

Diseases of Cacao in Papua and New Guinea

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CACAO in Papua and New Guinea is free from several of the serious diseases which in countries overseas, cause considerable economic loss, such as the virus diseases, and Witches' Broom (caused by the fungus *Marasmius perniciosus*). The rigorous quarantine which has been enforced in the Territory has without doubt been mainly responsible for this state of affairs.

Following are brief notes on the diseases and other conditions which have been recorded on Territory cacao. If any planter is in doubt as to the cause of a condition in his cacao, it is recommended that he contact the local agricultural officer, who, if the condition is not one of the common diseases, will request that specimens be forwarded to Port Moresby for examination. If such specimens are sent, information on the symptoms present, and the extent and duration of the condition will be of the utmost assistance to the pathologists, especially as specimens often deteriorate during transit to the laboratory.

Specimens of leaves and small twigs should be forwarded in a plastic bag if delivery can take place within 24 hours, otherwise they should be put between newspaper and wrapped in brown paper. Pods should be forwarded in a cardboard box—if they are sent in a tin with a tightly fitting lid the resulting high humidity encourages the growth of saprophytic fungi whose spores might be lying dormant on the surface of the pods or which have already invaded the moribund tissue.

The co-operation of every planter is enlisted to report any unusual condition immediately so that steps can be taken to determine the cause with as little delay as possible.

BLACK POD caused by *Phytophthora palmivora*.

Black Pod disease occurs in all the cacao growing countries of the world, but, although

figures for reputed losses are available for many countries, precise methods for assessing loss of crop have not been worked out and it is uncertain if the figures for percentage loss reported by some workers overseas can be directly compared.

Symptoms.

Brown lesions appear on pods 3-4 days after infection has occurred, and production of fungal spores generally begins on the night following the second day of visible symptoms. The spores are produced in large numbers on the surface of infected pods and these are distributed in rain splash droplets.

Pods of all ages can be attacked, but usually the susceptibility of pods increases with age. In some areas the fungus causing Black Pod also contributes to wilt of cherelles, although in many cases Cherelle Wilt is primarily a physiological condition.

Lesions can occur at either end of the pod or in the centre, but usually occur at the place where moisture has been retained, i.e., where drops persist at the tip of pods, or where moisture is retained around the stalk.

The lesions enlarge rapidly and the whole pod becomes brown, and later black (after about 10 days. (Plate I.) At this stage secondary fungi have usually suppressed the primary fungus. During this period, crops of spores are continually produced, and often white powdery spore masses can be seen on the pods. (It should be noted, however, that all white spore masses on diseased pods need not be the *Phytophthora*—they could well be secondary fungi.) The fungus spreads in the pod shell tissue extensively but does not immediately penetrate the beans.



Plate I.—Lesions of *Phytophthora palmivora* on cacao pods.

Organism.

The causal organism is the fungus *Phytophthora palmivora* (Butler) Butler. This species has been recorded on many other plants, but the isolates from cacao were formerly regarded as a biologically distinct strain. It now appears, however, that the cacao strain can attack other plants, e.g., rubber, but further study is needed on the full host range.

The most recent work on the cacao isolates themselves has revealed the existence of distinct strains which differ in lesion development on pods, spore size, and in geographical distribution. This study was done in West Africa and included isolates from many countries, including one from New Guinea.

The spores of the fungus are water-borne and only germinate in water or if relative humidity is over 95 per cent. (Dispersal in air has also been shown to occur, but at present is regarded as being insignificant as far as dissemination of the fungus is concerned.) Spores can also be carried by insects, by hands, and on knives. A few workers are now investigating whether the fungus can survive at all in the soil or

in old pods on the ground, and if so, whether this has any importance in the life cycle of the fungus.

Environment.

Work in many countries has shown that Black Pod incidence increases with greater rainfall and some workers have claimed that atmospheric humidity is important. Infection does not necessarily occur only in a period of heavy rain, but after the infection stage, the disease is generally stimulated by prolonged rains and, as mentioned above, water is usually necessary for the germination of the spores. It has also been claimed that lower temperature might lead to higher incidence of the disease.

It has been shown that the larger the number of pods per tree, the greater the percentage infection, although this tends not to apply at very high levels of infection.

Control.

