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The Consultancy in Suriname for

Diseases in Oil Palms and Coconuts

by

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MINISTRY OF FOOD PRODUCTION
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THE CONSULTANCY IN SURINAME FOR DISEASES IN OIL PALMS AND COCONUTS FOR THE IICA.

By

REGINALD GRIFFITH, D.Sc. Dr. Agr. (Hon.)

12th May, 1987
SURINAME.

Oil palm showing some crown-leaves affected in spearrot disease.

(Photo courtesy of Mr. W. Fung Kon Sang - A colour slide reproduction)

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THE CONSULTANCY

The Consultant, Reginald Griffith, D.Sc., Dr. Agr. (Hon), having been invited by the IICA (Trinidad) to visit Suriname from April 20 - May 11, 1987, given the following terms of reference :

1. To determine the nature of a pathological condition called 'Spear rot' which has recently been identified in the main oil palm plantations and to advise on procedures for its control;

2. To prepare a detailed proposal for a Programme of Research on Oil Palm and coconut pests and diseases in Suriname extending over the period 1988 - 1990 in the first instance,

submits the following conclusions and recommendations based on the visit for which the report: "The Consultancy in Suriname for Diseases in Oil Palms and Coconuts" covers in greater detail.

PROGRAMME FOR VISIT

April 28. 4.30 arrival. Met by Mr. Huiswoud, Director of Research, Ministry of Agriculture and representatives from the IICA (Mr, Telfer and Mr. G. Buckmyre).

April 29 9.00 a.m. Orientation and preliminary discussions with Mr. Jagbandhan, Mr. Huiswoud, Mr. Telfer and Mr. Buckmyre of IICA.

10.00 a.m. Further technical discussions with Mr. Huiswoud, Director Agricultural Experiment Station and Palm Research Centre.

12.00 noon. "Reformulation of the Coconut and Oil palm Research Project". Discussions with the programme co-ordinator and technical project leader, Palm Research Centre.

April 30.	07.30 - 08.00 a.m. Meet director of LVV 08.00 - 12.00 a.m. Visit and discussions with Technical Project Leader and co-workers. Discussions on the re-formulation, etc.
May 1, 2, and 3.	Programme to obtain diseased material from Victoria Oil Palm Plantations - aborted.
May 4.	08.00 - 14.00. Visit Agricultural Experiment Station. Discussions with co-workers in the fields of entomology, nematology, mycology/bacteriology, virology and soil fertility with reference to support for Palm Research Center.
May 5.	06.00 - 06.00 p.m. Visit experimental farm at Jenny and the coconut district of Coronie with Ms. Asgarali.
May 6.	07.00 a.m. - 03.00 p.m. Visit experimental farms Dirkshoop, La Poule and Tijgerkreek-West with Ms. Asgarali (coconut and oil-palm plots).
May 7.	07.00 a.m. - 05.00 p.m. Visit to project for oil palm, American oil palm, and hybrids with Mr. Huisweud.
May 8.	08.00 a.m. - 12.00 p.m. Plenary discussions of final draft. Slide show and talk on Pests and Diseases of Coconuts and the pathosystem (with reference to Spear rot disease).
May 9	08.00 a.m. - 04.00 p.m. Typing up of final draft.
May 11.	Meeting with the Honourable Minister of Agriculture, Suriname. Final discussions, presentation of final draft and departure for Trinidad.

CONCLUSIONS AND RECOMMENDATIONS

1. Spear rot Disease

The disease called Spear rot in Suriname existing in an epiphytotic condition at present has its counterpart in Africa, the region of origin of the imported cultivars of the oil palm, *Elaeis guineensis*, Jacq, to Suriname and Latin America. In the Southern Congo, in the region of Kasai, where the disease was researched in the 1950's and 60's, it was variously described as Spear rot, little leaf disease and heart, crown or Bud rot disease. The causal agent was determined to be a bacterium similar to *Erwinia lathyri* which was capable of affecting certain susceptible lines (cultivars) of *E. guineensis* when the growth rate of susceptible leaves was either arrested or reduced due to water-deficit or nutritional stress. The pathogen is air borne.

The disease in Suriname is co-identical in symptomatology, similar in epidemiology and appears more frequently in poor soil conditions and at the end of the dry or beginning of the rainy seasons. Among other microorganisms found by the Suriname researchers, *Erwinia sp.* was named. Mainly due to inexperience, the appropriate inoculation tests were not made, as was done in the Congo.

Advice has been given on the method of testing for pathogenicity and control measures, utilizing pruning of the infected leaves, since the growing point is not always killed by the pathogen. Following this, the sterilizing of the crown region with a spray of 1% formaldehyde has been recommended. Harvesting knives are also to be sterilized, in areas with disease, by dipping them for 10 - 20 seconds in 10% formaldehyde solution.

Various records are to be taken concerning spore release in an attempt either to forecast the disease or determine whether or not the pathogen is something new and indigenous to the new world. This disease is also now appearing in imported material in countries as Colombia and Brazil. The implication is that the pathosystem of the introduced plant is disrupted by the differences in ecological condition of Latin America and Bud rot, which is not an economic disease in Africa, has now assumed economic proportions here.

All the information obtained in Suriname was by way of reports, slide-presentations and interviews since the area; in which the disease occurs is now inaccessible.

2. <u>The IICA/Suriname Project</u>

This project which was conceptualised as a joint inter-institutional building project between the IICA and the Palm Research Centre (PRC) of the Ministry of Agriculture did not achieve satisfactory goals. The primary reasons related to the anticipated pattern of development for the project. The initial plans, as devised by the IICA advisor to the programme, were over-ambitious and were not managed in such phases that any portion would succeed. Apart from the poor pattern of development, the resources of the technical staff were not managed with enough flexibility when adverse social conditions developed. Moreover, with reduced staff and finances, the original programme was not modified in any way to achieve even the minimum goals possible.

In the meantime, the specified pest and diseases of the coconut and oil palms increased in frequency. Yet, some original control measures continued in the oil palm plantations. As a result of this alarming increase, the programmes for the next two years will concentrate on control campaigns which the existing staff are capable of managing. Their research will consist in refinement of practised control measures.

3. The Programme for controlling the Pests and Diseases referred to from 1988 - 1990.

a) The programme for controlling Spear rot has been organised first as an emergency programme with assistance from the IICA for the provision of:

i) Chemicals and equipment for phytosanitary control measures.

ii) Training programmes of 2-weeks' duration in Trinidad for studies in spore-trapping methodology and field and laboratory innoculation techniques for the 2 staff-members of the PRC.

iii) An emergence pilot programme of phytosanitary activity for a period of 6 - 7 months on the Phedra plantation, where the disease is not so widespread.

The emergency programme will dovetail into the programme for 1988 - 1990. The main activities during this time will be to determine levels of innoculum, the nature of the soil-stress factors, forecasting disease, continued phytosanitary compaigns and analysis of aetiological findings to determine the exact nature of the causal agent. The programme will be monitored by the consultant.

b) The programme for control of Hart rot will be mounted first as a survey of the disease among coconuts and oil palms followed by a programme for control utilizing known effective practices. The information will be analysed to determine the eventual level, after two years, and the future direction of research.

c) The control programme for <u>Castnia</u> (<u>Cyparissius</u>) will be confined to the oil palm plantations where the damage is economic. In coconuts, the damage is cosmetic, but the affected palms yield insects which affect the oil palm plantations. Control measures will employ BHC and Furadan. Preliminary laboratory investigations will be made with pathogens as <u>Beauveria sp.</u> and the Green Muscadine fungus against the insect before field trials are attempted.

4. <u>The Relationship between the PRC, the oil palm companies and the coconut farmers</u>

There is an urgent need for a firmly established agreement between the PRC and the oil palm companies, in the first instance. The three companies operate with a tentatively unified board but without official commitment to assist the PRC in its programme of control and research for which the companies are the direct beneficiaries. There is an urgent need to rectify this anomaly and ensure that a high level of managerial co-ordination exists between the two bodies. The oil palm companies have recently concluded that they should support the PRC financially especially as the Dutch aid has been halted.

The absence of this essential arrangement also proved disconcerting to the management of the previous 3-year programme. Financial support from the IICA should only continue contingent on a firm policy arrangement both for financing and co-operative research between both paries.

A major problem is the coconut growers who, by and large, have abandoned essential cultural practices because of the preferential treatment now given to oil palm. Since coconut palms are the source of infection to oil palms for Hart rot and Red Ring diseases and also the breeding ground for <u>Castnia</u>, an effort should be made to rehabilitate the 2,000 ha. of this crop. The small factory should be remodelled and the co-operative reestablished with membership on the same Board of Management with the oil palm companies and the PRC.

5. <u>Laboratory facilities</u>

There is an absence of laboratory facilities in the PRC to carry out even the Spear rot programme. The IICA has agreed to supply some equipment and chemicals for the short-term emergency project. It may be easiest for them also, instead of supplying a permanent consultant, as was done before, to re-direct such funds to initiate the facilities for Spear rot research in the PRC. The impact would be to affirm emphatically IICA's policy of developing self-reliance in the human resources of a country.

Other facilities for the necessary programmes may be funded by the oil palm companies and the Government itself. In the meantime, there is sufficient research equipment in other departments of the Ministry to strengthen temporarily the efforts of the PRC.

6. **Training and Consultancy**

The remodelled programme of work for 1988 - 1990 is based substantially on the capabilities of the staff present at the PRC. The strategy employed is allowing control programmes to determine the new lines of research. Since the existing staff are able to organize and execute these programmes, the major external input required should be training for the development of new techniques that become necessary as the programmes develop. Thus, IICA should, in time, be able to arrange suitable short-term visits to relevant institutions from which the staff would learn the various techniques. Short-term consultancy contracts for monitoring the progress of the work should be the only other necessity during the transition period.

THE TERMS OF REFERENCE

1. To determine the nature of a pathological condition called "Spear rot" which has recently been identified in the main oil palm plantations and to advise on procedures for its control;

2. To prepare a detailed proposal for a programme of research on oil palm and coconut pests and diseases in Suriname extending over the period 1988 - 1990 in the first instance.

THE MAIN SECTIONS OF THE REPORT

The following have been suggested as the main components of the report:

a) A detailed review of the plant health problems of oil palm and coconut in Suriname.

b) A detailed review of the research work that has been done to date in Suriname on the plant health problems of oil palm and coconut, including IICA's contribution.

c) A detailed analysis of the institutional infrastructure currently involved in this research in Suriname.

d) Recommendations, in outline, for a revised research program into the plant health problems of coconut and oil palms but with 'Spear rot' as a priority area.

e) Recommendations as to the organization of the research program specifying:

   - Co-ordination

   - locations

   - personnel and responsibilities

   - required facilities, equipment and materials.

f) Training and consultancy requirements

g) Financial requirements and sources of finance.

h) Specific participation and contribution of IICA as part of the technical collaboration of the office in Suriname.

SPEAR ROT DISEASE OF OIL PALM ELAEIS GUINEENSIS JACQ., IN SURINAME

INTRODUCTION

Fatal diseases of the oil palm, Elaeis guineensis Jacq., always terminate with the death of the growing point. On the other hand, diseases which only cause the death of the growing point may not necessarily cause the immediate death of the palm. Thus, a fatal disease would usually cause general malfunctioning of the major transport systems disturbing both water relationship and nutritional balance. Consequently, the plant may visibly suffer from thirst or starvation. Very often, toxins or antimetabolites may be introduced by a pathogen during its multiplication or growth phase. These may become systemically dispersed and so act directly and deleteriously on the growing point.

Thus, characteristically, when such fatal diseases occur as a direct inducement of pathogenic agents, external symptoms are very often correlated with systemically transmitted malfunctioning and appear chronologically, usually in accordance with the vascular disposition and arrangement in the palm. Diseases which only produce death of the bud mainly, often are the product of more localized pathogenic action, and are due to direct invasion of cells of the parenchyma by pathogens which have a lower potential for dispersal throughout the plant system. Such diseases do not include common leaf diseases caused by Cercospora on oil palms, since these are not fatal.

