# SCHEME FOR THE INVESTIGATION OF THE ROOT AND LEAF DISEASES OF THE COCONUT PALM IN SOUTH INDIA

## CONSOLIDATED FINAL REPORT OF WORK DONE FROM 8TH MARCH 1937 TO 31ST MARCH 1948

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### INTRODUCTION — ECONOMIC IMPORTANCE

TO the people of Travancore-Cochin, coconut is the most important money crop and the peace, contentment and happiness of the people of these areas depend far more on the coconut palm than on any other single item. The loss sustained by the coconut industry due to ravages by the coconut diseases is colossal. It was reported in an earlier publication (Menon and Nair, 1948) (1) that the estimated loss caused by the leaf rot disease of coconuts in Travancore amounted to 56 lakhs of rupees a year. The wilt or root disease of coconuts is a far more serious disease and, therefore, it may be computed that the annual loss due to the coconut diseases to the coconut industry is to the tune of more than one crore of rupees. (Menon and Nair) (2).

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### DISTRIBUTION OF THE DISEASE IN TRAVANCORE-COCHIN

There is record to show that the disease was in existence in the State more than 75 years ago at Erattupetta in Meenachil taluk. Later on it was reported from Kaviyur and Kalloopara in Thiruvella taluk and a little later from Kayangulam. It may be mentioned in this connection that these places are more than thirty miles distant from one another and the coconut areas intervening were devoid of any disease

symptoms. It my, therefore, safely be assumed that the disease broke out in Travancore from more than one independent focus of infection and since then it has been spreading steadily. Along with the leaf rot disease of coconuts root disease also occurs in a virulent form in Meenachil, Changanacherry, Thiruvella, Kayangulam etc. The northern boundary of the disease zone lies between Narakkal and Thottuva in the north and the southern boundary lies between Quilon in the south-west and Punalur in the south-east. The coconut palms within this area may be seen to be suffering from the diseases in different degrees of infection. It is believed that the disease made itself significantly manifest after the great floods of 1882, when the land was waterlogged for a considerable period. It cannot, however, be definitely said to what extent waterlogging of the soil is responsible for producing pre-disposing conditions for disease incidence even though it is seen that the coconut palms growing on the banks of rivers which remain flooded for some days every year show disease symptoms in a severe form. In 1900 an officer of the Travancore Agricultural Department who was deputed to report on the disease, postulated two probable causes for the disease (3) one of which was an indirect and predisposing cause and the other a direct one in the shape of an insect or fungus attack. In 1906 Mr. T. F. Bourdillon (4), Conservator of Forests, Travancore investigated the disease and he concluded that it was fungoid in character, probably identical with the "bud rot" of coconuts in Ceylon and the "pythium" rot of palmyra and coconuts in Godavary. He was of the opinion that the disease was infectious and hereditary in character and that for its rapid spread some predisposing factors were necessary. The problem was next tackled by Dr. E. J. Butler (5), Imperial Mycologist at Pusa in 1908. He visited the infected areas of Travancore, collected samples of diseased material, examined and analysed them and prepared an exhaustive report on his findings. Butler refuted Bourdillon's suggestion that the disease was similar to the bud rot of palms in Godavary and said that a rotting of the bud occasionally met with was not of primary importance with regard to the etiology of the disease. According to him the disease manifests itself chiefly through alterations produced in the leaves and the roots. The wilting of leaves and discolouration of leaflets are not produced by parasitic attack. The leaf tissue becomes pale and flaccid probably due to a condition of drought and starvation. He observed that the lateral roots affected by

rot were invaded by a parasitic fungus which kills the cortical cells. They quickly turn brown and collapse. At a later stage the whole root appears blackened and shrunken and as a result of the destruction of a large number of cells it becomes useless for food absorption. He isolated a species of *Botryodiplodia* from infected roots and stated that probably the root rot produced by the fungus was sufficient to produce the disease. In 1920 a Mycology section was started in the Agricultural Department of Travancore State. Work carried under its auspices (6) showed that what was loosely termed "The Coconut Palm Disease of Travancore" was not a single specific disease, but consisted of different diseases like "Bud rot", "Leaf rot", "Leaf Blight" etc. As control measure the Department advocated the eradication of infected trees. Slowly and steadily the disease was on the increase and by about the 1930s its intensity grew to alarming proportions.

## THE SCHEME

As a result of the seriousness of the disease and its eventual impact on the most important industry of the State, a scheme for the investigation of the different diseases of coconuts, chiefly the root and leaf diseases was started by the Travancore State with financial aid from the Indian Council of Agricultural Research. The scheme was actually commenced in Travancore on 8th March, 1937 and was to run in the first instance for a period of three years. The scheme was subsequently extended from time to time to 31st March 1948. From 1st April 1948 it was absorbed as a part of the work of the newly formed Central Coconut Research Station, Kayangulam of the Indian Central Coconut Committee. Particulars regarding the sanction of the scheme, the expenditure involved and the staff who worked the scheme from time to time are given in appendix 1. The authors gratefully acknowledge the financial and other help rendered by the Government of Travancore-Cochin, the Indian Council of Agricultural Research and the Indian Central Coconut Committee without which it would have been impossible to undertake this all important investigation on coconuts.

