. It is further an ideal method of disposing of decaying vegetable matter, which the Entomologist wants to burn and the planter wants to keep as the Entomologist is satisfied if it is more than 8 inches below the surface and the planter if it is not burnt.

Tying Cattle for Manure.

"Tying cattle" for manure is a common practice both in estates and in the villages. Trees to which cattle are tied bear well for about a year only. If the cattle used for this purpose are grazed on the estate itself only a small part of the estate could be treated in a year. It is true that this part is benefitted, but it is at the expense of the rest of the land. Therefore no value could be attached to this system of manuring, unless the cattle are grazed on pastures outside the estate or stall-fed. But with the present prices of straw and poonac stall feeding for manuring purposes is out of the question. Cattle manure, owing to the presence of a larger quantity of organic matter in it, is more suited for coconut soils than any other manure.

The only way to get it in sufficient quantity is to have a large extent of grazing land attached to the estate.

Manure Mixture.

There is much difference of opinion as to the proper mixture to be used in manuring coconuts. There are some who consider the application of common salt as essential, while others hold that a compost containing Nitrogen, Phosphoric Acid and Potash meets all the requirements of coconuts. Here, too, there is no unanimity as some advocate an excess of Nitrogen, while others are for Phosphoric Acid and Potash. Fletcher in his "Soils" states that "the chemical analysis of a crop is of very little practical value to the man who wishes to know what fertilizer to apply to that crop." Hence an analysis of what is removed by the crop is no guide as to what we should return to the soil. Under the circumstances I shall venture to give my own personal opinion which is backed by over 30 years' experience in manuring and also the results of various experiments. The compost that could bo recommended for the use of any coconut estate is :—

			N	P_2O_5	K_2O
Fish Manure	...	4 lbs.	·20	·20	—
Castor	...	4 ,,	·16	·00	—
Bone Meal	...	6 ,,	·18	1·32	—
Sulphate of Potash	...	2 ,,	—	—	1·00
Total	...	16 lbs.	·54	1·52	1·00

16 lbs. per palm once in two years. This gives about ·50 lbs of Nitrogen, 1·50 lbs. of Phosphoric Acid and 1·00 lbs. of Potash per palm.

Though in the opinion of many this mixture contains an excess of Phosphoric Acid, experience has clearly demonstrated that this quantity is essential to give the best results. At the Manning Coconut Trial Ground :—

In 1922 the plot	without	Nitrogen yielded	822	Nuts
Do	do	Phosphoric Acid	620	,,
Do	do	Potash	450	,,

These results confirm the independent deduction drawn from long experience in manuring.

Application.

It is the general practice to buy manures mixed in bulk, but as no solids could be mixed mechanically to yield an uniform composition it is always safer to buy the manures separately and weigh out the quantity of each constituent required for each tree. This has been practised with success and very little expense. The manure is applied in shallow circular trenches 3 ft. wide and 3 ft. away from the tree and forked in. The trench is then filled with coconut husks, fallings and available weeds and covered up.

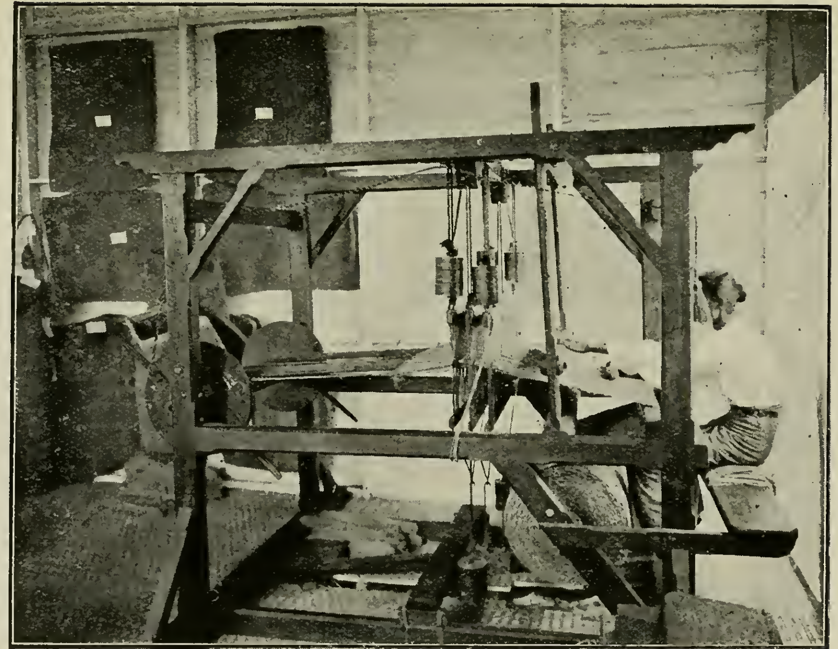
Catch Water Drains.

Experiments carried out in the Phillippines have determined that the water lost by transpiration through the leaves of a coconut palm amount to about 20,000 litres per annum. This is equivalent to about 12 inches of rainfall. As the rainfall in some districts is not much above 50 inches and the greater part of this is lost to the coconut tree by wastages such as surface wash, underground drainage, transpiration from weeds and evaporation from the soil, it is of paramount importance to conserve as much water as possible for the use of the palm. Nowadays much stress is laid on dry-farming to eliminate losses through transpiration from weeds and evaporation, but it is first necessary to fill the reservoir before protecting it from loss. Catch drains are intended to fill the reservoir by intercepting the surface wash before it runs off the land, and making the soil absorb it.

Surface wash is heaviest on undulating land and hard soils: hence it is on such lands that catch drains are opened. These should be opened at right angles to the slope or flow of water, the earth thrown up being arranged on the upper side to form a continuous ridge. A great deal of designing skill is necessary to make these ridges as level as possible. To prevent water running along the ridge and escaping at the ends, the ridge is bent upwards at its two ends. These drains are generally cut 6 ft. wide and 3 ft. deep, but if stronger ridges are needed their size may be increased. To distribute the water held up by the catch water ridge evenly short arms at right angles to the main ridge are constructed by means of earth from small cross drains on the upper side just above the ridge. A series of small basins are thus formed and if this is done systematically it is possible to collect all the rain water and make the soil absorb it.