The foregoing is not expected to imply that only a particular kind of pathogen may cause a particular kind of symptom expression in the oil palm. Often, in the case of a fungus, the differences between obligate and facultative parasites become apparent in the course of infection within the host. A facultative parasite may often kill the tissue by enzyme action in advance of the growing hyphae as does Fusarium sp. which can live saprophytically also in the host and usually grows intracellularly; whereas, an obligate parasite causes little cell destruction. Its mycelium is inter-cellular with haustoria. Invasion of the obligate parasite might be checked by hypersensitivity of the host or death of the invaded cells preventing further hyphal growth. Also, barriers might be developed like gum deposits, tyloses etc. In the case of bacteria, if they are too large to travel through the end-plates of the vascular tissue, their migration would be restricted to softer tissue.

Bacteria, like fungi, may also cause vascular wilts, or simply, leaf necroses, cankers and soft-rots among others. And no one symptom may be exclusive to one pathogen. Yet, the host range for such ubiquitous pathogens as Agrobacterium tumefaciens, Pseudomonas solanacearum, and Erwinia carotovora is extraordinary with a species of Erwinia being found on some diseased oil palms in Africa. Similarly, a virus infection may be localized at the point of infection causing a local lesion or it be systemic. The macroscopic effect of the latter type of infection ranges from depression in growth rate of plant organs in

an apparently healthy plant to rapid death of the host. Apart from the similarity in symptomatology, there is extensive variability of expression dependent on the cultivar and its genetic status. Leaves may show different colorations, they may collapse or may not collapse with the same pathogen.

To some extent, therefore, it should be clear that the description of a disease in oil palms based only on visible macrosymptomatology may only partly relate to the cause of death or indeed even to the nature of the pathogenesis or still yet vaguely to the pathogen. In fact, in oil palms, one may detail a list of pathogens which can occasion the same overt symptoms in different varieties of oil palms.

Nomenclature and Symptomatology

The list of names often given to what is considered to be Spear rot in Suriname, may not be synonymous with the identical disease in the whole of Latin America. For whereas, 'pudricion del cogollo' in Colombia has the identical translation as 'podridao do broto terminal' in Brazil, that is, Bud rot. It will not mean Fatal Yellowing disease, in English, or Spear rot in Suriname. It is primarily this element of standardization of nomenclature with essential symptoms of the same disease that is noticeably lacking in the first instance. Contrastingly, Red Ring disease, in both oil palm and coconuts, has standard descriptions of basic identifiable symptoms and, therefore, has correspondingly direct translations as 'anillo rojo' in Spanish-speaking Latin America Latin America and 'anel vermelho' in Portugese-speaking Brazil. Cedros wilt, on the other hand, is 'Marchitez de cedros' or 'Marchitez

sorpresiva' with Hart rot' being an older name describing only a limited area of the symptom expression, a Bud rot.

Understandably, the older terminologies for diseases, then of unknown aetiology, which have often persisted in the literature have often given rise to the present confusion when a complex of such diseases generally described as Bud rot say, is elucidated by later research into separate diseases of known aetiology. Very often, the existence of several different diseases of similar symptomatology is not clear until one is elucidated finally. The remaining unknown entities having now to be reclassified. To what extent Cedros wilt or Hart rot and Spear rot or little leaf have been previously confused and recorded as identical or different will never be known.

There is yet a final phenomenon which relates to coconut palms and oil palms which occupy similar agricultural regions. It relates both to such pests and diseases which, by and large, show common functional niches in both crops. The same strain of the pathogen might affect either crop. Examples of these diseases are: Red Ring, Cedros Wilt (Hart rot) and Bud rots. I have said Bud rots to indicate true bud ro but by different possible pathogens as will be explained fully later.

<u>Bud rot of Coconut and Oil Palms</u> (The Present Status)

Essentially, by common description, this relates to any condition in which the terminal bud is destroyed by a localized (non-systemic) pathogen. Generally, also, only the crown leaves and the bud are affected, but the pathogen is often restricted in its movement to the softer and more easily invaded non-woody tissue. As a result, even though the plant cannot grow, it may still retain or even produce fruit in the axil of the older non-affected leaves. This obtains both in the coconut palm and the oil palm.

The pathogens often associated with these conditions are Phythophora palmivora (fungus) and Erwinia sp. (bacterium. Phythophora is world-wide, also causing black pod in cacao; whereas different species affect different crops like potato, cucumber, tomatoes and citrus. A different strain of the bacterium Erwinia sp. causes Banana Head rot. Such species causing a soft rot possess enzymes which break down the middle lamella of plant cells. The species of Erwinia tracheiphila on cucumber, and E. stewartii on sweet corn which are wilt causing, as they move throughout the plant tissues, depend on a mutualistic relationship with an insect host. Other examples are well known. However, in certain coconut growing states of India, there appears to be an interchangeable niche between Erwinia sp. and strains of Phythophora palmivora, in the Bud rot or Crown rot syndrome. P. palmivora, however, is well-known to destroy the bud whereas Erwinia sp., produce a soft rot within the crown.

In oil palms, as far back as 1963, Bud rot disease was associated with a strain of bacterium similar to Erwinia lathyri which was found in plantations in the Belgian Congo. This condition was variously described as Spear rot, little leaf disease, and Heart, Crown or Bud rot disease. There was the enigmatic fact that some palms were quickly killed whereas others recovered. The latter typically passed through a 'little leaf phase' indicating that the bud was not always attacked. Often, similar situations have occurred with coconuts. However, with Phythophora palmivora, infection conditions prevail when temperatures are above 21° C and R.H. between 97% - 100%. Apparently, conditions for Erwinia sp. relate more to the physiological state of growth of the spear leaf tissue.

Actively growing young leaves do not necessarily provide an infection count. Very often, when growth rate is arrested by natural conditions in the plant or imposed by external conditions as drought or water deficit, infection due to Erwinia sp. will occur.

Distribution of Oil Palm Diseases in E. guineensis in the New World.

The natural distribution of the African Oil Palm Elaeis guineensis Jacq. is between 15° N. and 10°S on the West Coast of Africa and Eastward as far as the Great Lakes. Its ecological habitat is limited to the transition region between rain-forest and savannah and on the grass lands, also to moist hollows and along river banks. Early attempts to naturalize the plant outside its natural region bagan with the Dutch East Indies, Sumatra in 1911 and British Malaya a few years later. Later, the palm spread to other locations. Generally, there are accepted three species of the oil palm. These are: E. guineensis, E. madagascariensis (the Madagascar oil palm) and E. melanococca (oleifera) a South American species . E. guineensis has a complex genetical constitution and four main varieties have been generally recognized. These are; Macrocarya (extra thick-shelled) dura (thick-shelled) tenera (thin-shelled) and pisifera (shell less).

As far as Bud rot is concerned, it was already shown by Bachy (1954) that different genetical lines of palms have different susceptibilities to the disease. Moreover, cultivars or varieties which withstood unfavourable conditions better did not show a high incidence of disease. Bud rot lesses in Africa related to critical environmental conditions which made some host plants more susceptible.

With regard to Elaeis melanococca (oleifera), the American oil palm, it originated in equatorial America. Its biology is close to that of the oil palm, E. guineensis, from which it differs, however, in certain anatomical characteristics of its trunk, leaves and inflorescences. Observations on wild populations show that varieties differ widely in vegetative characteristics and bunch composition. E. melanococca has certain agronomic advantages in that it grows taller, at a slower rate, than E. guineensis. Further, it is more resistant to some diseases. It also hibridizes easily with the African oil palm.

Be this as it may, the oil palm industry in Central and South America began with imported seed of the African oil palm varieties some of which have shown susceptibility to Bud rot due to Erwinia sp. A change in the pathosystem for the imported variety makes it more susceptible than it would normally have been to the same disease which would bear a distinctly new relationship to the same crop in a new environment. A similar situation is reasoned for Lethal Yellowing disease of coconuts which may have originated in South-East Asia but is considered now to be present in Africa, Florida and Jamaica as coconuts moved around the world. Thus, the advent of Spear rot in oil palms originating from parent material from the old world should be understood in this context as the disease assumes epiphytotic proportions, in a few years, in new ecological conditions which create different stresses in the pathosystem of the introduced varieties.

SPEAR ROT DISEASE - AN INDUCED DISEASE IN LATIN AMERICAN CONDITIONS

One might regard the commercial introduction of oil palm cultivation in Central and South America as dating back only to the 1960's. In Brazil, in Para, there were two development areas originally; the plantation in Paricatubu with the initial variety of *E. guineensis* var. *tenera* (800 ha.) and small plantations also initially 1,500 ha. of *tenera*. In Bahia, plantations were of *dura*, but were changed to *tenera*. Spear rot disease is known to exist in the Para region among the imported varieties.

The commercial expansion of oil palm continued in Central and South America. Ecuador, began experimenting with small areas around 1953 but plantings began seriously in 1964. By 1968, there were about 6,000 ha. Honduras also, with introductions in 1953, had about 4,000 ha. Colombia had some 24,000 ha. planted up between 1957 and 1967. From Colombia comes the report that a disease similar to Spear rot has caused serious damage to a large plantation - "La Arenosa". There have been various reports of diseases of similar symptomatology. However, because of the confusion which existed between Cedros wilt (Marchitez sorpresiva or Hart rot) and various other conditions, the reports of Spear rot are not entirely reliable. The disease also exists in certain regions of Venezuela as "Pudricion del cogollo".

THE CONDITION CALLED SPEAR ROT IN SURINAME

To a large extent, information on the present status of Spear rot in Suriname has been obtained from Ms. H. L. van de Lande, Head of the Division of Mycology/Bacteriology in the Agricultural Experiment Station; Mr. W. Fung Kon Sang, Co-ordinator Palm Research Centre; Mr. P. Rellum, Crop Protection Officer for the Oil Palm Plantations and Mr. R. Huidwoud, Director Research Agricultural Experiment Station. The rest came from the available literature.

In Suriname, there are three major plantations with oil palm: Victoria plantation which was established in 1969 (1650 ha.) Phedra plantation which began around 1977 (896 ha.) and in 1980, the Patamacca project comprising now about 3,300 ha. out of a proposed 5,000 ha.

Officially, Spear rot disease was first recorded in Suriname in 1982 in the plantation of Victoria. It was apparently linked to a "strange" disease which was found in 1974/1975 in a particular Block (1). In the ensuing years, the disease was found in increasing frequency in several other Blocks in Victoria and later in Phedra and Patamacca plantations. A record to date, utilizing two-monthly counts in Victoria estate from November/December 1983, shows that approximately 25,000 palms/250,000 trees are affected. In Phedra, roughly 6000/142,000 palms and Patamacca 300/472,000 palms have been affected and exist in various stages of pathogenesis.

The symptoms correspond very closely to those of Bud rot in the Belgian Congo in that:

1. The disease may be fatal or
2. Palms may recover through the 'Little leaf" pattern and
3. Crowns may fall-off leaving unaffected green leaves with racemes with fruits of varying sizes.

Generally, the first symptoms seen is a chlorosis of the youngest leaves. However, it is believed that the initial symptoms might have begun with blotches in the 3/4/or 5 leaf according to Van de Lande.

At about the time of the presence of distinct clorosis, one or more of the spear-leaves show a wet rot in pellucid patches in the unopened leaves. Finally, the affected spear leaves may break near the base and hang down. As the chlorosis progresses in the leaves, in order of age around the crown, the centre of the palm assumes a distinct yellow colour, though variable, compared with the general green of the older non-affected leaves. Gradually, the yellow leaves turn brown as they die and the affected leaves may collapse at the base where a wet rot is sometimes found with putrid odour.

When the crown rots, there is normally the same putrid smell and the heart leaves may be pulled out from the rotted crown. In circumstances where the rot has not progressed to the apical meristem, new leaves may be formed but much smaller than the original. These are described as the 'little leaves'. Fruits in the axils of unaffected leaves are not affected and palms without crowns may continue to produce fruit, without growing, until they die. Pathogenesis may vary from a few months to 3 or 4 years.