The most obvious method of control is by the removal of diseased pods from the trees. This immediately reduces the sources of infection and helps to cut down cushion infection. The removal of diseased pods

has been shown to reduce the disease greatly, especially for low yielding trees. For the best results, the pods should be removed as soon as the lesions become evident or, failing that, every week if possible.

The above method of control not only has an immediate effect, but is thought to also have a cumulative effect by reducing cushion infection and soil infection, although more research is needed on the latter before its importance can be assessed.

Chemical Control.

Good control has been reported from some countries with Carbide Bordeaux, particularly on high yielding trees, and by high volume spraying with Bordeaux and other copper compounds, and by low volume mist blowers, particularly with cuprous oxide. In general, organic fungicides have not given good results.

Claims for increases in yields resulting from chemical spraying differ from country to country. The reasons for the varying results are not known, but two factors which might influence the efficiency of the spraying are perhaps whether the infections are mainly distal or proximal on the pod and which strain or strains of the fungus are present (as previously mentioned the strains have slightly different growth rates.)

Resistance.

This would be the most desirable method of control but to date none of the varieties in commercial use shows any degree of resistance. Some reports of resistance have been shown to be merely disease escapes, but the search for resistant lines is continuing. There have been several suggestions that green pods are more resistant than red pods. One of the major problems in assessing resistance is to find a reliable standard method of testing. One of the complicating factors in assessing "resistance" in the field is that infections on low yielding trees are lower than on high yielding trees.

Assessment of Loss.

Losses caused by the Black Pod disease are not as obvious, for instance, as the death of a cacao tree by a root rot fungus, and the losses are sometimes discounted as

unimportant or not worthy of special attention by the Pest and Disease team on the plantation. Only a little thought is needed, however, to calculate the loss of yield per annum if only one pod per tree per month is diseased, and from observation the loss, on some plantations, is far greater than that. It is recommended that a record of the number of diseased pods be kept for two or three rounds of the Pest and Disease team so that the loss of yield per annum, caused by this disease can be assessed on a plantation.

*CANKER caused by *Phytophthora palmivora*.*

At one time this was one of the most widely spread cacao diseases in the world, but since the predominance of other types over Criollo, it has disappeared in most countries.

Symptoms.

Canker is usually first detected in the field when an exudate or drip mark is noticed on the bark or sometimes on the main branches. The liquid can be traced to a small longitudinal crack in the bark, often only half an inch long, which would be unnoticeable without the drip mark. If the bark is cut away in thin slices, with a scalpel, the underlying tissue will be obviously discoloured, usually light brown but often assuming a deep red colour when exposed for a little time. The edge of the canker is distinctly delimited from the unaffected tissue surrounding it. If further underlying slices of bark are removed, the canker will usually be found to penetrate to the wood, but rarely further; only occasionally is the wood also attacked. (Plate II.)

Trees can have one canker, or if severely attacked, many cankers. If very severe the tree can be killed, the foliage becoming gradually thinner over many months.

Organism.

The causal organism is the fungus *Phytophthora palmivora*, but it should be noted that high black pod incidence need not be, and usually is not, correlated with high canker incidence. To illustrate this further, canker rarely occurs in Ghana, where types of cacao other than Criollo are now grown, whereas incidence of black pod is still very high.