A consolidated account of the work done under the scheme from its inception in 1937 to the end of March, 1948 is given in this report.

## SURVEY OF DISEASE

During the period under report extensive tours were made in the coconut areas of Travancore and Cochin. The particular and peculiar conditions obtaining in different localities, the respective percentages of crop infection etc., in diseased areas were recorded. Samples of soil, root, leaf etc. were collected

for examination and analysis. The root and leaf diseases of coconuts were met with in most of the places visited in Central Travancore. The areas bordered by Quilon in the south-west, Punalur in the south-east, Oachenthuruthy in the north-west and Malayttur in the north-east may be considered as the infected area in the Travancore-Cochin State. A map showing the distribution of the disease in the Travancore-Cochin State is given in the report (Plate I)

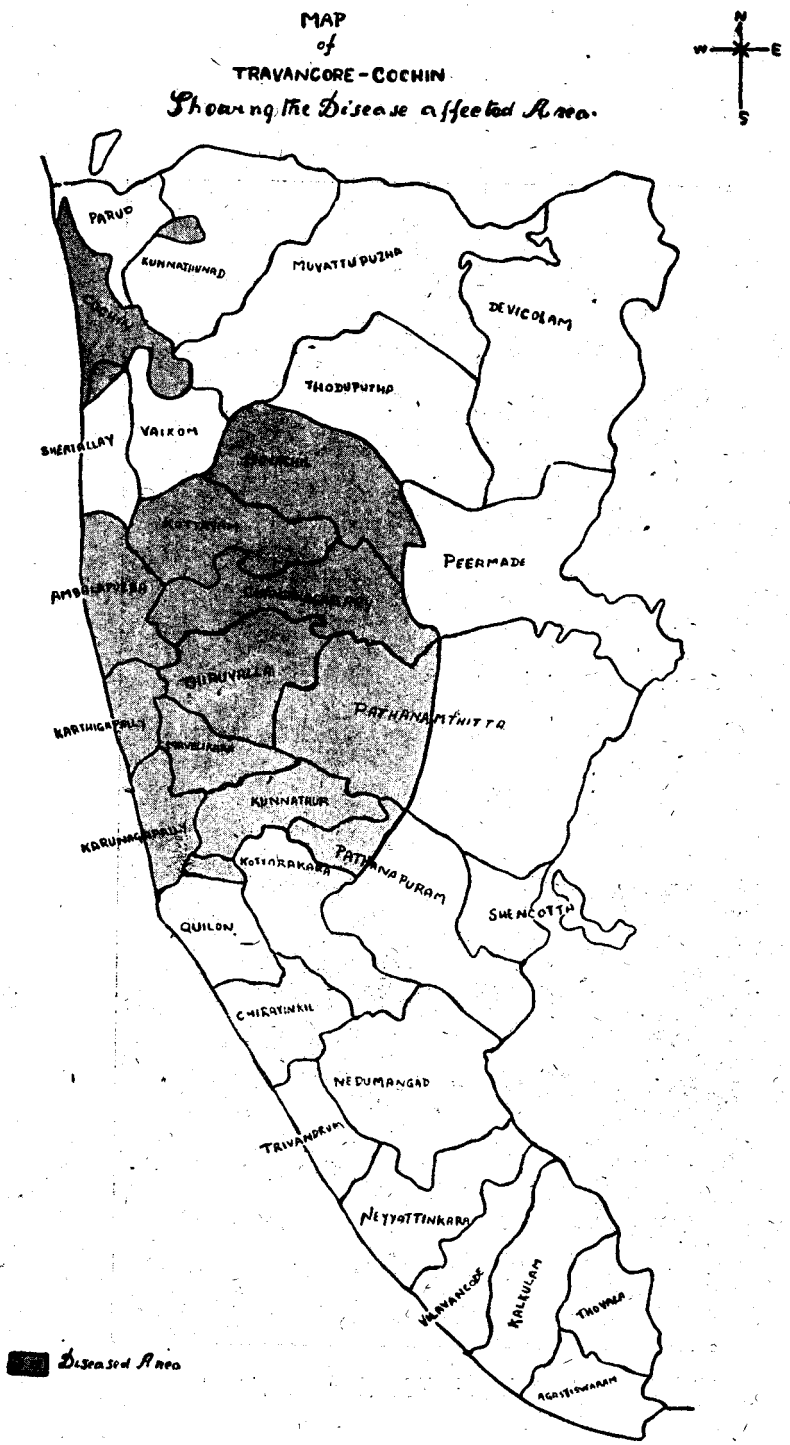
In this tract the disease occurs in varying degrees of intensity. Very heavy infection is observed in the coconut areas surrounding Kayangulam, Alleppey, Thiruvella, Changanacherry, Meenachil, Erattupetta, Pathanamthitta, Mattancherry, Ernakulam etc. Similarly on the banks of the rivers in Central Travancore, like the Meenachil Aar, Pamba Aar, Manimal Aar, Achankovil Aar, Kallada Aar etc., the coconut trees can be seen to be severely infected. The courses of these rivers were traced from their estuaries to almost the high ranges and the coconuts growing on either banks were invariably observed to be diseased. From young seedlings to very old palms the disease has been found to exist. Differences in soil also appear to have little relation to disease incidence since coconut palms growing in all different soil types show disease symptoms. Usually in a garden it is the heaviest yielder that develops disease symptoms first. The leaf disease of coconut occurs along with the root disease and generally the same palm shows symptoms of both the diseases (Plate II). Cases of 'bud-rot', 'stem-bleeding' etc. were also met with during these tours of observations.