Copra.

The preparation of copra of good quality is essential for Ceylon copra to command a high reputation in the world's market. The quality of Ceylon copra to-day is much superior to that of some years ago, and this fact is recognised by the world buyers. This improvement in quality can be attributed to better drying. Before the war a large quantity was sold under-dried, as "cart copra." When the absence of freight during war-time necessitated storage for a long period, this quality, which spoilt quickly, failed to find buyers and the preparation of it ceased. To prepare copra of the best quality only the ripest nuts (those falling and about to fall) should be picked and as much sun drying as possible resorted to, by avoiding the rainy months as May-June and October-November.



Coir Mat Making.

To face page 148.

REPORT ON THE MANNING COCONUT TRIAL GROUND, NEGOMBO, CEYLON.

From May 1st, 1922, to May 1st, 1923.

A CENSUS OF THE PALM IN THE EXPERIMENTAL PLOTS.

"A" plots denote good soil; "B" plots denote poor soil.

Plot No.	Trees in bearing.	Trees in flower.	Trees about to flower.	Young trees.	Total number of trees.
1 A	25	8	2	nil	35
1 B	11	16	8	—	35
2 A	31	—	3	1	35
2 B	12	11	12	—	35
3 A	26	3	4	2	35
3 B	18	10	7	—	35
4 A	24	8	3	—	35
4 B	20	9	3	3	35
5 A	29	3	3	—	35
5 B	17	7	9	2	35
6 A	19	15	1	—	35
6 B	23	6	2	4	35
7 A	26	6	—	3	35
7 B	23	3	3	6	35
8 A	11	7	17	—	35
8 B	nil	4	24	6	34 (1 plant dead)
9 A	23	3	7	2	35
9 B	4	7	17	7	35
10 A	22	7	6	—	35
10 B	4	12	16	3	35
11 *	34	—	—	—	34 (1 plant dead)
12 †	29	4	1	1	35

* In plot 11 the manured circle is mulched with coconut husks.

† In plot 12 the manured circle is mulched with fibre dust.

The manuring of the plots was carried out in June, 19 2, the manure being applied in a circle at a distance of five feet from the tree.

The table given below will show the quantities of manure applied and also the total expenditure. These plots with the exception of the Control (Plot 8) and the monthly cultivated (Plot 5) are ploughed deep once a year.

MANURIAL MIXTURE.

Plot	Ground-nut cake in	Bone meal	S. of Potash	Degel Bones	S. of Ammonia	Con-supephosphate	Potassium Nitrate	Sodium Nitrate	Basic slag	Nitrolim	Kanit	Lime	Value of Compost	Cost of labour etc.	Total Expenditure on the plots
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	R. c.	R. c.	R. c.
1 A	180	69	30	—	—	—	.	%	%	%	%	%	20·57	8·70	29 27
1 B	180	69	30	—	—	—	—	—	—	—	—	—	20·57	7·20	27·77
2 A	—	—	30	50	—	—	—	—	—	—	—	—	7·28	7·80	15·08
2 B	—	—	30	50	—	—	—	—	—	—	—	—	7·28	8·15	15·43
3 A	214	—	30	—	—	—	—	—	—	—	—	—	18·45	9·15	27·60
3 B	214	—	30	—	—	—	—	—	—	—	—	—	18·45	6·90	25·35
4 A	207	—	—	50	—	—	—	—	—	—	—	—	18·69	8·85	27·54
4 B	207	—	—	50	—	—	—	—	—	—	—	—	18·69	7·95	26·64
5 A				Monthly cultivation										23·65	23 65
5 B			do		do									16·75	16·75
6 A	—	—	30	—	—	—	—	—	75	84	—	—	15·62	7·95	23·57
6 B	—	—	30	—	—	—	—	—	75	84	—	—	15·62	7·35	22·97
7 A	—	—	—	—	75	36	—	—	—	—	125	—	18·06	8 55	26 61
7 B	—	—	—	—	75	36	—	—	—	—	125	—	18·06	7·50	25·56
8 A			Control								Control				2·41
8 B			do								do				2·07
9 A	—	—	—	—	—	15	43	74	—	—	—	—	15·22	8·70	23·92
9 B	—	—	—	—	—	15	43	74	—	—	—	—	15·22	7·20	22·42
10 A	—	—	30	—	—	—	—	—	75	84	—	111	18·62	8·70	27·32
10 B	—	—	30	—	—	—	—	—	75	84	—	111	18·62	8·25	26·87
11	180	69	30	—	—	—	—	—	—	—	—	—	20·57	8·25	28·82
12	180	69	30	—	—	—	—	—	—	—	—	—	20·57	8·55	29·12

THE CROPS OF "A" PLOTS.

Plot	Annual Crop	Average Number of Nuts per Bearing Tree	Comparative Order	Total Expenditure on Plots.	Cost of Producing 1000 Nuts to the nearest Rupee	Average Number of Nuts required for a candy
				Rs. cts.	Rs. cts.	
1	581	23·24	6	29 27	50 00	1,012
2	732	23·6	4	15 08	20 50	1,058
3	445	17	9	27 60	62 00	1,013
4	297	12·32	10	27 54	93 00	1,260
5	366	12·27	11	23 65	64 00	1,280
6	437	23	7	23 57	54 00	1,092
7	663	25·5	3	26 61	40 00	1,142
8	94	8.5	12	2 41	—	1,330
9	421	18·3	8	23 92	57 00	1,050
10	517	23·5	5	27 32	53 00	1,106
11	1,225	36	1	28 82	24 00	973
12	754	26	2	29 12	39 00	1,084

THE CROPS OF "B" PLOTS.