This situation is congruent with the symptomatology expressed in plants in Africa. However, there may be differences in the yellow colour expressed by different varieties of oil palms.

Predisposition to the disease

It has been generally observed that the disease is prevalent in bearing trees of any age beginning from 3 years old. In Victoria plantation, emphasis has been placed on symptoms expressed on the bearing palms at any age of maturity. It would appear, however, in some fields of Brazil, that palms of earlier age may contract the disease. In Victoria estate, on the other hand, the older palms on the northern side of the plantation display a higher incidence of the disease which is at present in the logarithmic phase of its development.

There are two dry periods or "seasons" in Suriname annually. The shorter period is from January to March and the longer or true dry period is from July to October. During these periods, the growth rate of the palm slows and water deficit and even nutrient imbalance can occur. The commonly reported observation by Van Slobbe and Rellum is that the increment of disease is highest after the dry periods. Figure 1, submitted by the Palm Research Centre, based on (Table 1) 2-monthly observations beginning from November/December 1983, indicates this general trend that the incremental step in the frequency of the disease appears about the end of the dry season or at be beginning of the new rainy season.

A similar situation has been noted with the Bud rot in Belgian Congo. In fact, the essential observation (Wardlaw, 1968) was that whereas the disease was relatively scarce in the more northerly oil palm plantations where rainfall and soil moisture conditions were adequate if not optimal, it was abundant and widely distributed in the southern Congo especially in the region of Kasai, where rainfall is either marginal or inadequate. As such, there were plantation areas where palms ceased growing or grew only very slowly in the dry season. Thus, infectivity was conditioned largely by the physiological state of the palm in the presence of suitable inoculum.

Accordingly, in the symptomatology and pathogenesis of Spear rot in Suriname, whereas the crown leaves are affected in turn, the bud is often not attacked immediately. Further, the sheath-leaves above the bud may be attacked and the infection temporarily arrested before the meristem is infected. It would appear that basic control measures should relate to this observation. For the pathogen does not penetrate directly into the bud of the old palms but moves intracellularly through the bases of the surrounding leaves. It would mean, then, that infected leaves in Spear rot can be removed and the crown sterilized by an antiseptic solution like 1% formaldehyde which can be sprayed on.

TABLE 1

FREQUENCY OF SPEAR ROT DISEASED PALMS IN VICTORIA PLANTATION, SURINAME, GIVEN AS CUMULATIVE TOTALS (1983 - 1987)

Time of Sampling	No. of Diseased Palms found (Cumulative)	% of Total No. of Palms
November/December, 83*	ca. 1,000	0.4
June/July, 84	ca. 1,900	0.8
December/January, 85	ca. 3,200	1.3
May/July, 85	ca. 4,650	1.9
August/September, 85	ca. 5,678	2.4
October/November, 85	ca. 6,873	2.9
November/December, 85	ca. 8,202	3.5
January/March, 86	ca. 10,465	4.4
March/April, 86	ca. 11,494	4.8
May/June, 86	ca. 13,619	5.7
June/July, 86	ca. 15,417	6.9
July/August, 86	ca. 17,070	7.1
January/February, 87	ca. 24,000 (Estimated)	10.1

*Before this period more than 500 Spear rot diseased palms were eliminated.

The Epidemiology of the disease

From the information available, the epidemic builds up naturally from an isolated focus to suscepts in the immediate vicinity. Generally, oil palms are planted 8½ m. or 9 m. within the row, and neighbouring palms in any direction may contract the disease and show the reported symptoms after 6-9 months. The probability of a plant being infected appears to vary inversely with the distance from the source of inoculum. In fact, under estate conditions, this refers more to slight eddies of wind and convection currents which would allow spores a short transport distance before they fall out in still air or encounter a new infection court. Thus, large foci or infection encompassing eventually over a hundred trees may steadily develop in sequence as more inoculum is emitted over a sufficiently long period of time continually from each infected tree. In other words, the rapid build up of an epiphytotic due to this pathogen is also a function of the survival of the propagules and the long duration of infective phase of the diseased plant.

Control measures previously applied

Discussions indicated that the major control measures applied have been roguing the diseased trees where possible. This practice did not noticeably influence the spread of the disease. Experiments were performed using Benlate, Endrin and injections of Tetracycline HCL and Streptomycin. At the time most of the experiments were carried out, infection was often too advanced in the estate generally, and it seemed that survival time of the pathogen was greater than the persistence of any effective and protective chemical. Injections into palms do not often produce death of all the micro-organisms in the affected portion of the leaves, since this depends on the transpiration rate of the affected leaf.

The use of endrin seemed by corollary to be unnecessary and if the causal agent is a bacterium that is air borne, as it is in the equivalent disease in the Congo, Benlate, a fungicide, would not have been effective.

ISOLATES FROM SPEAR ROT AFFECTED PALMS IN SURINAME

Van de Lande (1984) reported preliminary studies with organisms associated with some diseased palms already in an advanced stage of infection. Over a period of two years, isolations were made regularly from affected rachis and leaf tissue with both initial and advanced symptoms of Spear rot. Her report states that isolations resulted in the consistent presence of Fusarium sp. In a few instances Botryodiplodia sp. and Colletotrichum sp. were isolated from the remnants of the affected spears. The only bacterium isolated was an Erwinia sp. from the affected leaf tissue from a diseased spear.

Inoculation trials were made in vivo and in vitro on spear leaf tissue from healthy, vigorously growing oil palms of 6 and 18 months. No results occurred in spear leaves that were attached to the plants. However, with Fusarium on detached leaves, a rot appeared. The inoculations with Erwinia sp. were only tested on oil palm seedlings and did not result in any infection in any of the palm seedlings.

It is well known that many actively growing leaves will not be attacked by several species of fungi or bacteria. In the case of Spear rot, where the incidence of disease in Suriname increased after the dry season as leaf-growth had ceased, then, the indication should be that tests for pathogenicity would best have been done on attached leaves which had matured or had ceased growing for some reason.

The work by Duff (1963) on Bud rot of oil palm with Erwinia sp. indicated this. In a comprehensive series of experiments carried our in the field and laboratory, he showed using growth-rate of the leaves as an index of susceptibility, that leaves in which the growth-rate had been arrested were susceptible to the bacterium. Previously, several other answers were sought, including other organisms - various fungi. Even though Erwinia sp. had been found commonly associated with the disease, an appropriate infection court could not have been found. For years before, therefore, the disease had evaded proper etiological definition.

Thus, in Suriname, the appropriate experimental conditions for inoculation should be obtained with organisms, Erwinia sp, already known to be available in the diseased leaves. A knowledge of the causa l organism would allow control measures to be organised more effectively. Essentially, the persistence of the pathogen in the soil or leaf tissue makes it available for infection to the suscept. Areas which are often browsed by fires would be sterile for some time if diseased trees were removed before.

Despite this, spraying the affected crown with a mild solution of formalin (1%) after the infected leaves have been removed, would allow for satisfactory reduction of the continuous flow of inoculum. Their removal and burning would eliminate residual 'spores' which might be carried by wind or rainsplash. Together with this, it should be seen as risky to utilize harvesting knives in diseased fields without sterilizing them with 10% formalin as a dip, especially since, in the method of harvesting the fruits, the subtending leaves, which may also be affected, can allow inoculum to be spread from tree to tree with the same harvesting knife.

CONCLUSIONS

Whereas the tests for pathogenticity have not yet been done adequately to confirm the etiology of Spear rot in Suriname and Latin American oil palm plantations with material originating from varieties of E. guineensis, conditionally susceptible to Spear rot or Bud rot due to Erwinia sp, the parallels in pathogenesis, symptomatoloty, epidemiology and conditions for infection have been established as being equivalent. The major predisposition to the epiphytotic appears to be the change in the pathogystem of the plant due to movement from its original ecosystem to another, which perhaps requires a more xerophytic form in an ecosystem which is not exactly equivalent in several unknown ways. One expects a plant to be adapted over sufficient time which would be enough to isolate it into being a new biotype or even a new species as is E. melanococca (oleifera) which is resistant to certain diseases that would affect E. guineensis. Moreover, in Latin America, E. melanococca is in its own ecosystem.

In the history of the oil palm, E. guineensis, selection has always been done. Sumatra first selected the Deli type around 1[illegible]1. Several years later, the Dutch began and higher yielding types than the Deli became available. Yet doubts still exist as to the pure varietial strength of 'tenera' which appears to be an unstable form of 'dura'. The principle is that with hybridization between E. guineensis and E. melanococca it is equally possible to introduce a more appropriate group of palms to the new world ecosystem.

It may be that more epiphytotics other than that for Spear rot would develop out of the series of introductions. Vascular wilt is already known in Brazil, due to Fusarium oxysporium. Blast disease has not yet shown up in the Latin American nurseries and various Cercospora are around to cause

leaf-spotting which appears to be related to regional environmental factors, cultural practices and palm to palm varieties.

Very appropriately now, one can utilize the problem with Bud rot in coconuts to illustrate the present phenomenon with oil palms. Coconut plantations have been commercial since before the turn of this century in most parts of the world. Despite the fact that the palm originated in South East Asia and that Latin America was the last area, as it were to be dominated by the crop (Griffith, 1975), Bud rot due to *Phytophthora palmivora* thrives as a disease in monsoon areas in India and Sri Lanka. Yet, today, in every country where coconuts are grown the fungus is present awaiting the appropriate conditions for germination and producing diseases. Such conditions are humidity and temperature.

EMERGENCY ACTION PROGRAMME TO INVESTIGATE AND ALLEVIATE SPEAR ROT IN SURINAME

The emergency action programme, which would occupy the rest of the year in investigating and alleviating Spear rot in Suriname can be regarded in phases such as:

1. Research Activities

   a. Isolation and identification of the causal organism from early infected leaves.

   b. Spore trapping to determine conditions for 'spore' liberation and dispersal.

   c. Inoculation trials and determination of Kock's postulates using isolated and captured organisms.

2. Field Control Measures

In an attempt to reduce the spread of the disease in an area of low infection, the Phedra plantation might be utilized for control measures using sanitation and 1% formalin solution as a crown spray. Since the pathogen is localised in the crown leaves and in the uppermost bracts of the heart, the objective of the exercise is to reduce the spread of the disease in an affected tree and also remove the source of inoculum. The exercise would be easiest in younger trees than in the older and very tall palms. Despite the difficulties, jeeps and ladders and long lances on spray-cans provided on these jeeps might be employed. The cut leaves should be transported away by a vehicle and destroyed by burning.

Such sanitation measures would take into consideration the sterilization of the tools for harvesting and cutting of the subtending leaves. A solution of 10% formaldehyde (formalin) can be used as a dip for 10 seconds to bring about sterilization of the cutting knives during harvesting between trees. Generally, formaldehyde is cheap an easily available and, at sufficiently dilute concentrations, relatively safe for general use. It is a powerful fungicide and bactericide and at low concentrations can cause precipitation of protein of the superficial cells of the crown as well as in the bacterial organisms causal to the disease. Any saprophytes which might enter the wounds to cause rots will also be killed.

Personnel required

The personnel required for these research and field programmes are at present available in the Palm Research Centre and the Research Division of the Ministry of Agriculture. Some are at the estates themselves. Personnel at the Palm Research Centre (PRC) would need immediate training in techniques of spore trapping and field experimentation, together with inoculation techniques for determination of Kock's postulates. Such training would allow them actual work-practice in setting up and analysing results.

Apart from the technical staff of the PRC, various facilities for basic microbiological work is available in other sub-divisions of the Ministry of Agriculture. Trained research officers who man these facilities would be used to strengthen temporarily the PRC by devoting about 20% of their time during the emergency programme (Figure 2).

The following organizational chart (Figure 2) has been discussed with the Director of Research who at present co-ordinates all programmes of the PRC.

Figure 2.