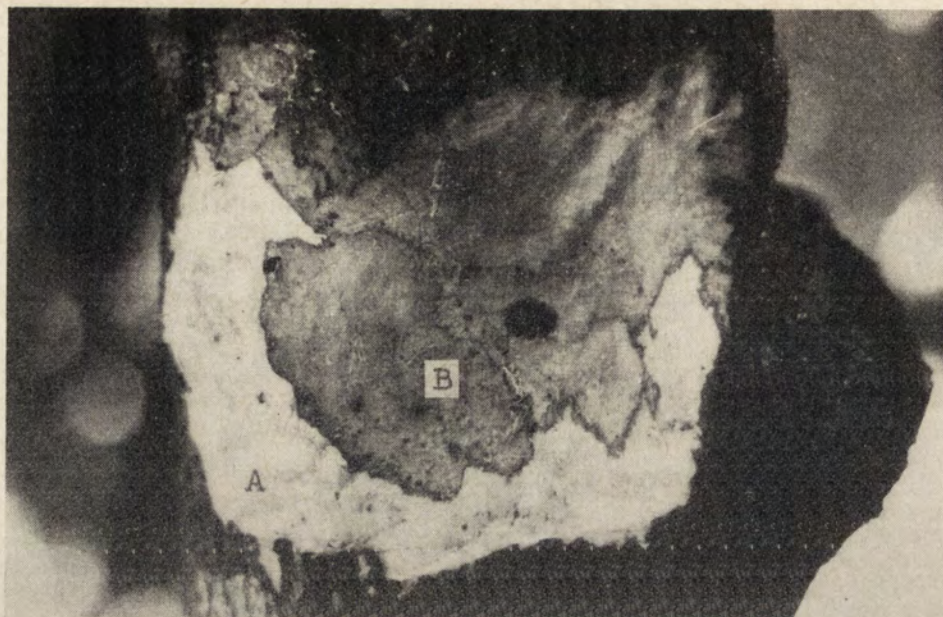


Plate II.—Canker caused by *Phytophthora palmivora* on cacao trunk just below jorquette. The surface of the bark has been cut away, showing unaffected tissue at A and affected tissue at B.

It is not known at present whether the canker-causing strain or strains of *P. palmivora* are the same or different from the Black Pod strains.

Control.

Very often the trees recover from canker as the dry season progresses. If cankers are examined at this stage, a small callus will be noted surrounding the lesion (under the bark). In very dry weather, the whole lesion can dry up, and sometimes separates completely from the healthy wood by a layer of wound cork. Very wet conditions and moist soil, of course, favour the fungus.

The direct treatment of the trees by excising the affected parts has great drawbacks; the trees generally suffer considerably and the remedy is not completely effective. This treatment is therefore not recommended. Shaving off the bark superficially to enable the spot to dry out, so that the fungus dies, has been tried in some places, and painting the shaved lesion with Bordeaux Paste has also been used overseas. However, it is now considered that it is better to prevent infection by strict plantation hygiene, than to cut the trees in

an attempt to excise cankers, as exposed wood and tissues can become sites for secondary fungi and insect attack.

CHUPON WILT caused by *Phytophthora palmivora*.

Occasionally chupons are also attacked, and these then die back. The point of attack is usually in the axil of a leaf, the affected area first becoming darkened in colour, and then sunken. The infection spreads upwards, downwards and around the stem, which then dies.

DIE-BACK OF CACAO.

Ordinary die-back of cacao twigs and branches can be caused by many factors, e.g., attack by various insects, deficiency and toxicity diseases, over-exposure, drought, water-logging, etc. In these cases, one or more lateral buds are stimulated to develop (following the death of the terminal) and normal growth is resumed if and when the causative factor is corrected.

If a branch with ordinary die-back is split longitudinally, the dead wood will be seen to stop abruptly, with normal, unmarked wood directly below.

Die-back of cacao in West Africa has usually been associated with capsid damage or periodic drought, although the factors of soil fertility, thrip damage, and invasion of the fungus *Calonectria rigidiuscula* following capsid attack have also been important. Cacao trees in Ghana infected with virus die back more rapidly when infected with *C. rigidiuscula*.

Botryodiplodia die-back occurs when the fungus enters through damage, wounds or weakness, as listed in paragraph 1, usually at the tip of the branches or twigs (both terminal and lateral). (Plate III.)

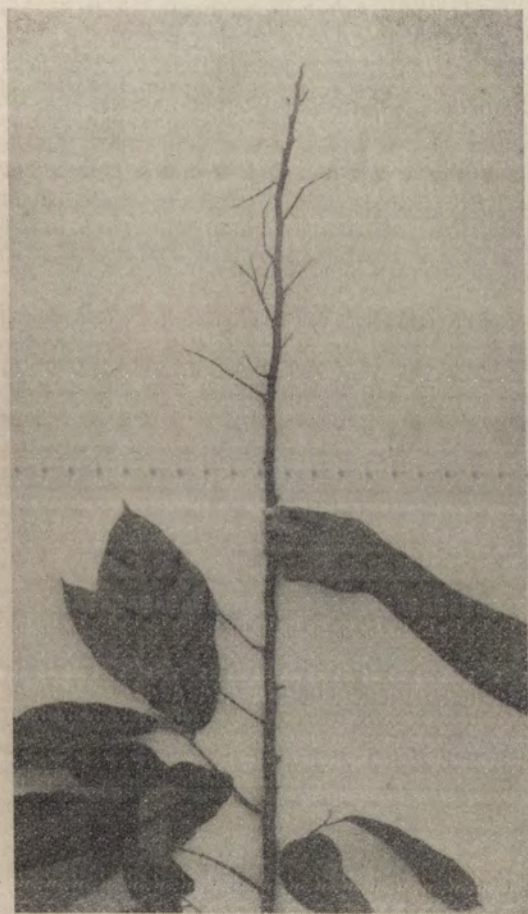


Plate III.—Terminal die-back of cacao.