1 B	119	10 8	3	27 77	233 00	1,267
2 B	150	12·5	1	15 43	103 00	1,004
3 B	175	9·7	5	25 35	151 00	1,160
4 B	153	7·65	7	26 64	174 00	1,370
5 B	103	6	9	16 75	162 00	1,330
6 B	256	11·13	2	22 97	89 00	1,180
7 B	202	8·9	6	25 56	127 00	1,052
8 B	None	None	—	2 07	No nuts	—
9 B	41	10·25	4	22 42	541 00	1,112
10 B	21	7·25	8	26 87	1,280 00	1;175

A NOTE ON THE INDUSTRIAL POSITION OF COPRA, COCONUT OIL AND COCONUT CAKE.

(Based on Imperial Institute Reports.)

In view of the present unsettled condition of trade with Europe the figures given below represent the last available before the war, and are reproduced as indicating the producing capacity of the various coconut-growing countries. These figures showing the annual export ten years ago will give a fair idea of the possibilities of the coconut industry when normal conditions of trade prevail.

	Quantity. cwts.
British Territories:	
Ceylon	1,117,292
India	763,832
Federated Malay States	185,753
Seychelles	58,738
Tongan Islands Protectorate	222,400
Fiji Islands	158,585
Papua	15,880
British Solomon Islands	83,920
Gilbert and Ellice Islands Protectorate ...	41,700
East Africa Protectorate	31,283
Zanzibar (value £ 216, 842)	—
Gold Coast	12,589
Trinidad	10,308
Foreign Territories:	
Philippine Islands	1,618,080
Java	1,556,000
Sumatra (East Coast)	80,860
Celebes	580,340
Indo-China	157,074
New Caledonia	53,173
French Oceania	117,662
Samoa	220,423
Bismarck Archipelago, German Solomon Islands, and German New Guinea	223,814
East Carolines, Marshall Islands, and Nauru ...	94,940
West Carolines, Pelew and Mariana Islands ...	21,706
German East Africa	83,468
Portuguese East Africa	78,820

The following statement shows the distribution of coconut products of Ceylon in the year before the war. It will be noted that no less than ¾ of the trade was with Germany:—

	1913.	
	cwts.	£
United Kingdom ...	1,500	2,001
India	163	244
Austria-Hungary ...	30,041	37,518
Belgium	18,000	23,422
Denmark	25,667	34,639
France	1,003	1,000
Germany	814,979	1,013,486
Holland	1,059	1,200
Roumania	4,000	5,600
Russia	220,880	278,174
United States	—	—

In 1913 Ceylon exported roughly 550,000 cwt. of coconut oil. The Cochin oil, which is more carefully prepared, fetches a better price in London.

The copra exported to Europe and elsewhere is there used as a source of oil and cake (poonac). The quality depends largely on the copra used. That prepared from imperfectly dried copra is of higher acidity and inferior quality. The oil content depends upon the thoroughness with which the copra was dried. The sundried kernels contain about 50 % oil, kiln-dried 63-65 % and hot-air-dried as much as 74 %—the yield from average copra being 62-63%. At the average European temperature the oil is a solid fat. By refining an odourless and tasteless product can be secured. The following table gives the range of the principal constants of coconut oil:—

Specific gravity at $\frac{99° C.}{15° C.}$ ...	...	0·874
Iodine value	*per cent* ...	8·0–10·0
Saponification value ...	...	246–268
Hehner value	...	82·4–90·5
Reichert-Meissl value ...	...	6·6–7·5
Polenske value ...	...	18·0
Titer test	...	21·2° C.–25·2° C.

Refined coconut oil is used in the preparation of solid edible fats, such as margarine, vegetable butters, cooking fats, and chocolate fats, as well as in the manufacture of cakes, biscuits, sweetmeats, etc. In order to obtain a fat of firmer consistence and higher melting point, a certain proportion of the liquid constituents of the oil (' coconut olein") is removed by expression. The "coconut stearin" which is left is used for the purposes indicated above when obtained from the high-grade oil, while that obtained from the lower grades is used for candle manufacture.

The following are the conclusions arrived at from numerous feeding trials with coconut cake (poonac) :—

1. Coconut cake forms an excellent feeding-stuff for milch cows, when fed at the rate of 4½ lb. to 5 lb. per head per day. It tends to produce a firm butter and is thus especially well-suited for feeding during warm weather and to counteract the effect of feeding stuffs which tend to give a soft butter. The results so far as its effect on the milk yield is concerned appear to be inconclusive, and further trials to elucidate this point are necessary.

2. The cake may be safely fed to fattening cattle at the rate of about 4 lb per head per day, without detriment to the animal or the quality of the meat

3. The meal is suitable as a food for pigs, but owing to its relatively high price compared with meals usually used for pig feeding, it is doubtful whether it could be employed profitably for this purpose.

4. With regard to the feeding value of coconut meal for horses, it has been shown that it can replace an equal weight of oats in a ration without adversely affecting the animal.

POLLINATION OF COCONUTS IN MALAYA.

Messrs. Jack and Sands, Botanists of the F.M.S. Department of Agriculture, writing in the Malayan Agricultural Journal of January 1922, contribute the following of interesting notes on this subject. After referring to Petch's observations in Ceylon they remark : —

In the warm humid atmosphere of the lowlands of Malaya. coconuts appear to behave differently. The length of duration of the male phase is curtailed, while the duration of the female phase would appear to be longer in both tall and dwarf trees ; but the most striking difference is the fact that in Malaya the female phase not only begins, but most frequently ends before, or at the same time, as the male phase, thus rendering self-pollination the rule instead of being an occasional chance occurrence.

The results of investigations have convinced the writers :—

(1) That the inflorescences on the same tree follow each other after an average interval of four days.

(2) That in two cases only out of forty-three, did overlapping of inflorescences occur.