Organizational chart for Emergency Programme to alleviate Spear rot disease

Coordinator of Research
(Mr. R. R. Huiswoud)

PRC
Technical Project Leader
(T. Nanden)

Entomology	Agronomy	Phytopathology
(J. Asgarali)	(T. Nanden)	(J. Moll)
Assistants	Assistants	Assistants
(Vacant)	(M. Palmtak)	(M. Parsadi)
	(Madari)	

Available
Support Sources from
Agricultural Research Station - 20% of time

Entomology	Nematology	Virology	Mycology
(A. van Saueurs)	(M. Dipotardoeno)	(P. Klas)	(Silos)

Spore Trapping in Spear rot disease

The objectives of trapping can be:

1. To determine the load of infective pathogenic propagules carried by the wind.
2. To indicate the level for an epidemic to begin.
3. To obtain information about the periodicity of 'spore' showers and the persistence of the dispersal cycle.
4. To determine the correct timing of protectant sprays and other control measures. Such programmes would continue beyond the end of the year.

Basically, two types of information can be obtained for quantification. (a) the concentration of spores in a given volume of air and also (b) the number of spores deposited on a surface. The correlation between both methods is not always exact. Thus, very often a choice has to be made with regard to either method. Concentration methods often use standardized equipment which are available readily. In the Andersen Sampler (J. Bach. 76. 471, 1958) spores are deposited on solid media in petri dishes, fractioned into 6 ranges. The Hirst automatic volume section trap is a robust instrument widely used for continuous sampling in the field. Several newer models are availa ble which allow for many different objectives to be accomplished. On the other hand, the deposition methods use sticky horizontal microscope slides, or open petri dishes with medium exposed to air in a sheltered location to keep off rain. Some slides are mounted on a vane so that they face the wind. Also, there are other methods available.

THE EMERGENCY PROGRAMME AND ITS RELEVANCE TO AN INTERNATIONAL SEMINAR ON SPEAR ROT

From all appearances, the principles involved in an understanding of the pathosystem with regard to this disease and coconut diseases like Lethal Yellowing are implicated. A useful understanding of how it applied to introduced crops such as coconut and oil palms is essential. Moreover, the stimulus is needed to develop hybrids between the local E. melanococca (oleifera) and the various cultivars of E. guineensis to prevent the continuous introduction of older diseases which clearly relate to genetically susceptible material that widespread development of oil palm seeds in one geographic location can produce.

Apart from this, the disease itself needs more understanding since research had been discontinued since the 1960's in the old world. Basic concepts as nomenclature and symptomatology must be standardized despite the heterogencity of the genetic responses found in the dura and tenera cultivars. Then, the methods of control must be constantly reviewed as selection methods are being developed for resistant imports growing in optimal and some semi-arid conditions of Latin America. In reality, there have been some older estates in Latin America from which basic information can be gained. In Venezuela, for example, in the state of Yaracuy, a pioneer industry began in 1938 with more than 2,000 ha. Whether or not such a disease appeared before now is not known. The original seed may have been from a more resistant stock.

Essentially, an international seminar is required, yet including all Latin American countries with imported oil palms and no experience with the disease. The present epidemic in Suriname, Colombia, Brazil and other countries where the disease might be confused with Cedros wilt (Hart rot) or even Red Ring should be attended to by an international forum including the FAO, IRHO, IICA and the various foundations involved in coconut and oil palms like the GTZ in Germany.

Costs for Emergency Programme

The essential costs for the programme in the phases given (1) Research (2) Control (3) Training would give priority to the immediate needs as chemicals for research and control measures. The only apparatus which will be bought would be spore trapping machinery which should be easily obtainable. Training facilities would be available in Trinidad.

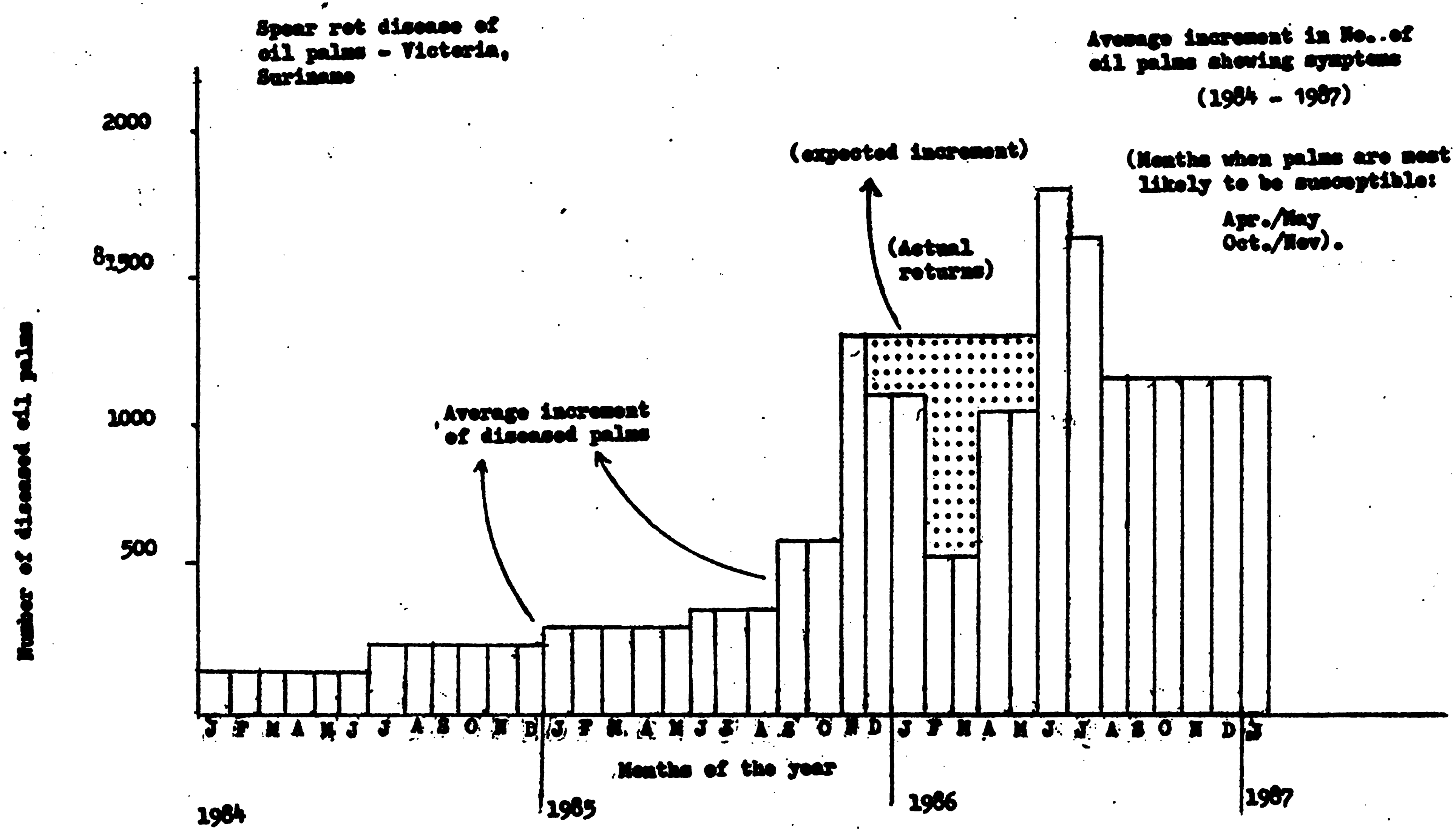
a. Research - Costs

Chemicals + Equipment	US$1,750

b. Control Measures

Chemicals etc.	US$1,000
Minor equipment	US$ 500
Incidentals	US$ 250
Training passage (2 persons)	US$ 350
Per diem 2 weeks 50 x 14 x 2	US$1,400
Costs to Trinidad & Tobago	US$3,000

Figure 1


Spear rot disease of
oil palms - Victoria,
Suriname
Average increment in No. of
oil palms showing symptoms
(1984 - 1987)
(expected increment)
(Actual
returns)
(Months when palms are most
likely to be susceptible:
Apr./May
Oct./Nov).
Average increment
of diseased palms
2000
1500
1000
500
Number of diseased oil palms
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J
Months of the year
1984
1985
1986
1987

A PROGRAMME OF RESEARCH TO CONTROL SPEAR ROT DISEASE IN SURINAME 1988 - 1990

It is well known that there are two major diseases of the oil palm and the coconut palm which originated in Latin America (Griffith, 1978). These are Red Ring disease and Cedros wilt (Hart rot). *Elaeis guineensis* encountered and succumbed to both diseases after having been introduced to this region roughly from the middle of this century. There is no counterpart for these diseases in the old world. I have alluded to this to draw attention to the alternative issue, of the probability, in the absence of proof of pathogenicity to date, that Spear rot might be a new disease encountered here in Latin America for the first time. Apart from the fact already mentioned which makes this extremely unlikely, any new disease would more than likely have come out of the coconut agro-ecosystem. The presence of *Erwinia sp.* in relation *Phytophthera palmivora* in the same ecological niche and the fact that the counterpart disease already exists in the old world should tend to allay any fears of some remotely abstruse phenomenon in the oil palm agro-system which might produce something new and so prevent forward planning.

Objectives of Programme

The basic objectives, therefore, of the research programme will be:

1. To understand more about the causal agent e.g.

   a) survival time outside of the palm host

   b) forecasting of outbreaks

   c) conditions for invasion of healthy tissue

2. To analyse the effect of the control efforts resulting from the removal and destruction of diseased tissue and the sterilizing of the crown area with 1% formaldehyde or different strengths.

3. To examine the effects of non-sterilized harvesting equipment (use of 10% formaldehyde) in comparative studies with soil water relation in the North and South of Victoria

4. To initiate a programme for the selection of seeds from imported plants which have not succumbed to the disease for the replanting of the new areas, which must afford at least near optimum conditions for plant growth and development.

5. To obtain a counterpart agency for the commencement of a hybridization programme with E. melanococca (oleifera) and E. guineensis in order to select high yielding and fertile plants with resistance to Spear rot disease.

AN ANALYSIS OF THE PROGRAMMES AND THEIR JUSTIFICATION AND BENEFITS

Programme No. 1 is a direct continuation from the emergency programme which would have already begun in 1987. It is, indeed, the essential step to determine the further development of a plant protection programme. The forecasting of outbreaks bears an important link for protective spraying when conditions are ripe for inoculum to invade the healthy tissue from the imported E. guineensis stock.

Forecasting has received considerable attention in recent years but so far it has not been used in oil palm ecosystems of Latin America. The topic is well covered by Muller and O'Brien (1957) in the Annual Review of Microbiology, (77-110) with a comprehensive bibliography relating to forecasting in several countries of the world. Van Everdingen in the Netherlands had envolved 4 rules concerning weather conditions for certain diseases. However, these have been modified. Concerning forecasting for Spear rot, nothing is known about the conditions for spore transfer, even though basic emphasis is on reduction of leaf growth. Both conditions, of course, must prevail adequately for the development of the epidemic.

The forecasting from meteorological data of conditions that may be expected to render the eco-climate of oil palm more favourable to an increased attack can enable timely application of a protectant pesticide. The same will allow for a calculation and prediction of a probable yield loss. Thus, some form of meteorological equipment would be necessary in the plantations with which to correlate water-stress, particularly,

and plant susceptibility to invasion.

The analysis of the effect of control efforts should present no problem in new fields or in Phedra plantation where inoculum is low. In Victoria, however, where on the northern section the disease is widespread, drastic measures will have to be taken to prevent the rapid movement of inoculum according to the results of dispersal in programme No. 1. It may be that the conditions which provoke infection might not be the same which initiate dispersion and the time lag for infection may cause reduction in the distance through which huge masses of inoculum might be transferred. Thus, an analysis of the harvesting mechanism which has been in progress for 6 years or so in the north, where the plants are older, might result in the major difference between the two regions if contaminated harvesting knives infect nearby trees. The issue that infected palm bear fruit which are harvestable is now being contested as one of the conditions which make the northern region of the plantation more diseased. The comparative trials should be established in programme 3.