## SYMPTOMS

### *A. ROOT DISEASE OR "WILT DISEASE" OF COCONUTS*

The most common obvious symptom of the disease is a general yellowing and drooping of the outer whorl of leaves. Generally in a healthy palm it is common for the oldest leaf to become yellow in colour before it falls off. But when a coconut palm is infected with the disease, not only the oldest leaf, but the entire outer whorl develops a yellow colour and droops. In some cases a sickly pale yellow colour is developed in the leaves of inner whorls also. All the leaves of an infected palm become flaccid, the leaflets curling slightly at the tips and the observer gets the impression that some derangement has taken place in the normal metabolism of the palm arresting its normal growth and development. The leaflets soon become brown in colour and start drying up from their tips. The

MAP
of
TRAVANCORE-COCHIN
Showing the Disease affected Area.




The shaded portions in the map alongside show the areas in which the Root and Leaf diseases of the coconut palm are prevalent in the Travancore-Cochin State.

Plate I

COCONUT ROOT AND LEAF DISEASES (combined)

Plate II

leaves are shed in quick succession. After a palm is infected the leaves that are subsequently produced in it get smaller and progressively stunted in size. They are also shed quickly and the crown gets greatly reduced in size. In a coconut palm the presence of a large number of leaves is an index of its health, vigour and productivity. The reduction in size of the crown adversely affects the normal growth of the palm and it starts tapering at its growing point. A photograph of diseased palms is given in Plate III.

Shedding of all immature nuts, if the tree is bearing at the time of infection, is an important and early symptom of the disease. This might happen either before the yellowing of leaves occurs or soon after it, but these two symptoms are sure signs of initial infection. The shedding of nuts stops after a few months. The tree now appears to be considerably weakened. The spathes that appear later are smaller and weaker and the inflorescence contains fewer female flowers. This adversely affects the yield of the infected trees. The quality of nuts also is affected. The husk is thinner and the fibres weaker. The shell does not harden properly. The kernel or endosperm is thinner and when it is converted into copra it does not dry up properly, but remains soft and flexible. The milk of the tender coconuts in infected trees has a flat and insipid taste.

In very advanced stages of the disease the spathes of infected trees become very small and weak and in some cases they are unable to burst open normally. All this time the heart of the crown remains healthy. It dries up after the tree is completely exhausted or in its weakened state it falls an easy prey to the bud-rot organism which quickly develops a soft rot, destroying the crown which is blown off in the wind leaving the headless stem.

The roots of the infected trees show distinct deterioration. The cortex develops a deep brown discolouration and dries up in flakes. Under the microscope the Cortical portions may be found to be interspersed with fungal hyphae. In order to examine *'in situ'* the root systems of infected palms, trees showing typical symptoms of the disease in different stages were selected. Trenches about six feet in depth were dug at right angles some distance from the base of these stems, thus separating a quadrant at the base of each. The soil within this area was washed out by applying a powerful jet of water with a foot pump and bailing out the soil that was being washed down into the trenches. A fourth part of the root system could thus be exposed for examination. In the case of trees in advanced stage of the disease

the roots were found to be in an extreme state of deterioration. The horizontal feeding roots which are so necessary for absorption of food materials from the soil had nearly all been destroyed. The vertical water roots when traced along their courses easily crumbled up and broke away due to their tips being rotten. When infected roots were split and examined, a dark stain was observed proceeding upwards along the roots. With trees showing symptoms of the disease in its earlier stages, the root system was observed to be quite elaborate and comparatively fresh. Horizontal roots were found in abundance and were branching profusely. These were traced along their courses to over 30 feet and were found to be quite fresh and healthy, but ultimately their root tips were found to be damaged by rot. The vertical water roots grew straight into the water table and were healthy. The percentage of rotten roots in such trees was small and they appeared to have adequate supplies of healthy roots to carry on the normal function of food absorption. Still these trees were showing visible external symptoms of the disease. A coconut palm in normal health puts forth a fresh complement of new roots every year to replace those that may be destroyed. When a tree becomes infected its capacity to produce fresh roots is weakened. With the onward progress of the disease lesser number of roots are produced progressively every year. The disease lingers on undermining the health of the tree till, in course of time, the latter succumbs to it. The boles of trees examined were quite healthy. When conditions for growth of the palm are favourable with improvements in cultivation, drainage and manuring, the disease symptoms become masked while discontinuance of these operations brings about a relapse of the disease.