(3) That the average duration of the male phase was 21 days, with a variation of from 15-24 days.

(4) That the average duration of the female phase was 8 days. This average seems independent of the number of female flowers on the inflorescence, but might be reduced over a longer period as the weather was unusually showery, though sunny, during most of the period covered by these records.

(5) That in forty out of the forty-three cases, the female phase began before the end of the male phase.

(6 That in forty out of the forty-three inflorescences the female phase ended at the time of, or earlier than, the male phase, thus making self-pollination not only possible but very highly probable.

(7) That the end of the female phase was never more than three days behind the end of the male phase, making self-pollination still possible in dry weather, since coconut pollen-grains appear to maintain their viability for several days under fairly dry conditions.

(8) That overlapping of inflorescences only occurred twice out of forty-three cases.

The trees on which the observations were taken were approximately eight years old and fairly widely planted, but not well cared. However, shortly before the observations commenced a space round each tree was cleared and cultivated. In support of the facts revealed in the above table, three unopened inflorescences were bagged in muslin bags and it was found that in each case, self-pollination was effected naturally and fruits, which still remained on the trees, were formed.

Again, three other inflorescences were emasculated immediately on opening and it was found that, though the female flowers behaved normally, no pollination took place and no fruits were formed, although male flowers on adjacent trees were in full bloom. In a similar connection, it has been observed that odd isolated coconut trees growing even under bad conditions produce fruit so that self-pollination must have taken place. When coconut flowers are in full bloom, at about 10 a.m., when the dew has dried up and when gentle breezes frequently begin, clouds of pollen can be seen floating away in the sunlight. In a very slight breeze these pollen clouds do not travel far owing to the weight of the pollen, but it is highly probable that with the strengthening of the breeze as the day advances the pollen clouds are carried to a considerable distance and thus cross-pollination is effected.

THE MACAPUNO COCONUT.

(SINHALESE: DIKIRIPOL)

The Macapuno is a sport fruit of the coconut.

The word MACAPUNO means full, and indicates that this coconut contains no water, but is nearly or quite full of a viscous, white, translucent jelly, whose texture next the shell more or less closely approaches the firmness of ordinary coconut meat.

No means is known whereby a tree bearing macapuno coconuts can be distinguished from one which bears normal nuts; the natives recognize their macapuno trees only by the fruit they bear, The only way of telling an unopened nut of this kind from an ordinary one is to shake it; since it contains no water no sound is made.

The fruits borne by a macapuno tree are not all macapuno. From a cluster containing about ten nuts about one to four may be gotten. The usual number is two.

The only fact which seems to be well established is that a tree which bears a few macapuno nuts one year is likely to do so again. It is generally believed that normal nuts from a tree which bears macapuno nuts will produce other trees of the same kind. The macapuno nuts themselves contain a well marked embryo, but will not germinate. They soon spoil if an attempt is made to store them.

Macapuno bearing trees are often found grouped together in the older coconut groves, a fact which might be supposed to indicate some soil peculiarity as the predisposing cause of the abnormal fruit.

As a preliminary study of the nature of the macapuno nut, and the way in which it differs from the ordinary coconut, an analysis is here presented, together with figures given by Semler (Tropische Agrikultur. Vol. 1, p 617). The percentages of protein, oil, and ash have been recalculated to a moisture free basis.

	Semler's Coconut.		Normal Nut		Macapuno Nut.	
	Meat.	Milk.	Meat.	Milk.	Firm outer portion.	Soft inner portion.
Water	46.64	91.50	63.62	95.13	71.59	90·65
Protein	10.79	5.41	9.09	1.09	11.76	10 69
Oil	67.33	0.82	68.63	Undet.	41.67	18.89
Ash	1.81	14.00	2.11	Undet.	1.81	3.74

The solid portion of the macapuno nut is slightly richer in protein than the common nut, but is considerably poorer in oil. The soft portion of the macapuno contains more protein and oil than does the milk of a normal nut.

The macapuno is valuable for the making of preserves. Sometimes it is eaten fresh with sugar, but is rather unpalatable unless sweetened. When boiled in syrup it is relished by all who have occasion to try it.

The existence of this kind of a variation from the normal form of fruit of the coconut raises interesting questions as to the possibility of the transmission of such a characteristic; the chemical composition of the abnormal nuts needs to be more closely studied, especially the nature of the carbohydrates and proteins they contain; and there are physiological questions as to what influences have produced the sport form and why such nuts fail to germinate.—*Philippine Agriculturist.*

LIME IN AGRICULTURE.

Lime occurs in two forms in Ceylon, viz.: as Coral Lime and Dolomite. The former is practically a pure carbonate of lime containing traces of organic matter resulting from the decay of the minute animals which produce it. The latter is a mixture of the carbonates of lime and magnesia with varying proportion of quartz or silica, and is to be seen cropping out in various parts of the tea districts.

Coral Lime is what is usually employed for manurial purposes in Ceylon either in the burned or unburned condition, and it is this kind of lime that is referred to in the following remarks:—

Large supplies are obtained from coral formations near Ambalangoda. As imported from India or the Maldives, it occurs in hard lumps of irregular shape and size, and in this form is practically useless for agricultural purposes. To render it useful, it is either ground to a fine state of division and sold as ground coral, or more commonly it is burned in special kilns with the aid of wood fuel, when it is sold as "burnt or quick-lime."

Burning Lime.

In burning, pure coral loses about 44% of its weight as carbonic acid gas, 100 parts of the coral yielding 56 parts of quicklime. This quicklime has a strong affinity for water, and if exposed to the air will absorb 30% of its weight of water when it falls to an extremely finely divided *dry* powder, known as slaked lime. Quicklime can be slaked immediately by pouring over it the above quantity of water, great heat being developed by the chemical combination, the rise in temperature being sometimes sufficient to cause ignition of any organic matter in contact with it.