I have already indicated that the disease, Spear rot, exists in some palms in Venezuela and not in others. Earlier, I tried to emphasise the fact that some strains of the varieties of E. guineensis showed greater resistance to the disease. In fact, that some plants die rapidly whereas others continue to survive for a period of 3 to 4 years should indicate varietal tolerance of some measure even in susceptible forms. Therefore, among estates, there will be plants from which seeds can be selected with varying degrees of tolerance .

The issue is immediately pertinent since the intention of the PRC was to continue to expand their oil palm production albeit from imported seed of the _E. guineensis_ stock. It is necessary that such importations be substituted by selections made from cultivars growing under conditions of stress while not having contracted the disease. Yield factors for such selections can be analysed in much the same way as coconuts. That is:

a. Production of inflorescences

b. Sex ratio - the proportion of female inflerescences instead of female flowers per inflorescence.

c. The percentage of pollination

d. The number of fruits per bunch.

e. Weight of individual fruits.

f. Proportion of oil bearing tissues to stony endocarp.

g. Oil content of mesocarp and kernels.

The most conspicious variation, and the one that has been most studied, is that of the stony endocarp. It is convenient to recognise 'varieties' based on this character have only been for convenience and have little genetical significance, the genetically important unit being the individual genotype. Another feature of importance is the development of the different sexes and the sex ratio as mentioned before. Hartley (1977) has compiled an adequate review of the work done. More recently, work by Van Heel et al (1987) has pointed out the fact that the logical stage when sex is determined is inferred to be not before the first appearance of the spikelet primordia. Female flower groups develop acropetally as triaxial cincinni whereas the male units do so as reduced ones.

Recent work in Colombia concerning hybridisation in an attempt to arrest the disease started in 1967. Hybrids were made from _E. melanococca_ and _E. guineensis_. Recent expectations in production from hybrids is about 4 tonnes per hectare per annum of palm oil. Apart from this, the programme for determining data on soil and meteorological conditions is in effect in the dry zone south of Lake Maracaibo.

In further work on hybridisation, (Schewendeman et al, 1987) some misgivings were expressed about the Fi hybrids which sometimes showed partial sterility and so wide fluctuations in yield were to be expected. The crosses were made with _E. guineensis_ and biotypes of _E. melanococca_ derived from Colombia and Brazil. The explanations were noted as due to fertilization failures, absence of division of the fertilized secondary nucleus and competition between sacs. Continued work in hybridisation will yield further results as was in the case with various varieties of P.B. 121 etc. in coconuts. The essential challenge is to improve the varietial resistance to Spear rot disease apart from producing sufficient returns.

Assistance in Breeding Programme

Because of their interest in palm breeding generally IRHO can be approached to assist in the development of hybrids originating from biotypes in Latin America with the most compatible biotypes of _E. guineensis_. Notably, the basic method which was established by the West African Institute for oil palm research in the early sixties for bunch quality analysis has been modified in different ways. New procedures with respect to ripeness standards, stalk length, spikelet sampling, fruit storage, pericarp drying, oil extraction and nut drying have been utilized.

In fact, since palm oil and kernel yields depend on total fruit bunch yield and the oil and kernel content of the individual bunches, the components and sub-components of yield should always be emphasised as important parameters and their precise and accurate estimation determined during the process of selection against Spear rot disease.

Alternatively, in view of the history of oil palm research in West Africa, training programmes may be requested and instituted there for selections to be made here both from resident E. guineensis with favourable disease tolerance qualities and from simply more xerophytic forms which may hybridize more easily with selected biotypes from Suriname or Latin America in general.

PROJECTS EXTRACTED FROM SPEAR ROT RESEARCH AND CONTROL PROGRAMMES FOR 1988 - 1990

Project 1.

Isolation of causal organism and the determination of Kock's postulates.

Objective:

To find out and identify the causal organism of the disease from diseased plants growing in the field in order to adjust qualitative and quantitative aspects of the control measures.

Justification:

Despite the accepted evidence that strains of *Erwinia sp.* cause the disease in Africa, an exact identification of the organism under Latin American conditions is required. Further, already documented knowledge might be available for use of the exact species is known. The determination of Kock's postulates on living material susceptible to the organism will also give evidence about the general nature of conditions for susceptibility.

Duration:

6 months to 1 year.

Project 11

To determine the sequence of emission of infective propagules of the causal organism and the range of transmission.

<u>Objective:</u> To find out:

a) Over what distance pathogen will travel in the air and under what conditions such will be emitted.

b) What level of concentrations there are naturally existing in both infected and non-infected fields.

c) To relate these to meteorological conditions and to attempt disease forecasting.

<u>Justification:</u>

Conditions which affect emission and/or dispersal of pathogens in the field can allow for the correct timing of pesticide application. The sequence of these spore emissions will indicate the nature of the programme for control.

<u>Duration:</u> 2 years

<u>Project 111</u> To determine:

a) The effect of roguing of diseased leaves and the use of 1% formaldehyde solution as an eradicant or sterilizing agent to control the level of inoculum and

b) To determine the benefits of sterilisation of harvesting knives in 10% formaldehyde solution.

<u>Objectives:</u>

To control the disease already established in Phedra plantation and to compare harvesting practices in older fields in the North of Victoria with younger fields in the South with sterile harvesting knives.

Justification:

The disease must be controlled and the level of inoculum should be reduced with a sterilising agent which would not destroy the growing point if it is not yet affected by the pathogen. Moreover, an explanation should be sought for the condition in North Victoria which has been harvesting for a longer period (6 years) than the fields in the South. In any case the function of harvesting knives, if any, in the transmission of the disease should be checked.

Duration: 2 years

Project IV

To determine the correlation of climatological data and physiological stage of the plant on infection by the pathogen.

Objective:

Cultivars of *E. guineensis* have been known to contract the disease under certain stress conditions in the plant - water stress, nutritional unbalance. The exact climatological conditions when correlated with the physiological stage of the plant will assist in the location of new fields, the preparation for control measures and indication of loss in yield expected.

Justification:

Resistant varieties of *E. guineensis* which came out of the old world may be present among susceptible plants. Such may be found and selected if they escape disease under the conditions which would normally affect susceptible palms. This will aid in selection of mother palms for new seedlings for newer areas.

Duration: 2 years and more

Project V

The development of a selection programme of E. guineensis for more xerotrophic conditions and high yielding. Commencement of a programme for hybridisation with E. melanococca biotypes.

Objective:

To produce plants which are adapted to Latin American or Suriname conditions of cultivation which are high yielding and inherently resistant to Spear rot disease.

Justification:

This programme is of absolute importance to ensure that native seed or hybrid seed sufficiently adapted to local conditions would produce plants resistant to Spear rot and other diseases yet unknown which might be introduced by a change in the pathosystem of the plant.

For this exercise expert training and guidance is needed from countries or agencies with expertise. This program should begin 1987/1988 and would continue with reviews at 3 year periods.

Available Staff for Projects 1 - V

Most of the programmes require an experienced microbiologist/pathologist and agronomists. The field sanitation programmes require a field sanitation staff capable of keeping adequate records. The selection and breeding programme can be organised as joint-ventures with IRHO or another interested agency. Similar hybridisation programmes are already under way with Brazil and Colombia but not with Spear rot resistance as an objective.

Equipment and Funding

The necessary equipment for the selected programmes and the funding for their execution will be discussed elsewhere in this report.

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A DETAILED REVIEW OF THE RESEARCH WORK THAT HAS BEEN DONE TO DATE ON PLANT HEALTH PROBLEMS OF OIL PALM AND COCONUT, INCLUDING IICA'S CONTRIBUTION

For the purpose of a comprehensive review of the research work done on the plant health problems of oil palm and the coconut palm in Suriname, one should begin by emphasising research that is ongoing with reference to the major economic problems. Indeed, IICA's contribution related to the two major problems associated with and common to both crops. Such problems as Hart rot (Cedros wilt) and Castnia (Cyparissius daedalus) in both coconuts and oil palms are not recent either in origin or in economic importance. However, the nature of their epidemics, over time, often dictated their relevance and their priorities in research.

Apart from these two conditions which exist now at economic levels, Red Ring disease which also affects both oil palm and coconut is endemic in Suriname. Originally, the disease developed in coconuts which, as far as oil palm is concerned, being a more recently introduced crop, is the source of all infection. Thus, a reduction in the status of this disease in coconuts can mean a parallel reduction of its economic importance in oil palm. Indeed, the same is true with Hart rot and Cyparissius.

The basic principle alluded to here, is the well known concept that a pest or pathogen which can be associated with different species of the flora in the ecosystem must be recognised as a function of the entire system and not pertinent to either or anyone of the related plant species. In this case: coconut, oil palms or wild palms. Thus, despite the low economic profile of coconuts in the economy of Suriname at present, its importance as a major source of inoculum for both pests and diseases must be regarded as paramount.

Another introductory feature often experienced in analysing perennial problems of pests and diseases in coconuts is the voluminous reports of repetitive work all attempting to justify accelerated attempts at solving the same old problems at different critical times with only modified answers. To some extent, in Latin America as a coconut and oil palm cultivating region, whereas the diseases are not isolated to any country, the researchers themselves are often isolated by language barriers and various socio-economic conditions which cannot be standardised adequately enough to cause clear interpretations of similar scientific findings in coconut pests and disease problems.

There is, therefore, an urgent need for cooperative efforts even at the level of standardisation of nomenclature for the same disease problems. A further corollary to this sentiment often relates to various researchers' approach to a problem. There is the general observation that the work of each country, in the perspective of the local researcher, is entirely independent and so self-containing enough to provide all the essential answers immediately.

Finally, of the two major economic problems being addressed by both the IICA and the Suriname researchers, Hart rot disease originated among the coconut palms in Latin America only. The disease is now endemic throughout Central America and most of the Caribbean. On the other hand, the Lepideptoran family, Castnidae, to which Cyparissius daedalus belongs has its roots in the old world. The implication here, is the comparative role of the agroecosystem in restraining both the vectors of Hart rot and the insect pest of Cyparissius. It would be more usual to expect to find parasites and predaters for native vectors to Hart rot, than to encounter the same for Cyparissius here in its introduced ecosystem.

The likelihood is that Cyparissius (Castnia) would be sufficiently unrestrained by the ecosystem for it to attack other crops, for example, isolated species on sugar-cane.

The specific objectives of the IICA project

The specific activities indicated in the project document of 1984 were to solve the urgent problems of Hart rot disease and Cyparissius insect pest which affected coconut and oil palm production in Suriname (later on Spear rot was apparently added). Such a programme of research was to be executed within the ambit of a national Coconut and Oil Palm Research Centre (PRC). It was anticipated, however, that at the end of the initial 3-year work-programme, if the results were of benefit to other neighbouring countries, then the national centre would become accredited as an international institution technically adapted to manage a wide range of plant sanitation problems (palms).

In August, 1983, therefore, the Ministry of Agriculture, in anticipation of technical assistance from the IICA, inaugurated the PRC as a division of the Department of Research. All the original senior technical staff were foreigners who had been contracted to work in the programme. These consisted of an Agronomist (Ph.D), an Entomologist (M.Sc.) and a Bacteriologist/Parasitologist (M.Sc.).

As a forerunner to this concept of the PRC, it was the opinion of the Ministry of Agriculture, about 1980, with the advent of oil palm becoming a second crop of agricultural importance to the country, and with an anticipated expansion of close to 8,000 ha. in 4 years, that problems of Hart rot and Cyparissius would have become more urgent. This was especially so, since there were also similar plans projected for an expansion of the present 1339 ha. of coconuts.

Generally, the urgency was justified in view of the fact that Hart rot (Cedros wilt) of coconuts had just been shown by Griffith 1977, to be different from Lethal Yellowing and was identical with a 'new' disease called 'Broken-leaf' in Suriname. Accordingly, though the aetiology was known and control measures were being rapidly devised in Trinidad where the problem is now under control, the universal mode of transmission of the disease in other countries was not yet known. Notwithstanding the fact that the disease was endemic in these parts for many decades, international interest was not being kindled. Griffith's major contribution had been to clarify the problems inherent in the symptomatology of a complex of similar diseases, determine the aetiology and to discover the local vector for Cedros wilt in Trinidad.