### *B. LEAF DISEASE*

The first visible symptom of the disease is a blackening and shrivelling up of the distal ends of leaflets in some of the inner whorls of leaves. On drying up, these are broken off in bits by the wind and the infected leaves assume a fan-like appearance which is characteristic of the disease. The central spindle also gets infected. Reddish brown spots and patches appear on the tender leaves and these penetrate to some distance into the interior of the shoots. The spots enlarge in size and a soft rot of the central shoot is gradually developed which in its later stages attracts a large number of insects and maggots. The central shoot grows and when the weather gets hot and dry, the rotten portions dry up, turn black and fall off in the wind. If the disease is allowed to

proceed along unchecked, each successive central shoot of a diseased tree gets infected in turn and a stage is soon reached when all the leaves of the tree show disease symptoms. In severe cases the rotten portions, on drying up, will be so completely cemented together that the central shoot is prevented from opening out. Generally the progress of the disease is slow because the hardening of leaf tissue due to maturing of leaves acts as a limiting factor. The severity of attack is generally apparent on the tender leaves. The 'leaf rot' disease does not kill the palm outright, but it progresses slowly and steadily until finally the tree succumbs to the disease. Due to disease attack the leaf lamina gets destroyed and this reduction in leaf surface adversely affects carbon assimilation, thereby causing considerable reduction in the yield of coconuts. 'Leaf rot' disease has been observed on trees of all ages, but it generally flourishes on palms below 25 years of age. It does not attack seedlings in the nursery stage. It is most severe during monsoons when the atmospheric humidity is high. Illustration of trees infected with leaf disease is given in Plate IV.

## DISEASE PROBLEMS IN OTHER COCONUT GROWING COUNTRIES

*West Indies:*– Two forms of wilt have been described by Briton–Jones (7) in the West Indies, namely, the "Bronze Leaf Wilt" and the "Tapering Stem Wilt". Of the two the Bronze Leaf Wilt is the more serious problem there. Briton–Jones and Bain (8) who investigated the disease in Trinidad are of the opinion that it is a non-parasitic wilt caused by unsuitable soils which inhibit the proper formation of an adequate root system, thereby reducing the necessary supply of water to the palm in dry weather. Bain tried to correlate soil factors with the incidence of bronze wilt. He collected soil samples from wilt and wilt free areas in Trinidad and examined them for texture, reaction, organic matter, nitrogen content C/N ratio, available potash and available phosphate. He could get no correlation between the chemical soil factors but concluded that physical condition of the soil and allied water relationship are important. He classified wilt soils into three types: (1) surface soil close textured and overlying a sub-soil which is impervious to water; (2) (a) soil and sub-soil open textured and free draining leading to poor water supply in dry weather and (b) soil and sub-soil compact, drying out quickly in times of drought; and (3) friable top soil with an intolerant sub-soil layer. Martyn (9) who worked on a similar disease in Jamaica is, however, of the opinion that the experimental evidence on which this theory was based is somewhat scanty. He

thinks that the appearance of 'bronze wilt' in Jamaica is suggestive of an infectious disease and that a disease of a virus nature could be considered as possibility. After Martyn, investigations on this disease in Jamaica were continued by Leach (10). He made a detailed study of the symptoms and stated that Martyn was fully justified in maintaining that Bain's hypothesis could no longer be accepted as an explanation for the behaviour of the disease in Jamaica. He visited Trinidad and British Guiana and made a comparative study of the symptoms of the disease obtaining in these places at first hand. As a result of his investigations he came to the conclusion that the Jamaican disease was not the same as the bronze wilt in Trinidad. He gave it the name of "Unknown Disease of Coconut Palm in Jamaica". He thought that the disease may be associated with a facultative root parasite but that soil conditions might be the main controlling factor in as much as they affected the nutrient status of the palms. He also suspected deficiency of some minor or trace element as responsible for producing pathological conditions. In his opinion the problems had to be tackled simultaneously from the plant pathological, physiological and chemical aspects.

*New Guinea*.— In New Guinea coconut disease has been receiving attention for a long time by Bryce (11), Dwyer (12), etc. Dwyer gives the following description of the condition of coconut palms affected by root disease. "The outer leaves of palms affected wither and hang, dropping downwards around the stem. The central upright leaves and the unfolded sword-like leaf remain green and of full size. A few green half-ripe nuts may remain on the palm while the bud is quite sound. Later the outer drooping leaves fall away leaving a cluster of upright leaves at the top of the stem. This condition may persist for some years, the new leaves formed being successively smaller until at last they wither away and the bud decays. The palm in this condition does not set any nuts and later ceases to produce spathes and flowering bunches. It is hardly necessary to point out that this description fits in accurately with what occurs under conditions of soil deficiency causing die-back, incipient chlorosis of the coconut palm".