When still further exposed to the air for some weeks the slaked lime absorbs carbonic acid gas and is re-converted into carbonate of lime, the same chemical compound as the original coral, but in a more perfect state of division than any grinding machinery could effect.

As re-carbonating goes on simultaneously with slaking when quicklime is merely exposed to the air, slaked lime usually consists of a mixture of mild carbonate of lime and hydrate of lime.

Lime a Plant Food.

Lime is of universal occurrence in soils, and its salts are no doubt necessary constituents of all plants.

Lime and Nitrification.

The nitrification of the organic nitrogen of soils, or of the various forms of organic nitrogen in manures, is brought about by the agency of various bacteria, some of which transform the ammonia compounds into nitrites and others, which oxidise the nitrites into nitrates.

It is this nitrification process which renders the nitrogen of the soil available to the roots of plants, and it can only go on in slightly alkaline soils; the *nitrous* and *nitric acids* produced by these processes must therefore combine with a base as soon as formed, otherwise nitrification ceases and the plant cannot obtain the necessary supplies of nitrogen. Many Ceylon soils are somewhat deficient in lime and show a slightly acid reaction, in which case nitrification can only take place slowly.

Lime Liberates Potash.

Lime by powerful chemical action liberates the mineral reserves of soils, especially potash. This potash occurs in Ceylon soils in combination as double silicates of alumina and potash, and these are decomposed by the lime with the liberation of potash.

Lime and Phosphoric Acid.

The action of lime on the phosphates of the soil is equally marked; this solving action is of some value, since the phosphoric acid in Ceylon soils is only available *in traces* to the roots of the tea plant.

Quantity to Apply.

As lime itself is only in a limited sense a direct food to the plant, but sets principally in action the dormant constituents of the soil, its continued application in large quantities without manuring would soon result in exhaustion of the land at least as regards its fairly easily available plant food. But the applications recommended in Ceylon of 2 to 3 cwts. per acre every second or third year after pruning are not likely to do harm in this respect, especially as the additional plant food that would be liberated for the tea bush by its use is more than replaced by the manuring that follows the liming process.

In temperate climates the usual application of lime is from 2 to 4 tons per acre every 8 or 10 years, but in Ceylon heavier applications than 3 to 4 cwts. per acre are rarely necessary.

Method of Application.

As a rule lime has usually been applied to buried prunings to hasten their decomposition and destroy any fungus growth, but now broadcasting over the stems of the pruned bushes to destroy lichen, and over the surrounding soil, is becoming more general, as the lime is better distributed through the soil for nitrification purposes. Experiments in other countries have shown that where lime is also applied the effect of the latter is increased by 10 to 20 per cent.

One drawback to the application of quicklime or slaked lime is its effect on the coolies' hands and feet, especially when the weather is wet. A suitable hand machine for broadcasting lime would be of much service. The effect of the lime on the skin can be minimised by rubbing with coconut oil after the day's work.

Finely ground coral or stale slaked lime has the advantage over quicklime in that it does not injure the hands, but its slower action on most soils renders its use limited. It is also of no use for broadcasting over the stems of bushes to destroy lichens and mosses, but on some very light soils poor in humus it might be employed with advantage.

Ceylon Limestone or Dolomites.

As mentioned before, these are mainly mixtures of carbonates of lime and magnesia with varying quantities of quartz. As a rule they are not generally regarded as suitable for manurial purposes, and in some cases they have proved injurious rather than beneficial, this being probably due to the magnesia present, as it has been found that many plants require a much larger proportion of lime in the soil than magnesia. For cocoa, however, which does well in the soils containing a good proportion of dolomitic limestone, its application might be of service.

From numerous analyses of Ceylon soils that have been under cultivation for varying periods, it would appear that the available lime originally present in the virgin soils has more or less disappeared, which is only to be expected, as lime is the chief base removed in the drainage water.

Other Sources of Lime.

Liming can, to a certain extent, be obviated by the use of manures containing lime.

Amongst the manures containing lime the most important is undoubtedly

Basic Slag.

This is a byproduct of steel manufacture by the Thomas and Gilchrist process. In Ceylon the value of basic slag has been recognised long ago, and this manure constitutes a favourite and *cheap source of phosphoric acid.* This latter ingredient is required in large quantities for the formation of the stem, branches and leaves of the tea plant; but, besides this, *every ton of basic slag contains approximately half its weight in lime.*

The following is a complete analysis of this fertilizer : –

*Phosphoric Acid	21·24	per cent
Lime	47·40	,,
Magnesia	3·60	,,
Oxide of Iron	10·40	,,
Manganese, Alumina, Sulphuric Acid, &c.	8·56	,,
Silica	6·00	,,
Loss on Ignition	2·80	,,
	100·00	
Citric Soluble Phosphoric Acid ...	15·87	per cent
Fineness	90·25	,,
*Equal to Tribasic Phosphate of Lime	46·36	,,

The article is usually sold on the basis of—

20 per cent Phosphoric Acid and 85 per cent fineness
17 ,, ,, ,, 80 ,, ,,

The Value of Basic Slag.

Basic Slag is undoubtedly well suited for Ceylon soils. These soils contain the phosphoric acid in combination with various elements, principally as phosphates of calcium, aluminium, iron, manganese, and these phosphates are generally tribasic, *insoluble* phosphates, incapable of being taken up by the plant, unless being previouly rendered available by chemical or microbical action.

Rate of Application.—The rate of application is from 2 to 4 cwts. per acre per annum. Loss of phosphoric acid through draining water is practically *nil.*

[For these notes we are indebted to A. Baur—"Ceylon Manure Works.]"

USEFUL FACTS AND FIGURES.

METHODS OF RECKONING THE AREA OF LANDS.

a. Divide the land into as many triangles as possible (the length of the base into the altitude divided by 2 is the area of a triangle) and add the areas of the triangles.

b. To find the area where the boundaries are very irregular. Lay out a base line and at right angles from the base measure offsets to the various bends and angles of the opposite boundaries. The land is then divided into approximate triangles, trapezoids, rectangles and probably squares. Add the areas of these spaces together; the sum will be the area of the land.