Botryodiplodia die-back has been recorded in many cacao-growing countries of the world, particularly in Ceylon, Trinidad and North Borneo, and is in fact one of the oldest known diseases. It has been present in New Guinea for many years and in 1938 it was recorded as being widespread in the Gazelle Peninsula. Little was heard of it during the early post-war years although undoubtedly it did occur.

Symptoms.

The main symptom is death of the extremity of the twig (either lateral or terminal) or branch. Below the dead area (i.e., proximal to the trunk) the bark is apparently healthy but when the twig or branch is split longitudinally, light brown streaks are found to occur in the wood for some distance, until they imperceptibly fade away, and apparently unaffected wood is reached.

From research work which has been carried out in the Territory during the last few years, it is now known that the fungus can be isolated from the dead areas, from the area with streaks, and even from the apparently healthy wood below the streaked wood, the distance varying with size of twigs and branches, vigour of the tree, etc.

Once the fungus gains entry into the wood of the tree it will continue growing, especially if the tree is not in the most vigorous health (through root rots, repeated insect attacks, over-exposure or water-logging, etc.), and unless action is taken to prevent it, succeeding branches and eventually the whole tree will die.

Often associated with the die-back are the following:—sponginess of bark, increase in thickness of bark, enlargement of lenticels (giving a rough bark) and prolific production of lateral buds (which, however, often wither quickly). Some at least of these symptoms, however, can occur even when this fungus is not involved, e.g., enlargement of lenticels with disturbed physiology.

Organism.

The fungus isolated from affected tissue is *Botryodiplodia theobromae* Pat. This fungus is pan-tropical and occurs on the moribund parts of many plants, including old cacao

Pods, where spores are produced in abundance. There is no evidence that it can attack healthy undamaged cacao wood, or that there has been any change in its virulence in recent years. Once it gains entry the fungus can proceed down the inside of the branch in the wood without difficulty.

The pycnidia or spore bodies of the fungus do not readily form on die-back branches, although occasionally they are found. Once the bark dies, secondary fungi (many of which have now been recorded) invade the dead tissues and sporulate on the surface, especially on the lenticels.

Control.

The first requirement is to prevent, if possible, any factor which damages the tips or weakens the cacao (such as insect attack) or to adjust other factors (such as over-exposure or soil deficiencies) which reduce the vigour of the trees.

Trees should be kept under close observation by the manager, and any die-back should be immediately reported by the Pest and Disease team. As soon as it is noticed, the dead twig and the streaked wood below and at least one foot-two feet of good wood below that should be removed. If this is done as soon as the condition is reported, not much damage will have occurred.

If the condition has been allowed to progress unchecked, then more severe pruning will be necessary. The ability of the tree to overcome any mycelium or fungus threads left in the branch after pruning, depends on the amount of fungus left in the tree and the vigour of the tree. Therefore, any practice which promotes the health and vigour of the tree will assist it to recover; judicious fertilising has been particularly successful on some plantations, and an insecticide programme might need to be considered. After pruning, the trees should be kept under close observation and any branches with a profusion of lateral twigs which are not vigorous should be especially examined, and removed if fungus is still present.

If a young seedling is attacked, remove the branch at the jorquette; if streaking occurs below the jorquette, stub the tree back to

about three inches above ground level; if streaking is still present at three inches above soil level, replace the seedling.

If die-back does occur, prompt action before the fungus progresses far in the seedling or tree is imperative in order to prevent greater losses. It is emphasised, however, that the best insurance against the disease is the preventive measures designed to keep and maintain the trees in an undamaged condition and in vigorous health at all times.

BOTRYODIPLODIA POD DISEASE.

Occasionally, in areas of low rainfall or in the dry season, a pod rot occurs from which *Phytophthora palmivora* cannot be isolated, but from which *Botryodiplodia theobromae* is obtained. The first symptom is a brown spot which becomes enlarged until the whole pod is black. On the mainland, loss of pods in this way is very rare. On the Gazelle Peninsula it seems that pod loss caused by *P. palmivora* might decrease to some extent and pod loss by *B. theobromae* rise slightly during the dry season.