The bronze wilt disease of the West Indies was not of much importance in New Guinea. According to Dwyer diseases associated with soil deficiency, soil exhaustion or unfavourable soil conditions were proving a serious menace to the coconut industry there. A disease of young coconut palms known as "Maturation Wilt" which is attributed to

ROOT DISEASE - EARLY STAGE

ROOT DISEASE - ADVANCED STAGE

LEAF DISEASE - MIDDLE STAGE

LEAF DISEASE - ADVANCED STAGE

physiological causes occurs in New Guinea. According to Dwyer, the relative importance of physiological disorders of coconut palms as related to fungus diseases or distinct from virus diseases is not yet determined. He emphasises the necessity for chemical and botanical research on the nutrition of the coconut palm in relation to soil conditions.

*Ceylon.*– Petch (13) in 1906 has described a root disease of coconuts in Ceylon produced by *Fomes lignosus*. Later on Small (14) who investigated it attributed the primary cause of the disease to *Rhizoctonia bataticola*. Park (15) who followed Small suggested that *R. Bataticola* may be present in the roots of coconut palms as a mycorrhizal fungus and that conditions which upset the balance between the root and the fungus are of great importance with regard to the etiology of the disease. Gadd (16) and Briton-Jones, however, do not accept this hypothesis and are of the opinion that the Ceylon root disease of coconuts is caused by physical or physiological drought.

*Philippines.*– A disease almost similar to the Travancore root disease has been described by Ocfemia from the Philippines. There it is named "Cadang Cadang" disease of coconuts which means in the local language growth failure or running out disease. After examining the infected palms and studying the symptoms, Ocfemia (17) suggested that the disease probably was of virus origin.

In the West Indies a leaf disease of coconuts which greatly resembles the 'leaf rot' present in Travancore and Cochin has been described by Ashby, Nowell and Briton-Jones (18). It has been named "Bitten Leaf" disease and has been attributed by Ashby and Nowell to an attack by the fungus *Thielaviopsis paradoxa*. Briton-Jones, however, is of the opinion that the primary parasite in all cases of "Bitten Leaf" disease is the bud rot organism, *Phytophthora palmivora*. From New Guinea, Dwyer has described a disease which also resembles the Travancore leaf disease. He has given it the name "Frond choke".

The investigations were undertaken on different lines and a brief account of each of these is given below.

## MYCOLOGICAL

### *ISOLATIONS*

(*a*) *Leaf Disease.*– Samples of diseased leaves were collected from different localities in Travancore and Cochin. They were washed in distilled water and small pieces of leaf tissue from the junction of the healthy and diseased portions of the leaflet were dipped in 1/1000 mercuric chloride solution for nearly a minute for external sterilisation. They were then thoroughly washed

in repeated changes of sterile distilled water and transferred to petridishes containing sterilised plain agar medium. When fungal mycelium began to grow out into the medium from these transfers, inocula from these were taken and subcultured on to sterilised culture tubes containing Brown's agar. A large number of isolations from material obtained from different parts of the State were made and studied. As a result of this it was observed that the undermentioned fungi appeared with great frequency in these isolations, *i. e.* species of *Helminthosporium*, *Gloeosporium*, *Gliocladium*, *Pestallozia* and *Fusarium*. These were purified by taking single spore cultures and increased for further experimentation.

(b) *Root Disease*.– In order to obtain the organisms associated with the root disease extensive tours were conducted in the diseased areas and samples of roots were collected from infected trees for laboratory examination and analysis. For isolation purposes small pieces of root tissue were dipped in 0.1 per cent mercuric chloride and then washed in repeated changes of sterile distilled water. They were then transferred carefully on to petridishes containing sterile plain agar medium. Fungal mycelium growing out of such transfers were sub-cultured into culture tubes containing Brown's agar.

In another series of isolations part of the root systems of infected trees was exposed by washing with a powerful jet of water applied with a foot pump. The roots were then examined carefully and isolations were made in the usual manner from the roots at the junction of the healthy and diseased tissue. In a third series of experiments pits 2′ x 2′ x 2′ were dug near the base of infected trees and filled with river sand. The pits were then carefully covered and the sand inside was kept moist by frequent watering. The pits were examined from time to time, in order to find out whether new roots had grown out from the trees into the sand. Roots showing necrosis were collected for further examination. Sections were taken from such roots and these sections were examined under the microscope. Sections showing fungal mycelium were used for isolations.

A very large number of isolations were made according to the above mentioned three methods and the undermentioned organisms were obtained, *Botryodiplodia theobromae*, *Rhizoctonia bataticola*, *R. solani*, *Fusarium* sp., *Panicillium* sp. and two species of bacteria, one having yellow and the other red pigmentation. These organisms were increased on suitable media and used for further infection and other studies.