N. B.—Area of triangle = length of base × altitude 2.

Area of a trapezoid = Average length of the two side × base.

Area of a rectangle = length × breadth.

Area of a square = length of a side × itself.

In the computation of acreage the easiest measurement will be links.

N. B.—Link = 7·92 inches.

Chain = 100 links.

Acre = 100,000 square links.

To reduce square links to acres point off 5 figures to the right, that is, divide by 100,000, the result is acres and a fraction in decimals. Multiply the decimals by 4 and point off 5 places again, which gives rood and a fraction in decimals. Multiply the decimal by 40 and mark off 5 figures, then we get poles—

e. g. 1234567 sqr. links.

= 12·34567 acres.

= ·34567 × 4 roods,

= 1·38268 ,,

= ·38268 × 40 poles.

= 14·30720 ,,

= 12 acres 1 rood 14·30720 poles.

Acre Plot in Field.

The following table may be found convenient for those who may wish to stake off one imperial acre in any plot of land :—

If the length	be	1,452	feet then	the width must be	30	feet.
,,	,,	726	,,	,,	60	,,
,,	,,	396	,,	,,	110	,,
,,	,,	363	,,	,,	120	,,
,,	,,	208½	,,	,,	210	,,
,,	,,	198	,,	,,	220	,,
,,	,,	181½	,,	,,	240	,,
,,	,,	99	,,	,,	440	,,
,,	,,	66	,,	,,	660	,,
,,	,,	44	,,	,,	990	,,

A square acre is 208¾ feet long and 208½ feet wide.

Plants Per Acre.

Feet Apart.	Square feet to each plant.	Number of plants to the acre.	Feet Apart.	Squaró feet to each plant.	Number of plants to the acre.
1 × 1	1	43,560	9 × 9	81	538
1½ × 1½	2½	19,360	10 × 10	100	435
2 × 1	2	21,780	11 × 11	121	360
2 × 2	4	10,190	12 × 12	144	302
2½ × 2½	6½	6,970	13 × 13	169	257
2 × 3	6	7,260	14 × 14	196	222
3 × 3	9	4,840	15 × 15	225	193
3½ × 3½	12¼	3,556	16 × 16	256	170
3 × 4	12	3,630	17 × 17	289	151
4 × 4	16	2,722	18 × 18	234	134
4 × 5	20	2,178	19 × 19	361	120
5 × 5	25	1,742	20 × 20	400	109
5 × 6	30	1,452	22 × 22	484	90
6 × 6	36	1,210	24 × 24	576	75
6 × 7	42	1,037	25 × 25	625	69
7 × 7	49	889	26 × 26	676	64
7 × 8	56	778	28 × 28	784	55
8 × 8	64	681	30 × 30	900	48

TREES PER ACRE.

The following table indicates from the distance of planting (square or oblong) the number of trees to the acre :—

	8	10	12	13	14	15	16	17	18	20	25	30	35	40
8	680	546	453	418	388	363	340	320	302	272	217	181	155	136
10	546	435	363	335	311	290	272	256	242	217	174	145	124	108
12	453	363	302	279	259	242	226	213	201	181	145	121	103	90
13	418	335	279	257	239	223	209	197	186	167	134	111	95	83
14	388	311	259	239	222	207	194	186	172	155	124	103	88	77
15	363	290	242	223	207	193	181	170	161	145	116	96	82	72
16	340	272	226	209	194	181	170	160	151	136	108	90	77	68
17	320	256	213	197	186	170	160	151	142	128	102	85	73	64
18	302	242	201	186	172	161	151	136	134	121	96	80	69	60
20	272	217	181	167	155	145	136	128	121	108	87	72	62	54
25	217	174	145	134	124	116	108	102	96	87	69	58	49	43
30	181	145	121	111	103	96	90	85	80	72	58	48	41	36
35	155	124	103	95	88	82	77	73	69	62	49	41	35	31
40	136	108	90	83	77	72	68	64	60	54	43	36	31	27

CATTLE NOTES.

In view of the importance of maintaining the health of cattle on an estate—whether kept for manure or for carting produce—the following notes on the two most common ailments should prove useful to the planter. We are in debted for these to Mr. G. W. Sturgess M.R.C.V.S., the Government Veterinary Surgeon :—

FOOT-AND-MOUTH DISEASE.

This disease is both contagious and infectious, and nearly all animals may suffer from it. As is indicated by its name, the feet and the mouth are the principal parts affected. In some outbreaks the feet are chiefly affected, in others the mouth, in most cases both mouth and feet.

The animal is feverish, there is constipation—if a milking cow the quantity of milk is diminished—loss of appetite, and probably a rough, staring coat. Generally a peculiar smacking of the lips is heard, there is a flow of saliva from the mouth, and generally lameness in one or more feet. The special eruptions are in the form of blisters containing a clear fluid, and are found on the upper surface of the tongue, on the roof of the mouth, and gums. The feet are swollen and hot, and the blisters appear at the back part of the foot and between the toes.

It is a mild disease, and many animals should not die from it if they are properly looked after. The feet especially should be kept clean, otherwise the matter penetrates or burrows down into the flesh and involves the tendons and ligaments, and even the bones, eventually causing the hoof to drop off.

Treatment.—All the affected animals must be segregated, as far as possible. For mouth and feet dressing the following are simple, good and cheap:—

MOUTH DRESSING.

Powdered alum (bazaar name "Sinakkaram")			$1\frac{1}{2}$	ounce
Water	...	... ...	1	pint

A little to be poured into the mouth night and morning.

FEET DRESSING.

Powdered Sulphate of Copper (bazaar name "Palmanikkan")	...	...	1	ounce
Alum	...	... ...	1	ounce
Water	...	... ...	1	pint

Apply to the sores on the feet twice a day.