ROOT ROTS.

Root rots of cacao occur to some extent in all the cacao growing areas of the world. Some of the fungi causing root rots on rubber are identical with those affecting cacao, and most of the research work which has been carried out on these species has been done by workers at the Rubber Research Institutes at Kuala Lumpur (Malaya) and Ceylon.

Symptoms.

The first sign of root rot is usually a slight yellowing of the leaves followed by death of the tree, often in a week or so. The dead leaves usually remain hanging on the tree for some time, as the quickness of the last stages does not allow the formation of an abscission layer at the base of the petiole.

It must be noted that, although final death occurs quickly, the first penetration of the fungus would have occurred months previously, and the fungus would have been permeating the tissues since that time.

On the outside of the affected tap root and laterals, strands of mycelium or fungal threads can sometimes be noted; some fungi, however, form a sheath rather than strands. In all cases the colour of the mycelium seen is a diagnostic character, and it should be noted whether it is stranded, sheathing or patchy and whether it is black, white, brown, purplish or some other colour.

Note should also be made as to whether soil is adhering to the outside of the tap root or not—some species of root rotting fungi secrete a substance which cements the soil particles to the bark, and these particles still adhere even when vigorously rubbed. (Plate IV.)



Plate IV.—Cacao infected with root rot. Note soil encrusting the tap root.

The fungus usually runs along the laterals until the collar is reached just below soil level, and it is in that region that the main penetration occurs.

One common form of one of the fungi on cacao (and on *Leucaena glauca*) is as a velvety to hard brown crust encircling the collar and lower trunk, sometimes up to one foot above soil level; this is clearly visible to the naked eye.

In order to be quite certain, however, that the death of a tree has indeed been caused by root rot, the trunk should be severed about three feet above soil level and then the collar and tap root split longitudinally and the newly exposed faces of each half examined. (Plate V.)



Plate V.—Same tap root as in Plate IV, split longitudinally to show discoloured interior.

Note first the undiseased wood at the uppermost part of the collar, particularly its colour and texture. Then note the wood about the region of soil level—if a root rot fungus is present, the wood will be a different colour, often lightish brown (but quite hard) and the discolouration will extend up the trunk for some distance and often down into the taproot and some at least of the laterals. Often the wood about soil level or just below has reached the last stages of rot—it loses its light brown colour and looks bleached, with a texture so soft that pieces can be broken off with the finger nail. Some of the root rotting fungi can also form "black lines" in the affected wood.

This examination should be carried out as soon after the leaves have wilted as possible; if the examination is delayed, difficulty will be experienced in distinguishing the unaffected wood from the diseased wood.

Organisms.

The main root rotting fungus recorded on cacao in the Territory to date is *Fomes noxius* Corner. The other fungi which can be concerned are *Fomes lignosus* and species of *Ganoderma*.

The identification of the fungi is made from brackets, but it should be noted that it is quite uncommon for brackets to occur on cacao; usually the tree dies and is removed before brackets can form. It must also be remembered that brackets which occur on old cacao wood could be those of secondary Basidiomycetes which help to break down moribund tissue.

The positive identification of any root rot fungus cannot be made unless the brackets are present, but a *probable* identification can be made from an examination of the symptoms, the type and colour of mycelium and rot produced, adherence of soil, presence of black lines, etc.

Source of Inoculum.

It is generally considered that the primary source of inoculum occurs from infected roots of forest trees which were allowed to remain

in the ground. Please note that *all* forest tree roots would not, of course, be infective, but only those which were carrying the disease originally. (This is mentioned because it is a point which is often misunderstood.)

If diseased cacao trees are removed as soon as they are observed, the inoculum from the primary forest will be used up in about five-10 years. However, if diseased cacao roots are not removed, a further build-up of inoculum will occur and new cacao trees will be infected from the old diseased cacao roots.

It is generally considered, though it is not finally proved, that there is very little, if any, spread of these types of root disease by spores borne on the brackets of fruiting bodies.

Control.

As will be apparent from the above, the diseased taproot and laterals must be removed and burnt.