## INFECTION EXPERIMENTS

(*a*) *Leaf Disease.*– Fungi for inoculation purposes were increased on Brown's potato starch medium in petridishes. In order to test for their pathogenicity preliminary inoculation experiments were conducted on small pieces of tender coconut leaf tissue placed in sterile petridishes in the laboratory. The inoculum was applied as drops of spore suspensions on to the leaf tissue in petridishes. Drops of sterile distilled water were used to serve as controls. Within this time rotting of leaf tissue was observed with *Helminthosporium* sp., *Gloeosporium* sp., *Gliocladium* sp., and *Pestallozia* sp. Of these *Helminthosporium* was found to be the most virulent.

Inoculation experiments were next conducted on longer leaves of the coconut kept under moist bell jars. Tender leaves were first dipped in mercuric chloride solution and then washed with sterile distilled water. They were then stuck into small flasks containing sterile distilled water. Spore suspensions of the different fungi were made in sterilised water and the suspensions were sprayed on to the leaves by means of atomisers. Controls were maintained in all cases where the leaves were sprayed with distilled water only. The small flasks holding the leaves inserted were placed in large potato dishes over a layer of sterile water and covered with tall glass bell jars to maintain humidity. Rotting of leave tissue was observed with *Helminthosporium* sp., *Gloeosporium* sp., and *Gliocladium* sp. Of the three, *Helminthosporium* was found to be the most vigorous.

These experiments were repeated on trees in the open, under field conditions. Spore suspensions of the fungi were made as usual in sterile distilled water. Swabs of sterilised cotton wool were soaked with spore suspensions and the cotton thus treated was carefully placed within the folds of young and tender central shoots of healthy coconut palms. Particular care was taken to see that the leaf surface was not mechanically injured during the course of these operations. The inoculated part of the central shoot was well wrapped with fibrous coconut stipules and this portion was kept moist by spraying water at intervals for a period of three or four days after inoculation. Controls were maintained similarly using distilled water instead of the spore suspensions. The bandages were removed after a fortnight and the inoculated palms were examined for infection. Rotting of the leaf tissue was observed with *Helminthosporium* sp., *Gloeosporium* sp., *Gliocladium* sp., and *Pestallozia*. As before, the severity of infection was greatest with *Helminthosporium*. These experiments were repeated a number of times year after year and at different seasons

in the year. Infection was found to be most severe during monsoons when the atmospheric humidity is at its maximum.

Experiments were made both in the laboratory and under field conditions to test the efficacy of different fungicides like Bordeaux mixture, Burgandy mixture, 'Oxi-cop' and 'Bar-cop', the latter two being Australian fungicides. 'Oxi-cop' is copper oxychloride and 'Bar-cop' basic arsenate of copper which is a combined insecticide and fungicide. It was observed that 'Bar-cop' and 'Oxi-cop' when used at a concentration of 2 per cent were as effective as full strength Bordeaux mixture.

The infection histology of *Helminthosporium* was studied in detail. It was observed that the spore on germination puts out a germ tube through either or both of its apical cells. The hyaline germ tube as soon as it comes in contact with the leaf surface produces a knot like swelling by which the tip of the germ tube is firmly attached to the surface of the leaf. The penetrating hypha is developed as a sharp peg-like point. Sometimes its shape resembles that of a cork screw. Cuticular penetration takes place probably due to mechanical pressure and the hypha enters the parenchymatous cells of the leaf as a thin transparent strand. Inside the leaf, it branches out freely and ramifies in all directions. The invalid cells soon get disintegrated thus causing rotting of tissue.

The species of *Helminthosporium* isolated from coconut leaves has the following spore dimensions, 36 to 98 x 10 to 18$\mu$. Conidia are more or less cylindrical and sometimes curved. The distinguishing character is that the septum at either end is thicker and more permanent than the intermediate ones and is darker coloured. This fungus has been identified as *H. Halodes*. It has not so far been recorded as a parasite on coconuts. In India it has been described as a root parasite of wheat by Mitra and as a parasite on the shoots of sugarcane by Subramonyam. Copeland has described a *Helminthosporium incurvatum* as a wild parasite on coconuts in the Philippines. The Travancore fungus is a very virulent parasite.

The *Gliocladium* species is identified as *G. roseum* and appears to be the same as described by Sundararaman in his earlier investigations on the Cochin leaf disease. The hyphae are thin and hyaline. The mycelium gives rise to short conidiophores having at their tips clusters of spores held together in heads. Later on more spores are produced arranged in chains and not in heads. The spores are globose to ellipsoid in shape, unicellular and hyaline.

In mass they appear to be salmon pink in colour.

The *Gloeosporium* has been labelled as *Colletotrichum paucisetum* since it develops setae sometimes. Acervuli are formed and the spores in these measure 11 to 16 x 4 to 5$\mu$. A *Gloeosporium* sp. causing shoot rot of coconuts in Pilicode has been recorded by Sundararaman and Krishnaswami, Coimbatore. The species of *Pestallozia* is ***P. Palmarum*** and it is generally found as a weak parasite on coconut leaves.