Thus, there was uncontestable justification in Suriname's desire to accelerate their own research in an urgent attempt to control these two chronic problems. It was therefore to be expected that neighbouring countries in Latin America who also had been experiencing both problems also had to come to terms with their private situations with the usual sauvez qui peut attitude. Thus, simultaneously, work was being carried out in Guyana, Venezuela, Trinidad, Brasil, Ecuador and Colombia with the normal degree of isolation but with different levels of foreign assistance.

It is chiefly in this context that the resources of the researchers in Suriname should be examined when the ultimate objective was for the PRC to become that necessary international body for research on these problems. IICA's role, therefore, as a source of technical advise and leadership in this acceptable direction can therefore now be properly reviewed. This can be done from two distinct points of view.

In the first instance, whether or not the progress of the research in Suriname still merits its desired objective as an international centre and secondly, what is the level of progress on these programmes in the countries around over the last decade when Hart rot was first being emphasised. An addition to the exercise, is the advent of Spear rot in Latin America as a disease which is now being understood. The primary examination may be segregated in two phases:

1. The direction of the original research activities.
2. The relevant content of the research findings.

1. Examination of the direction of Research Activities

A most elementary criterion for the justifiable direction of research activities by a given unit should relate to the level of coordination of the research programmes or projects in an attempt to elucidate, clarify and promote the most urgent aspects of the problem. In so doing, it would participate mutually and apply similar research findings of cooperating bodies whose functional objective is also that of solving the most immediate aspects of their own problem. The major constraint for the PRC, for example, which makes this *modus operandi* essential, is the specific or limited resources of its own staff and the normal limitations of finances which will allow only certain kinds of research activities to be competently executed within the 3-year probationary period.

It must be entertained that the centre had begun urgently in 1983 pressing for assistance to alleviate the now urgent problems of Hart rot and *Cyparissius daedalus* which were causing severe economic losses. Since 1980, reportedly, Victoria Oil Palm Plantation had been experiencing a loss in production due to the insect of about 15%.

Thus, IICA's input had an immediate goal to assist in arresting the current economic losses by establishing effective control measures and programmes, through the strengthening of the PRC's activities and the coordinating of the direction of all research projects to accomplish this urgent task in the three-year period. Finally, the various aspects of an orientation towards the projected international nature would become clearer after attempts to control both plagues were being instituted and modified by continuous, determinate and additive or complementary projects.

Strategy for the Programming of Activities

During the course of the analysis of these activities the pertinence of the documented strategy should always be recognised. It was proposed as an Inter Institutional building strategy. During the 3 years of the project it was proposed that the research capabilities of the PRC would be strengthened and complemented with additional technical resources so that the Suriname's efforts and results would be made known locally and abroad. In the light of this stated strategy and also of the urgent direction the 3-year programme can be assessed with comments.

Hart rot Activities

These were listed as follows:

1. Plant sanitation survey.
2. Technical literature review on Hart rot's research on coconut and oil palm.
3. Hart rot disease review. Paper for publication.
4. Field survey for Hart rot resistant coconut and oil palm clones.
5. Field testing of Hart rot resistance of available coconut and oil palm genetic material from Suriname and also outside.
6. Continue and strengthen coconut breeding programmes in Suriname (for Hart rot disease).
7. Techniques for flagellate growth under laboratory conditions.
8. Positive proof that flagellates are Hart rot causing pathogens.
9. Disclosure of flagellates' natural infection procedure under field conditions in coconut and oil palms.
10. Disclosure of mode of action of endrin in preventing the Hart rot's infection in coconut and oil palm.
11. Workshop to evaluate the Hart rot research progress.
12. Improvement of the control measures against Hart rot disease in coconut and oil palm.

Method of Analysis

One might first analyse the activities into:-

A. Those which are locally pertinent and urgent to arrest the spread of the disease.

B. Those which relate to technical activities already in progress elsewhere and so are complementary to the work of foreign researchers in understanding the problems.

C. Those which are absent from the programme but are necessary and for which local facilities are at hand to accomplish them.

D. Those which are desirable and require special technical disciplines and equipment not available in Suriname and only usually available among sophisticated specialists.

E. Those which are irrelevant with the present state of knowledge on the subject.

A similar analysis can be made with the activities for *Cyparissius (Castnia)* which have been recorded as follows:

1. *Cyparissius daedalus* bioregulators' survey with special emphasis on disease affecting the coconut giant borer in and out of Suriname;

2. Organization of an applied coconut breeding programme looking for the giant borer resistant varieties;

3. Life history and population dynamics of *Cyparissius daedalus* in Suriname;

4. Geographic distribution of giant borer damage in coconut and oil palm in Suriname;

5. Establishment of permissible economic damage levels for the giant borer in coconut and oil palm in Suriname.

6. Titration and storage procedure for eventually found pathogens of the giant borer in Suriname;

7. Improvement of existing chemical control techniques for the giant borer in coconut and oil palm in Suriname;

8. Integrated control techniques against _Cyparissius daedalus_ in coconut and oil palm in Suriname.

Analysis of Activities:

A. _Locally pertinent and urgent for control measures_

Hart rot (1) Plant sanitation survey
Hart rot (9) Natural infection procedure
Hart rot (10) Disclosure of mode of action of Endrin
Cyparissius (7) Improvement of existing chemical control measures.

B. _Relating to technical activities in progress elsewhere_

Hart rot (3) Hart rot disease review
Hart rot (8) Positive proof that flagellates are pathogenic
Hart rot (12) Improvement of control measures
Cyparissius (5) Establishment of permissible economic damage levels.

C. <u>Absent from activities to accomplish control</u>

Hart rot (1) Organizing of national campaign for control

Hart rot (3) Training of extension officers (farmer-training programmes)

Cyparissius (3) Reliable programmes for the dissemination of control measures to farmers

Hart rot (4) Serological typing of flagellates

D. <u>Requiring specialised technical disciplines and equipment</u>

Hart rot (4) Technique for flagellate growth under laboratory conditions.

Cyparissius (1) Bioregulators survey.

E. <u>Irrelevant with the present state of knowledge, available staff, financing and probationary time</u>

Hart rot (4) Field survey for Hart rot resistant coconut and oil palms.

Hart rot (5) Field testing of Hart rot resistance with available coconut and oil palm genetic material

Hart rot (6) Strengthening coconut breeding programme against Hart rot.

Cyparissius (2) Breeding programme for resistant varieties to giant borer.

Cyparissius (c) Life history and population dynamics

Cyparissius (6) Titration and storage etc.

Cyparissius (8) Integrated control measures against *Cyparissius daedalus*.

Conclusions from Analysis of Activities

For both problems, activities in A (locally pertinent and urgent) were immediately required and available staff should have been occupied with them as priorities. The pest and disease survey programme would have been necessary to continue to monitor the status of the disease and to examine and plan for conditions which would lead to outbreaks. The natural infection process would lead to research on the particular vector for Suriname. This would eventually lead to the understanding of the mode of action of endrin. Essentially, a national campaign for control utilizing already known measures should have been instituted. When comparing these urgent matters with those of other countries one finds, for example, that the particular vector for Trinidad and French Guyana were known and control measures were understood. There is only a suspicion that Lincus sp. can be a vector in Suriname and the mode of action for endrin has not been understood in the Suriname literature. The explanations were given by me in Guyana's programme for IICA.

Section B is clearly more instructive since this should have lead the way for greater participation with international work as part of the strategy for the development of the PRC. But, only after enough work was done in A. The most important contribution here is a literature review done by the IICA representqtive. Similar reviews have been done by Dollet of IRHO at the international level. The IICA review, however, was a good attmpt to cover internationally the recorded literature. But it was not a studied review of the research in progress, only summary reviews.

Regarding the aspect of positive proof of the pathogenicity of flagellates, the work in Trinidad has confirmed Kock's postulates.

Counterparts in Suriname, on their own, could have done the same. Finally, improvement of control measures would relate to the work done elsewhere on parasites for the vector found for Hart rot in Trinidad and Frency Guyana. Such cooperation was not attempted here because the vector was not confirmed. Moreover, control measures had to be on-going on a large enough scale to allow for any innovations.

Section C shows what important components are missing to ensure that the research work reaches the target population of farmers. Unless important findings are translated to farmers either by an extension training programme or by direct campaigns to control diseases, the research work would not have benefitted the population. In Guyana, for example, campaigns have been started to control Cedros wilt after an extensive survey was done and the information analysed. This was also done in Venezuela. The disease is under control in Trinidad.

In order to classify any flagellates and identify them as the appropriate ones taxonomically, causing infection in any location, serological methods have become necessary. In Suriname resides the expertise for making this international contribution along with countries as Trinidad, Venezuela and French Guyana. Such an activity was absent from the three-year programmes. It is specialised work but since the personnel were around in the Ministry of Agriculture, work could have started on such an important exercise.

From the point of view of strategic orientation, therefore, the programme, as stated in the 3-year period from 1985-1987 was too ambitious and apparently was never designed to be accomplished in the time since available staff and other resources would not have been able to attempt all the various activities satisfactorily.

On the other hand, there was expertise available to attempt to accomplish some facets of the programme like organising national control programmes in the 3-years. Those projects like attempting to rear the coconut flagellate *in vitro* have not been successful, because of the lack of very specialised expertise. This has not been done consistently anywhere in the world even by the specialised protozoologists whose job it is to do that.

Briefly, therefore, the choice of activities around which the entire programme was built, in attempt to strengthen the PRC, overburdened it to the extent that it appeared non-functional and misguided from its original goals.

National Control Programmes and Research Relevance

It should have been clear that the application of existing control measures at a national level would have been a primary indicator of the major direction for research emphasis. It would have been meaningless to do research on improved methods of control for either Hart rot or *Cyparissius* without some actual measures in progress relating to the constraints of the agro-ecosystem in such a way as to cause a researcher to seek other methods of greater efficiency and lower costs. In any event, at the end of three-years, with the present knowledge available about the control of Hart rot and *Cyparissius* in Latin America, actual data should have been available as to their economic levels and the modifiable constraints to improve the efficiency of existing control measures.

Another benefit of national control programmes is that they are indicators of unknown factors which can eventually relate to whether or not expensive work is necessary for the development of resistant varieties by actual hybridisation techniques at any given point in time.

One gets the impression from the original plan for the three year programme, that everything was immediately necessary before the problems could be controlled and that all facets had the same probable degree of success within the three-year plan. We have been attempting to breed coconut palms with resistance to Lethal Yellowing for the past 20 years.

Thus, a most notable feature is the indirect nature of the approach to the urgent need for an immediate control programme which, by itself, would have justified, by example to the world, that the PRC was capable of tackling its own problems, to what ever extent, and was therefore ready to expand with more fundamental research and continue to refine the answers to the problems. The needed level of confidence and credibility would have been developed. However, leaving this alone, one should now look at the management of the research lines in the light of the reduction in specially trained technical staff, except the IICA leader and the parasitologist, who remained after 1985.

Management of Research Activities, 1985

A major consideration in the strategy to strengthen the PRC would have been the flexible management of the research time available. From all appearances, after 1983 when the Dutch aid to Suriname was suddenly stopped and in addition, the world bauxite market contracted, Suriname's foreign currency earnings had decreased considerably. Mainly due to this, the foreign researchers left. The Entomoligist in 1983, the Agronomist in 1985 and the Bacteriologist/Parasitologist finally, in 1986. Within the projected period for the research activities on Hart rot and *Cyparissius*, the research programmes themselves could have been modified to suit the competence of the available staff and the level of finances.

Instead, a look at the 1985 research programme clearly showed that the remaining staff in the PRC were not resourceful enough either by training or by experience to carry out the tasks scheduled by the IICA's adviser to the programme.

The working (work) programme for 1985 contained the following activities with the associated leaders and their deadlines dates.