It is important to note that the ability of the fungus to infect is correlated with the size of the infective piece, and any piece of root with a volume of more than a few cubic inches is regarded as dangerous. While smaller pieces are considered unlikely to support the successful infection, they are still regarded as possible sources of infection.

Overseas experiments have been carried out for many years in an endeavour to detect and treat root rots at an early stage. These experiments, however, (which were carried out on rubber), entail careful freeing of the base of each tree from the soil, inspecting the collar and laterals near the collar, scraping off fungal rhizomorphs or strands, if present, and painting with fungicides (originally copper compounds and more lately organic mercurials such as "Tillex"). However, the interpretation of the results of these experiments is still under discussion and at present these treatments are not recommended. It will be apparent, anyway, that the cost involved of examining much of the root system

of every cacao tree even once in six months would be quite out of the question. It is also thought that the damage done to the roots during the inspections might do more harm than any odd attack of root rot. The above is only mentioned here in case some reference from outside the Department is made to these experiments.

Some planters like to dig a trench around the infected site, at a sufficient distance to encompass all the laterals, the trench being about one foot wide x one foot deep. If soil is sandy and labour available, this can be done, but it is preferable to devote the time and labour to removing all the laterals.

If all the inoculum or infected root pieces are removed from any one site, it is theoretically possible to replant immediately. If it has not been removed, then replants are exposed to infection—whether they become diseased or not depends on the number, size and position of the infective pieces.

Assessing Loss.

It is strongly recommended that records be kept on the plantation as to the number and position of root rots. The Pest and Disease team can be trained to report immediately the death of trees; these should be split longitudinally and checked by the manager or staff for the presence of root rot and if so, the appropriate control measures carried out. A record should be kept of the position of the tree, and the neighbouring trees kept under observation.

It is important that the number of trees lost by root rot be noted. On the other hand, undue attention is sometimes paid to root rot losses, because dead trees are obvious, whereas less spectacular loss (such as continual loss of pods throughout the year by *P. palmivora*) is often overlooked. Against this however, the cumulative effects of root rot over the years, if adequate control measures are not carried out, should not be discounted. If records on the number and position of trees lost by root rot are available each year, a true assessment of the importance of this disease on a plantation will be available.

OTHER ROOT AND COLLAR DISEASES.

Other root and collar diseases caused by fungi such as species of *Rosellinia* and *Armillaria mellea* and *Ustilina deusta*, have been reported on cacao (and other crops) in various parts of the world, but only a few have been reported occurring on cacao in New Guinea.

If any of these are suspected, it is recommended that specimens be forwarded for examination.

PINK DISEASE caused by *Corticium salmonicolor*.

Pink Disease is caused by the fungus *Corticium salmonicolor* Berk. & Br. which attacks many arborescent plants in the tropics, including cacao, coffee, rubber and citrus, as well as many leguminous shade crops.

The fungus occurs first as fine silver-white threads on branches, and at this stage is often overlooked. Later the cobwebby threads transform into the well-known, easily recognized pink-white crust, like kalsomine. The crust which usually forms on the under-surface of the branch, is at first continuous but later a fine network of cracks, mainly at right angles to each other, divides the surface.

The sexual spores of the fungus can form on the pink crust, but they are not visible to the naked eye. They can be windblown and therefore constitute a source of inoculum at a distance. The crust, however, is often sterile. The asexual or vegetative spore form (once thought to be another fungus called *Necator decretus*) has only been recorded to date in the Territory on coffee over 4,500 feet. The spores form as bright orange pustules about the size of a pin's head, on the upper surface of the branch (i.e., on the opposite side to the crust), protruding through the bark. These spores are water-borne.

Some of the fungal threads in the region of the crust penetrate the bark and may enter the wood, killing the upper part of the branch.

Pink disease does not occur often on cacao in the Territory and rarely causes any damage. Infected branches can be removed and burnt. Care should also be taken to see that other host plants which commonly occur in or near plantations, such as citrus, *Crotalaria anagyroides*, pigeon pea (*Cajanus cajan*), *Tephrosia candida*, and *Eriobotrya japonica* (loquat) are not infected or providing inoculum for adjacent cacao.

WHITE THREAD BLIGHT.

White Thread Blights occur occasionally on cacao in the Territory, especially in regions of high rainfall, but are seldom of economic importance.



Plate VI.—White thread blight on undersurface of cacao leaf and on stems.