*Studies with Aeroscope Slides.*— The coconut palm disease of Travancore is locally known as 'Kattu' (wind) and it is generally believed that the disease spreads along the direction of prevailing winds. In order to have some idea of the organisms present in the atmosphere in infected areas an aeroscope was installed at a height of about 40 feet on the trunk of a coconut tree in the Coconut Experimental Station at Kayangulam. The slides of the aeroscope were regularly changed twice a week and examined under the microscope at the Quilon laboratory. These observations were started in 1938 and continued for a period of four years. As a result of this it was found that spores of the leaf pathogenic fungi *H. halodes*, *Gloeosporium* sp., *Gliocladium roseum* and *Pestallozia palmarum* were generally caught on the slides exposed in the aeroscope. The largest number of spores were present in the atmosphere during the period June-August, *i. e.*, during the south-west monsoon when the atomospheric humidity is at its maximum. A graphical representation of this is given in Plate V.

(*b*) *Root Disease.*— Fungi for inoculation purposes in this case were grown in wide mouthed 500 cc. conical flasks on sterilised rice meal sand medium in the proportion of one part of starch to ten of river sand. All the fungi grew luxuriantly in these flasks and after about 15 to 20 days' growth the contents of the flasks were emptied into ordinary healthy garden soil in large size cement tubs and mixed with the soil. Healthy coconut seedlings about 18 months old were transplanted into the inoculated soil and controls were maintained by transplanting seedlings into soil in cement tubs not inoculated by fungi. Bacteria for inoculations were grown on glucose peptone medium in petridishes and the contents of the plates were mixed with soil to serve as inoculum. A large number of inoculation experiments were conducted in this manner. In some cases wilting of the leaves of seedlings was observed when *B. theobromae*, *R. bataticola* or *R. solani* were used as the inoculum.

In another set of experiments the seedlings in cement tubs were kept in a waterlogged condition for 48

hours at the time of inoculation by keeping the drainage holes of the tubs closed and freely pouring water into them. Controls were maintained by transplanting seedlings in waterlogged soil not inoculated with any fungi. After keeping the soil thus waterlogged for the period, the drainage holes were opened and the water drained off. Disease symptoms developed in the case of seedlings that were kept waterlogged at the time of inoculation. Steady progress of the disease was maintained and the seedlings died within the course of about two months. Seedlings in the waterlogged tubs which were not inoculated with the fungi showed an initial drooping of the leaves but quickly recovered and resumed their normal growth after the excess water was drained away. A large number of inoculation experiments was conducted in this manner and infection of seedlings took place when one of the three fungi *B. theobromae*, *R. bataticola* or *R. solani* was used as the inoculum. In all cases of infection the original fungi were recovered by isolation.

Soil in tubs was adjusted to different H-ion concentrations by the addition of the required quantities of acid and alkali. Due to the strong buffering action the range obtained was only between 4 5 to 6.8. Inoculation experiments, as before, were conducted in these soils and healthy seedlings transplanted into them and maintained in a waterlogged condition. No difference in the development of infection was noted in any of these soils.

All the above mentioned experiments were conducted on seedlings 9 to 18 months old. Inoculation experiments were next conducted on the roots of seedlings four to five years old. Root systems of these seedlings were exposed by washing the soil away with a powerful jet of water from a Hyject foot pump. The tips of roots thus exposed were inoculated with the three fungi by allowing the root tips to grow into wide mouthed culture tubes in which the organisms were growing. The roots thus inoculated were again covered up with the soil and examined later. It was observed that many of the inoculated roots developed root rot but the infection appeared to be localised because the usual disease symptoms were not observed on the leaves of the inoculated plants even though the roots were infected. Inoculation experiments were also done on the roots of adult bearing coconut trees with the three fungi. Here also even though some of the inoculated roots took infection disease symptoms were not manifested in the leaves.

Some experiments were also done to ascertain whether the diseased

condition of the tree is due to a virus. Virus transmission trials were attempted by which leaves of badly diseased trees were superimposed on to the central shoots of healthy trees and transmission tried by the pin prick method as is practised in the transmission of sugarcane mosaic. The results were negative. Infected soil and roots from the base of badly diseased trees from the affected areas of Kayangulam were transported to Quilon and applied round the base of some healthy trees in the garden of the Agricultural Research Laboratory. Even after eight years since this was done disease symptoms have not developed in these trees.