1.	Plant sanitation survey	IICA Consultant - December, 1985.
2.	Review of National and International literature on Hart rot.	IICA and all other staff - July, 1985.
3.	Hart rot disease symptoms and differentiation procedure from other related diseases	IICA Consultant - November, 1985
4.	Field survey for Hart rot resistant coconut and oil palm biotypes.	IICA Consultant - December, 1985
5.	Distribution and percentage of flagellate infection of possible host plants for Hart rot related flagellates.	IICA Consultant - November, 1985.
6.	Laboratory rearing of Hart rot flagellates	P. Kastelein (parasitologist) November, 1985.
7.	Survey of insect vectors for Hart rot related flagellates.	IICA Consultant December, 1985.
8.	Chemical weed control in coconut plantations.	IICA Consultant - December, 1985.

9.	Survey for entomophagous pathogens with special reference to <u>Cyparissius daedalus</u>.	IICA Consultant - December, 1985.
10.	Life history and population dynamics of <u>Cyparissius daedalus</u> in Suriname.	IICA Consultant - December, 1985.

I have left out three or four topics for brevity of the exercise. But, without looking at the procedures, the number of personnel involved and the cost for doing the <u>Plant Sanitation Survey</u> was sufficient for almost the entire year's work. Continuity as a basic part of the three-year programme required that it must be sfficiently done to be meaningful in adjudging the effect of any control measures. Obviously, the questions of a field survey for Hart rot resistant coconut and oil palm varieties would be unanswerable both in time and funds with the available specialist staff. Figure 3 shows the budget. A cursory examination of this shows the impossibility of the programme of work for 1985.

In such a context, all elements were present for the instability of the PRC. The ambitions set for the three years were thwarted by the originally over-ambitious programme having most of the faults common in isolated research programmes of Latin America and secondly, poor advise on research management pertinent to the available financial support and equipment available. Previously, nothing was said about equipment in the body of this report. However, to finalise this aspect a look at the indicators and final goals of the Suriname-IICA project will be useful.

Some indicators and final goals for the Palm Research Centre Organisation - 1985 - 1987.

a.	Training process for some of the PRC Technical staff	1985/1986.
b.	Laboratory equipment	1985/1986
c.	Elaboration of detailed instruction for each test.	1985/1986.

The most striking feature about the PRC is that it has little or no laboratory facilities of its own. At the inception in 1983, all senior technical staff utilised the major facilities in the Research Division of the Ministry of Agriculture and worked alongside other senior technical staff using equipment in turns. The laboratory space for the PRC remained as three large rooms of office space. The only facility available as the Centre's is a room, semi self-contained, for work on flagellates in the Division of Microbiology and Bacteriology whose director is Mrs. van de Lande. Thus, the indicators for final goals which would have had the most opportunities to succeed were:

a. Technical review of available literature on Hart rot disease 1985.

e. Several written reports, 1985/1987. Later on a review of the technical papers for publication could be given.

f. Half yearly reports. 1985/1986/1987. (Most officers left at various times, some taking with them their research results).

g. Usuable conclusions.

(Very often, the work programme was too indirect to obtain usable conclusions. The work on the attempt to grow the coconut flagellate *in vitro* ended up in the rearing of flagellates from other plants but not the coconut or oil palm flagellate causal to the disease. But as already mentioned this was not unexpected).

TABLE 3

BUDGET* FOR 1985 OF THE PALM RESEARCH CENTRE

Personnel costs	Sf.	192.334,-
Operational costs		
Materials and supplies	Sf.	61.500,-
Services	Sf.	1.000,-
	Sf.	62.500,-
Equipment		
Instruments and other technical apparatus	Sf.	16.500,-
Implements	Sf.	1.000,-
Mechanical implements	Sf.	7.000,-
	Sf.	24.500,-
Grand total	Sf.	279.334,-

* These are estimates for 1985, but the actual may be reduced according to the financial situation of the Government.

Figure 3

PALM RESEARCH CENTRE

ORGANISATION STRUCTURE (1985)

Coordinator
Ir. Jagbandhan, A. (Non technical)

Technical Project Leader ---------------------- **IICA Advisor**
Dr. Alexander, V.T. (left) — Dr. M. Revelo
(Counterpart: Ir. Fung Kon Sang, E.W. B.Sc)

Secretariat

Mrs. Marlan, Y.

Section Entomology

Head: Mrs. Asgarali, J. (B.Sc).

Ass.: Mr. Ramkalup, P.

Section Agronomy

Head: Dr. Alexander, V.T. (left)
(Counterpart: Ir. Fung Kon Sang, E.W. (B.Sc)

Assistants: Mr. Palmatak, M.A.
Mr. Koningferander, D.E.

Labourers: Mr. Kromoprajitno, S.
Mr. Kartamenawie, P.
Mr. Kasnan, Ng.
Mrs Partoredjo, R.
Mr. Bishop
Mr. Riedewald.

Section Plant Pathology

Head: Mr. Kastelein, P.

Assistant: Lab.

Mrs. Parsadi, M.

Field: Mr. Moti, Th.

2. THE RELEVANT CONTENT OF RESEARCH FINDINGS DURING THE PERIOD 1985 - 1987

Doubtlessly, the pattern of development for the PRC as prescribed by the IICA advisor was beyond the capability of the centre, including himself, when judged on the basis of attainable goals in the required period. However, one should still analyse the information obtained through whatever research was done before any objective summary might be made. A formal examination must be made through the concensus of examples to illustrate the concept of content that is relevant here. The most straight-forward case can be explained with the problem of Cyparissius with coconuts and oil palms.

The larvae of this large moth bores into the tissue of the trunk of the coconut palm and feeds there during its development. The palm is not killed in the process and the percentage of palms generally killed by such damage, anywhere in the world, is extremely small. Yield also is not significantly reduced with the average level of attacks to the trunk. Occasionally, however, the insect attacks the inflorescence which does not bear fruit, then economic loss is felt. Sometimes, too, the bud of the palm tree is attacked. Then, the palms will stop growing and the loss is even greater. For the average small farmer, there is never any significant loss since the majority of attacks relate to the mature resistant trunk. As a general rule then, farmers are not willing to spend money to buy insecticides which will only prevent cosmetic damage to the palm. Simply because of this well-known phenomenon, and in the absence of parasites and predators, the population builds up for several years still without creating any perceptible economic decrease in the production of

coconuts in a given area.

On the other side of the picture, the reported incidence of losses to the oil palm plantation in Victoria was about 15% of the production. The implication here is that the insect is now attacking the inflorescences which bear the fruit on the oil palm and destroying 15% of these. In other words, the immediately relevant information for control in the oil palm would relate to this significant difference in the behaviour of the population of Cyparissius for control measures to be effective when economic loss is being experienced.

Further, there is well development information in Venezuela and Brazil on the activities of Cyparissius in coconuts, but very little, if any, on its preferential behaviour in oil palms. Consequently, apart from continuing the normal control strategy of using BHC or Furadan and enforcing its application to coconuts, the research work on population development of Cyparissius in oil palms would still be more relevant. Thus, the content of the published research on Cyparissius should bear relevance to this need.

Perhaps a little more detail might conclude the illustration of the concept of relevant content. Before the oil palm plantations existed in Victoria, the coconut palm was the major known host to the moth. The population of the insect increased but not ad infinitum. Despite the fact that there are no known parasites or predators, the physical attributes of the agro-ecosystem are capable of limiting the insect's excessive development. Some factors may be: insufficient space for insects to live in the coconut trunk, the nature of the ambient environment, i.e. temperature, humidity, shade and light intensity. Or, simply the fact that the coconut tree does not provide an adequate number of suitable

inflorescences convenient for egg laying and development to the adult stage.

The development of the oil palm brought with it great differences in plant attributes. The stem differs from that of the coconut in being clothed in its upper parts with persistent leaf bases. Since subtending leaves must be pruned off during harvesting oviposition sites might be encouraged. The canopy is closed and less light is preferred generally by moths of certain families. The humidity is greater in the oil palm agro-ecosystem than in pure coconut stands. All or any of these factors are capable of stimulating an increase in the population of the adult in its newly found home. Thus, research information must seek to understand such existing phenomena and not continue only to probe the unlikely.

As testimony to the known improbability of the programme of research for Cyparissius the 3-year programme seeks to find: (a) Entomophageous pathogens for the insect. (b) Natural parasites and predators in Suriname (c) Life history and population dynamics in Suriname (d) Sites and patterns of egg laying for the female moth. Only in this last exercise (d) was the oil palm mentioned. However, the purpose of this was to be able to release parasites and predators of eggs or larvae if ever they were found. As yet, since the research programmes were not designed for that, no published information relates to the nature of control measures possible for Cyparissius daedalus in the oil palms of Suriname.

A considered feature about the content of relevant information is its ability to allow for mutual participation in research with external agencies. Thus, new information relevant to the control of Cyparissius

in the oil palm would certainly have had the immediate effect of controlling the interest of other researchers who could begin to envisage the international perspective of the PRC.

A similar situation relates to vectors for Hart rot and the oil palm. There was sufficient evidence that Lincus sp. (Pentatomidae) might have been a vector in several areas in Latin America for coconuts. However, there has been no cross-reference or cross-experiments done on oil palms. Information of this type would have had the same effect as with control features for Cyparissius.

The published annotated bibliography on Hart rot of coconuts and oil palms was well done. It was prepared by the joint efforts of the IICA consultant, Pieter Castelein, the last remaining foreign technician who also worked with the flagellates of several milkweed plants, Judith Asgarali and Woellen Fung Kon Sang, two local professionals who understudied the other foreign specialists. The organization of the subject matter was well thought out and in fact, it is a most useful document with its right place to fill in literature documentation. The natural follow-up to this should have been an authoritative treatise at the international level on the disease. Such a review was done by M. Dollet of IRHO and published earlier. This also has its place in research.

However, with the international concern for relevant content, none of the persons who prepared the excellent bibliography was of the level of proficiency with the disease itself to produce an equivalent review to Dollet's which attempted to point out international directions for research. The only principla involved here, is the highly specialised nature of the work when one is attempting international standards not only on Hart rot but on other pests and diseases of coconut and oil palms

as well. Perhaps this last feature would have finally explained the need for relevant content in research instead of just the collection of relevant information about the problems to be researched.

In the final analysis, relevent content in the IICA-PRC-SURINAME project in the first three-years would have had to relate to control measures and their efficacious development. The annotated bibliography indicated various types of control measures for Hart rot. A similar one for *Cyparissius* could have assisted in the cocount programme development. Therefore, after nearly three years of joint activity, the evaluation of the project by the stated indicators and goals for the general objective might now be employed with the given reservations that pest and disease control is also a function of the economy and not necessarily only that of adequate knowledge of control measures. Control measures that are costly must provide profitable returns to farmers.

INDICATORS AND GOALS FOR THE GENERAL OBJECTIVE

As stated in the project document, some of these were:

a. Progressive reduction of palms killed or damaged by the disease and the insect pest, once the improved or new developed control system is put into effect;

b. Hart rot disease damage eliminated or otherwise sound and scientific proof that such damage is not caused by the disease (a disease causing agent).

c. Progressive reduction of the actual expenses for insect control and Hart rot preventitive treatments.

The others have been left out for the time being since they were never really attainable goals in the perspective of the PRC's resources

and the limitation of time, given the prevailing socio-economic situation. The problem of Spear rot has been referred to in the general introduction and also already discussed separately. Progressive increase of cocoanut and oil palm yield is related to many other uncontrollable factors to which the IICA-PRC project is not now pertinent.

A visit to the district of Coronie (Tuesday, May 5, 1985)

It is opportune now to reflect on a visit to the cocoanut growing district of Coronie. The objective is, in this regard to observe the 'indicators for benefits' to users derived from the goals of the project. The document states that the growers are, in most cases, a big farmers' group of low income resources. They will be, certainly, the first social group in getting the benefits of " a best and less expensive plant sanitation technique".