Stockholm Tar should be applied to the feet daily, over the sores.

The feet must be kept quite clean by washing with water containing a little Jeye's fluid daily. Jeye's disinfecting powder may be dusted on the feet after cleaning.

When the sores on the feet do not heal properly, the following dressing should be applied in addition to the above twice a day with a feather:—

Margosa oil or coconut oil		...	8 parts
Turpentine	...	...	1 part

Internally give $\frac{1}{2}$ or $\frac{3}{4}$ lb. of Epsom salts daily for three or four days in a quart of congee, which will relieve the constipation and fever; or a dose of oil as a laxative.

Prevention.—With the view of preventing infection the healthy cattle and the sheds may be sprayed with Jeye's fluid and water daily, and both healthy and diseased cattle may get 10 drops of Jeye's fluid daily in the food (or in a quart of congee) for a week. It should then be stopped for three days and repeated if necessary. Infected cattle must be kept in strict segregation, and not allowed to go to the same fields or drinking places as the healthy cattle.

Rinderfest, Cattle Plague or Murrain.

Sinhalose—*Wasangataroga.* Tamil—*Madu-Kotari* or *Madu-Pedi.*

Rinderpest is a very contagious disease, especially affecting cattle and buffaloes, the cause of which is not yet discovered. Sheep, goats, deer, camels, and some swine may be attacked—not man, horses, dogs, or birds.

Symptoms.—Fever, indicated by a rise in temperature from 101·5° F. to 150° F. or over. The animal refuses to eat, and is dull; ears drooped; hair erect over the back, and sometimes shivering is noticed. Breathing is quickened, and a watery or mucous discharge flows from the eyes, mouth and nose. In cows the secretion of milk is diminished or arrested. An eruption resembling scales of bran may be noticed inside the mouth. The bowels are at first constipated, but soon acute diarrhœa sets in, when the dung has a foul smell and is mixed with shreds of mucus and blood. The animal loses strength and flesh rapidly, and may die in the course of a week.

The disease spreads rapidly from one animal to another. If an animal is opened after death, acute congestion and ulceration of the fourth stomach and intestines is noticed.

Dogs and birds by carrying away parts of the carcase help to spread the disease.

The discharges from a sick animal are highly infective.

Prevention and Suppression.—A diseased animal must be isolated, and all cattle in contact with it in separate sheds for at least ten days from the last case. It is a good plan to spray cattle, by means of a garden syringe, over the body with a disinfectant solution and to sponge down the face and nostrils with the solution daily. Sheds should also be sprayed, especially the mangers and floor; walls lime-washed, and the wash should contain some disinfectant.

A teaspoonful of Jeye's Fluid or Cyllin to each pint of water is a useful proportion for this purpose. Sulphur and Gas-tar may be burned near the sheds. Five drops of Jeye's Fluid or Cyllin may be given daily in the food to each animal for four days, stopped for two days, and repeated. Attendants upon the sick must not go to the healthy cattle without washing the hands and feet and changing the clothes. Waste litter, dung, and waste food from the sick cattle should be burned. Dead animals should be buried six feet deep with disinfectant solution or quicklime put over the body.

Care must be taken not to infect the water supply or food.

The law requires all cases to be reported to the nearest headman or police officer.

Recovery from the disease prevents another attack.

TREATMENT.—No particular line of treatment can be relied upon, but the following has been found distinctly useful in this country:—

(1) As soon as the animal is noticed to be ill (it is important to give this in the earliest stage)—

Turpentine, 2 tablespoonfuls (2 ounces) Raw linseed oil or gingelly oil, 1 pint (¾ bottle)	} mixed.

This may be given with advantage to all contacts, as it seems to modify the bowel lesions a good deal if an attack follows, and it can be repeated four days later.

(2) In the case of animals *not purging* give 8 hours after the above ½ to 1 lb. of Epsom Salts dissolved in four bottles of rice congee.

(3) Give daily night and morning for four days—

Quinine, 1 level teaspoonful Arrack, ¼ bottle Rice congee, 4 bottles	} mixed.

After four days give this *once* a day for a week.

If obtainable, ½ dram of Salol may be added to above.

FOOD should be soft—plenty of gruel or congee, tender grass; no hard food should be given until the animal is noticed to be chewing the cud.

Recovered animals should be kept separate from non-infected animals for at least a fortnight after recovery, and the dung burned.

PREVENTIVE INOCULATION.—There are several methods of inoculating cattle to prevent an attack. The following is the simplest:—

SERUM ALONE METHOD.—In this a dose of anti-rinderpest serum—prepared from the blood of cattle highly protected—is injected under the skin by means of a hypodermic syringe and needle (syringe must be perfectly clean and should be boiled before use). It is an easy and safe method, and may be carried out by an owner himself. The protection only lasts about three weeks, and must be repeated. Animals can remain at work. Contacts should be inoculated without delay.

A NOTE ON RAINFALL.

The south-west monsoon usually shows signs of setting in about April. It becomes more daflnite in May, and increases in force towards the end of May or the middle of June. In August or September it continues, but with diminished force; by October the north-east monsoon shows signs of coming in; and by the end of the month, the transition period between the south-west and north-east monsoons, tends to merge into the north-east. The north-east monsoon persists in November, December, and January, when it begins to die away, being replaced by a transition period, which gradually gives way to the south-west in April. During this tratsition period there are often local thunderstorms, but the wind is not confined to any one direction, and it is often calm.

MEAN* MONTHLY RAINFALL OF TWELVE SELECTED STATIONS.