The fungi causing White Thread Blights are probably species of *Marasmius*, *Marasmiellus* or *Corticium* but, as they usually occur as fungal threads only, without producing spores, the specific identification usually cannot be given. One collection from Bougainville with spore-bodies present has been identified as *Marasmius cyphella* Dennis and Reid while another from New Britain proved to be *Marasmiellus* sp.

The White Thread Blight fungi occur on the under-surface of the leaves, having spread along the petiole and up and down the branches. (Plate VI.) The leaves die prematurely and the petiole or leaf stalk breaks off at the junction with the stem. The leaves remain attached to the branch, however, by the fungal threads, but can be easily detected as they are brown and papery and hang vertically. As far as is known, the disease is spread by contact (e.g., piece of fungal thread carried by birds, insects, on pruning shears, etc.).

The spore-bodies are small white plaques of fungal material about quarter inch wide, appressed to the leaves, something like a tiny flattened mushroom without a stalk. We are anxious to receive any collection of White Thread Blight showing these fruiting or spore-bodies.

The blights can be easily controlled by removing infected branches and burning, at the same time checking shade and thinning if it is too dense.

HORSE HAIR BLIGHT.

Horse hair blights, caused by species of *Marasmius*, occur on cacao occasionally, but do little damage. (Plate VII.) The fungi cannot be identified from the black "horse hair" strands alone; the fruiting bodies, which are like small fragile mushrooms on slender stems, have to be present. Any collection with the fruiting body should be forwarded to Port Moresby for identification.

SOOTY MOULDS.

The sooty moulds include many different species of fungi, all black to the naked eye, which live on leaf and stem surfaces, and are particularly abundant in the tropics.



Plate VII.—Horse hair blight on cacao. Note dead leaves still attached by the black threads to the stem.

Many of these fungi are quite superficial and do not penetrate the leaf surface at all, mainly subsisting on insect honey dew or excretions from aphids and scales. If the "soot" or fungal material is carefully scraped with the finger nail, match or knife, the underlying leaf tissue will be seen to be quite undamaged.

Another group of these fungi is also superficial on the leaf surface, but they may attach themselves to the leaf by means of pegs or holdfasts. Others may adhere to the

epidermal cells of the leaf so intimately as to absorb their food, while others may send feeding organs or haustoria into the host tissues.

The sooty moulds are of no economic importance.

ALGAL SPOT.

This spot is caused by an alga, *Cephaleuros virescens* Kunze, which grows mainly epiphytically on the leaf surface, causing very little damage to the underlying tissue. With a hand lens the colony will be seen to consist of reddish filaments, topped by reddish spherical bodies which are the spore cases. The spot is rare on cacao in the Territory, but is abundant on many other trees, e.g., guava, citrus, coffee, etc.

Occasionally a fine fur, or short reddish down, can be seen on young cacao tips in some areas, if examined with a hand lens, although it would probably not be noticed with the naked eye. This fur consists of the filaments of the alga *Cephaleuros minimus* Karsten.

LICHENS.

Cacao leaves bearing colonies of lichens suspected of causing disease are sometimes received for identification. However, they are quite superficial and cause no damage whatsoever.

The lichens usually resemble small white circular crusts from 1-3 mm. in diameter on the upper surface of the leaves. They can be easily removed from the leaves with the fingernail, a match, or a knife blade, without any damage to underlying tissue.

A lichen colony consists of a fungus and an alga (many different species of both) growing symbiotically and because both prefer humid conditions, the colonies are usually most abundant in heavily shaded plantations or near the protected basal leaves of the plant. They are of no importance themselves but their abundance can be taken as an indication that humidity is very high and discreet thinning of shade might be desirable.

ENTOMOGENOUS FUNGI ON CACAO LEAVES.

Different sorts of fungi can parasitise live insects, or grow on dead insects. Occasionally the insects die on the leaf surface, and the fungal threads extending out from the invaded insects might be mistaken for fungi attacking the leaf. However, the fungal colony and the remains of the insect can be lifted off and the underlying plant tissue will be seen to be intact. (Plate VIII.)

DISEASES CAUSED BY SOIL DEFICIENCIES.

Various abnormalities of cacao in the Territory are caused by soil deficiencies, (e.g., zinc) or toxicities (e.g., salt spray on leaves), but these diseases are not featured in this article.



Plate VIII.—Fungus growing on insect on surface of cacao leaf. The fungus does not affect the leaf in any way.