## PHYSIOLOGY OF THE 'LEAF-ROT' FUNGI

Some studies were made about the physiological requirements of the fungi associated with the 'leaf-rot' disease of coconuts. Their rates of growth on Malt agar, Oatmeal agar, Brown's agar, Potato-starch agar and Richard's agar were studied. *Helminthosporium halodes* grew best in Oatmeal agar and *Gloeosporium* in Brown's agar. The effect of acidity and alkalinity on the growth of the fungi was next studied. They were grown in Brown's medium adjusted to different H-ion concentrations by the addition of boric acid and sodium bicarbonate. The range of pH tried was between 4.5 to 9.8. It was observed that optimum growth took place round about neutral point while high acidity or alkalinity had a depressing effect upon growth. The toxic concentrations of chemicals like copper sulphate, mercuric chloride and phenol were determined for these fungi. *H. halodes* tolerated a concentration of up to 0.3 per cent copper sulphate, *Gloeosporium* sp. up to 0.35 per cent, *Gliocladium roseum* up to 0.2 per cent and *Pestallozia palmarum* up to 0.15 per cent. Mercuric chloride and phenol were found to be lethal even at the smallest concentration tried. The thermal death points of the spores of the fungi were next determined and it was observed that the thermal death point of *H. halodes* was 60°C of *Gloeosporium*, *Pestallozia palmarum* and *Gliocladium roseum* 55°C.

[*To be continued*]

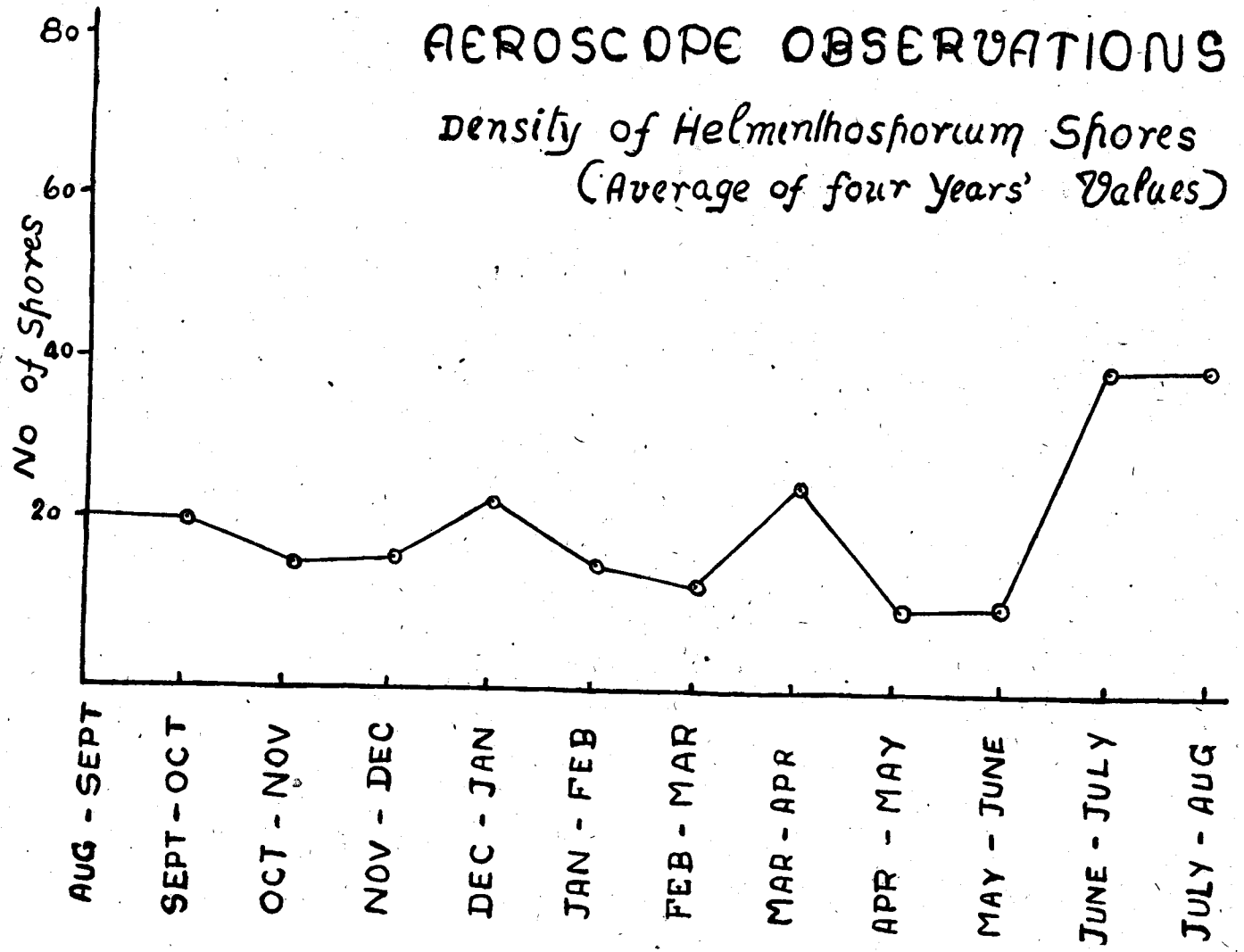

AEROSCOPE OBSERVATIONS
Density of Helminthosporium Spores
(Average of four years' Values)
No of Shores
80
60
40
20
AUG - SEPT
SEPT - OCT
OCT - NOV
NOV - DEC
DEC - JAN
JAN - FEB
FEB - MAR
MAR - APR
APR - MAY
MAY - JUNE
JUNE - JULY
JULY - AUG

Plate V