Station.	January.		February.		March.		April.	
	Inches.	† Dys.	Inches.	† Dys.	Inches.	† Dys.	Inches.	† Dys.
Colombo ...	3·29	9	1·83	4	4·14	11	7·07	15
Jaffna ...	2·14	6	1·18	2	1·00	2	2·03	5
Trincomalee ...	6·07	11	2·13	4	1·53	4	1·93	5
Batticaloa ...	9·83	13	3·38	6	2·99	6	1·84	5
Hambantota ...	3·35	7	1·51	4	2·13	5	3·26	7
Galle ...	4·34	12	2·73	7	4·11	10	9·38	15
Ratnapura ...	5·15	11	4·51	9	8·49	15	12·39	19
Kurunegala ...	3·26	7	1·62	4	4·74	8	9·26	15
Kandy ...	4·91	10	2·32	5	3·75	8	6·83	14
Badulla ...	9·55	14	3·14	6	4·35	8	7·51	13
Diyatalawa ...	5·94	14	2·67	9	4·33	12	5·36	16
Nuwara Eliya ...	5·60	12	2·12	6	3·32	9	5·59	14

Station.	May.		June.		July.		August.	
	Inches.	† Dys.	Inches.	† Dys.	Inches.	† Dys.	Inches.	† Dys.
Colombo ...	13·13	20	7·31	20	6·11	18	2·78	13
Jaffna ...	1·85	3	0·71	1	0·98	2	1·57	4
Trincomalee ...	2·49	5	1·30	3	2·15	4	4·25	8
Batticaloa ...	1 72	4	1·02	3	1·27	4	2·24	6
Hambanntota ...	3·19	8	2·34	9	1·59	7	1·26	6
Galle ...	11·43	21	8·11	21	6·05	19	5·44	19
Ratnapura ...	18·19	22	19·73	24	12·91	22	11·80	22
Kurunegala ...	6·51	13	8·22	19	3·97	15	3·37	14
Kandy ...	5·68	13	9·38	22	7·41	22	5·54	19
Badulla ...	4·58	9	2·27	6	2·05	6	3·25	8
Diyatalawa ...	4·87	15	2·00	9	2·27	9	3·60	10
Nuwara Eliya ...	6·86	15	12·73	23	11·83	23	7·90	21

Station.	September.		October.		November.		December.		Annual Average.
	Inches.	† Dys.	Inches.	† Dys.	Inches.	† Dys.	Inches.	† Dys.	Inches.
Colombo ...	5·56	17	13·34	22	10·77	18	4·71	13	80·0
Jaffna ...	2·91	5	9·19	13	14·37	17	10·82	14	48·8
Trincomalee ...	4·69	8	8·08	16	13·89	19	14·12	19	62·6
Batticaloa ...	2·77	6	6·39	13	12·85	18	16·81	19	63·1
Hambantota ...	2·31	7	4·80	11	6·68	13	5·52	10	37·9
Galle ...	7·51	18	13·51	21	11·27	18	6 62	15	90·5
Ratnapura ...	15·02	21	19·11	23	14·24	19	8·95	15	150·5
Kurunegala ...	5·07	15	15·43	21	11·01	17	7·72	14	80·2
Kandy ...	5·98	18	11·73	22	10·48	19	9·17	17	83·2
Badulla ...	3·45	8	9 60	16	10·53	18	12·60	19	72·9
Diyatalawa ...	3·86	12	10·53	21	9·50	21	8 35	21	63·3
Nuwara Eliya ...	8·28	20	11·03	23	8·96	19	8·74	17	93·0

* Over 40 years on the average. † Number of wet days in the month.

EXPORTS OF COCONUT PRODUCTS FROM CEYLON FOR 1922.

(The Ceylon Chamber of Commerce Returns.)

Countries.	Coconut Oil.	Copra.	Desiccated Coconuts.	Coconut Poonac.	Coconuts	Coir. Yarn.	Coir. Bristle Fibre.	Coir. Mattress Fibre.
	cwts.	cwts.	lbs.	cwts.	No.	cwts.	cwts.	cwts.
United Kingdom	300488	255659	32833151	3004	11560498	54[illegible]98	11232	69267
Belgium ...	5903	86995	1503710	101876	295545	600	28210	17070
France ...	1003	13983	1007370	6764	32425	2559	9005	640
Germany ...	05455	143949	9142593	—	980310	21365	14648	36497
Holland ...	13529	192712	948480	2001	1836660	150	6093	1459
Denmark ...	10	255961	383400	62	200	4161	200	—
Italy ...	17003	477991	119600	—	20000	627	25	1313
Spain ...	—	—	1133440	—	255	—	—	—
Norway ...	30416	127989	125710	100	—	2191	—	1749
Sweden ...	10424	62000	102050	—	—	525	—	244
Other Countries in Europe ...	119	4002	11700	—	—	—	—	—
Western Australia ...	—	—	225905	—	—	102	—	840
South Australia	—	—	339446	—	—	362	81	846
Victoria ...	943	—	1863884	—	—	3253	67	4854
New South Wales ...	110	—	1190536	—	—	2877	9	3716
Queensland ...	—	—	344619	—	—	40	—	8471
Other Countries in Australia ...	—	—	10400	—	—	—	—	15
New Zealand ...	94	—	764236	—	—	1302	135	740
United States ...	500	59986	30717479	—	—	525	9	9493
Canada and Newfoundland ...	99	—	2225521	—	8000	—	—	—
Other Countries in America ...	1900	—	1065260	—	—		—	80
Egypt ...	50734	4894	3974	—	7130968	—	—	—
Africa ...	12570	—	588867	—	—	68	311	27871
India ...	2755	657	9490	974	114800	2715	49	3945
Straits ...	—	—	10380	—	—	60	—	1026
China ...	—	—	13742	—	—	418	—	1575
Philippine Islds.	—	—	56	—	—	—	—	—
Japan ...	201	—	4875	—	2460	4613	35791	11064
Mauritius ...	—	—	—	—	1000	—	—	176
Other Countries in Asia ...	180	—	5150	—	104612	19	—	—
Total from Jan. 1 to Dec. 31 ...	554436	1686778	86695024	114781	22087733	102630	105865	202951

INDEX.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VISCOVNT·LEVERHVLME
OF THE WESTERN ISLES