A journey along the main highway through Coronie brought home the picture that it was a cocoanut growing district comprised mainly of small farmers and a few larger holdings. It is not difficult to understand with a projection of less than 2,000 ha. of scattered holdings that the key problem is the organisation of growers around a processing plant. A visit to the plant confirmed the view that there was not a strong enough group policy, as a registered cooperative, for example, to support the factory which had been lying idle for several months. Nevertheless, some small farmers had been reaping their cocoanuts and selling them for a high price elsewhere; or making their own oil which they would sell in the absence of local palm oil. Even in this panorama, some of the larger farms looked semi-abandoned and diseased principally with Hart rot and Red Ring disease. A cursory examination showed no presence of the cocoanut mite (Aceria)Eriophyes guerreronis Keifer. Several palms were damaged by Brassolis. This always happens.

The essential issue here is that apart from the lack of management practices generally, there seems never to have been an organization of a national control programme for Hart rot or Red Ring. The blessing with a small acreage of coconuts is that there are not many farmers to deal with. But the curse is, the source of both Red Ring disease and Hart rot to any oil palms in the country. Consequently, a most fundamental principle must be addressed by any organized programme for research on pests and diseases common to both oil palms and coconuts. It is a clear-cut and mandatory programme for the control of those pests and diseases in the coconut growing areas. There would seem to be no progress gained by attempting to control the pests or diseases generally if the functional and endemic region for both plagues exists as unattended sources of infection for whatever reason. On this essential point one might conclude the analysis of the thrust made to alleviate the problems in oil palm and coconuts in Suriname by the 3-year joint IICA-PRC project.

On reflection, there is justification for concluding as follows:-

a. The initial programme as set out by the IICA consultant to the project was over-ambitious and was not immediately sensitive to the urgent needs that motivated its inception.

b. That leadership was not sufficiently sensitive and flexible to adjust the direction of some relevant aspects of the programme to accomplish useful goals during the socio-economic changes which lead to staff and financial interruptions and

c. It is very doubtful whether or not any new practical scientific achievements of an original nature had evinced themselves during the entire exercise.

d. At this point in time, one is not sure to what extent the local staff were given adequate exposure and familiarity with 6year not research for them to continue on their own. . . .

<u>Trimester Report (March 28, 1986) by the IICA Advisor</u>

In this report for the trimester March 1986, the IICA consultant gave the following explanations for the limiting factors (internal or external) which might have influenced the achievements of results. These were:

a. The human problems include the shortage of technicians. From three available technicials one is insufficiently trained and the other affected by health problems which do not allow him to work in the field.

b. The supply of material resources is more critical because, in addition to the reduced budget, many of the commonly needed materials are no longer available on the local market.

c. The local technical project leader is a slow acting officer, has limited leadership capabilities, is often to, affected with health problems and is unable to take any decisions.

d. The organizational position of the PRC, within the Ministry of Agriculture, seems not to be the best to facilitate the use of laboratories, greenhouses, transportation services and other services that the PRC people are always complaining about.

Altogether, one major conclusion is unambiguous. It is that at the end of the three-year period, the listed products in the project document for the establishment of a coconut and oil palm research centre in Suriname have not been achieved. Notably though, progress in research with Hart rot or Cedros wilt has been made throughout Latin America. In some countries it is under control in coconuts and has not yet posed a serious threat to oil palms in countries like Venezuela. The problem of Cyparissius has greater importance here economically because of the vastly different economic relevance to the local economy between coconuts and oil palm.

Contrastingly, in most of the neighbouring countries, coconut enjoys a greater priority of agricultural status. Therefore, similar pests and diseases to those affecting Suriname are kept at a significantly lower level of incidence by the general farming population. Thus, intre-spectively, one would assume that the policy of the PRC should focus on actually controlling those pests and diseases with the already known measures. By so doing, basic research into further refinements can contribute more realistically to an international forum. The PRC can still retain its original resolve to becoming an institution of international accreditation and repute eventually.

A DETAILED PROPOSAL FOR A PROGRAMME OF RESEARCH ON OIL PALM AND COCONUT PESTS AND DISEASES IN SURINAME EXTENDING OVER THE PERIOD 1988 - 1990 IN THE FIRST INSTANCE

The specific problems with which the proposals will deal

Following approximately three years of a joint IICA-PRC programme to reduce the incidence of Hart rot disease in both coconuts and oil palms and a concurrent programme to control *Cyparissius daedalus*, a moth which had, by 1980, caused about 15% loss in oil palm production while building up its population in coconut palms, but only causing minimal loss in returns, the following programme is designed to alleviate significantly, the alarming increase in both plagues. Further, because of the epiphytotic nature of Spear rot disease in the oil palm plantations of Suriname, specific proposals will be indicated to arrest its spread. The programmes for such activities will be introduced in phases extending over the period 1988 - 1990.

Specifically, the programme will deal with control. In the first instance, the most pertinent and proven successful measures will be employed if they are applicable to the Suriname situation. Secondly, the programmes will be continuously monitored over the two-year phase to determine specific refinements in principles or practice which, by research and analysis, will determine the direction to greater efficacy. The choice of the most effective means of control will naturally be guided by the reactions of the agro-ecosystem to which both species of palms belong. Significantly, however, the economic attributes of the measures may determine the levels of their application.

This *modus operandi* will apply to Hart rot and *Cyparissius daedalus*. But, whereas the emphasis for Hart rot control will be on both oil palms and coconuts, that for *Cyparissius* will be mainly on oil palms. The reasons which contribute to this distinction relate to the fact that Hart rot is a fatal disease to both coconuts and oil palms; whereas *Cyparissius* causes economic loss at present only in oil palms. The reasons further relate to the epidemic nature of Hart rot in coconut palms. It has been documented that Hart rot in coconut palms develops to epidemic proportions because of over-crowding of palms and general abandonment of estates. The underlying principle is the contact of leaves between adjacent trees, one healthy and the other from an infected plant. The same principle may prove applicable in oil palms where spacing between 8½m and 9 m always allows for a close canopy of leaves in intimate contact.

The concepts involved in the control programme for Spear rot are different. Reliability will relate to the level of efficiency at which control measures are to be carried out. The principle involved with the use of 1% formaldehyde is effective sterilisation of the affected portion of the palm. It, however, has nothing to do with the predisposing factors which assist infection. Further, the control measure itself, is exploratory and so requires efficient and reliable information on which to develop efficacy and yield more data about the disease itself. Thus, apart from control measures, relevant research will be necessary to forecase and determine various unknown aspects both about the aetiology and the epidemiology of this disease.

A fundamental premise in respect of Spear rot disease is the effect on the pathosystem of a new environment. In recent times, it has been suggested that several diseases which affect indigenous crops only slightly in their places of origin become virulent epidemics in new environments as the cultivation zones expand in the modern world to ecologically marginal areas. This is an essential principle on which the anticipated development of protective measures in the research activities depend. Most of the cultivated oil palms originated in the old world. The new ecology of the Latin American agro-ecosystem allows the same pathogen belonging to their area of origin to break the barriers of a weakened defense system and cause epiphytotics in new areas. Knowledge of this concept has made it necessary to embark immediately on a plan to produce hybrids with the native E. melanococca cultivars.

The nature of this urgent activity which might be considered more of selection than breeding for resistance, allows it to be immediately useful for Suriname. The principle inherent in the method is to introduse 'local blood' into the foreign cultivars so that the tolerance of the pathosystem might be immediately improved. In other words, one selects, with the best criteria, plants of either parent with the knowledge that the dominant traits should reside with production emphasis while resistant qualities are being introduced into these linds. A programme for breeding and stabilizing of hybrids will be a long-term exercise in the perspective of resistant characteristics to the pathogen per se.

Conceptually, then, the operative mode in dealing with the specific problems is control with research as a tool influencing the nature and the efficacy of the control measures. Basically, the obligatory pattern for the next two years will contrast markedly with that of the past three years where studies were undertaken about the problems fundamentally instead of allowing known control measures to guide the development of research. In a summary, the application of control measures in this twp-year programmesby estate managers or farmers will itself be an exercise in fundamental and applied research.

The general problem surrounding the specific problems.

A major obstacle to be overcome will be one of conditional attitudes towards research on a problem. The scientific researcher continues to develop his capacity for doing research while being a manager of the particular problem. The problem here is control of a pest and two diseases in interrelating agro-ecosystems. The Entomologist, in this programme, becomes a manager of the control exercise and only pursues relevant research towards that goal. Moreover, that the agro-ecosystem of the coconut relates with that of the oil palm makes the problems of coconuts functional with those of oil palms. Various governments only spend money on what they consider developmental and urgent. In this case oil palm is economically urgent, but the fault, as it were, lies with the coconut. Thus, the emphasis on coconuts must be clear with respect to the urgency of Hart rot disease, for example. This would mean an economic revival of the crop if monies would have to be spent on it necessarily because it is a font of the disease to the developing oil palm industry.

The issue here should be clear. The 2000. ha of coconuts should be made economic, either by efficient utilization and marketing of the by-products or by developing new and more demanding products for different markets, as coconut cream, shredded coconuts etc, which will stimulate growth and care for the industry. It is very unlikely that farmers would take a keen interest in protecting a crop if the returns are not profitable. The economic perspective for this crop will pose a serious limitation to the control of pests and diseases common to this and the oil palm. The moral of the story is that coconuts cannot be abandoned when a country is thinking of controlling pests and diseases in a developing oil palm industry.

Institutions related to the specific problems and their limitations .

The PRC, as a division of the Ministry of Agriculture, is the competent authority to undertake the tasks of control and research into the specific problems already mentioned. Figure 2 shows the disposition and qualifications of the local staff. There is expected to be added to that structure a plant breeder (M.Sc), Patricia Milton, who will be in charge of the oil palm selection project. The important feature here is that the pattern of the programme for control will allow the staff to develop their research expertise as the exercise grows, since they are starting off with known methods and analysing their results to develop further. The major expertise required, other than the fundamental training which each has at the B.Sc. level, is the organisation and management of experimental data in the first instance.

At present, it can be said that there are no laboratory facilities in the PRC. But the programme of control can begin with basic apparatus for Hart rot like:

a. Research microscope
b. A binocular dissecting microscope
c. Dissecting equipment
e. Glassware and essential chemicals
f. Autoclave and microbiological media.

The division has transport, so that the available chemicals for injecting the trees which are diseased plus the cost of labour and general services equipment like a chain saw will cause the campaign to start among 2,000 ha. of coconuts. Whereas the oil palm plantations themselves have their own crop protective services, the coordination and record-keeping will be done at the PRC on a small computer.

The section for entomological research would require:

1. Insedt cages
2. Trapping material
3. Drying oven for preparing specimens;
4. A storage cabinet
5. a binocular microscope
6. some dissecting equipment and glassware
7. storage for insecticide/pesticides generally.

With Spear rot, some tools and chemicals would have already been bought under the short-term programme. The apparatus for spore-trapping and the necessary chemicals for spraying, together with spraying equipment, would have been there. A few other things would be necessary:

a. Portable autocalve
b. Transfer chamber or a clean-air-flow cabinet
c. Bunsen burners and gas
d. Glassware and microbiological media
e. Reagents for microbial work
f. Research balance

g. Basic general equipment

Basically, however, the equipment can be obtained in stages as the particular programmes are organised and staff become more flexible. Another reason for this is the availability of back-up services already present in the Research Division of the Ministry of Agriculture. Work on soil/water relations can be done by Dr. Noordam of the division of Soil Fertility and Agrohydrology, whereas, assistance with epidemiological analysis can be done by Dr. Ferdinand Klas of the division of Virology.

Major limitations of other institutions (Oil Palm Plantation)

The relationship between the PRC and the various oil palm plantations would have to be stabilized. At the moment, there is no one official Board of Directors for the three government plantations, even though they function with one aim basically and one Crop Protection Unit under the care of Mr. P. Rellum. This working relationship which is not official between the estates and the PRC is the major limitation to the successful development of control programmes and their management. This is especially so with Spear rot disease.

It is obvious that because the working arrangements between the estates and the PRC, which supports it technically, have not been formalised that the previous programme fell into research activities with no direct and active component for applying control measures. Further, it is normal for such an enterprise like the oil palm plantations to contribute financially to support its own research. Previously, it was indicated that some technical facilities were located at the Victoria estate. Now in the present crisis, these might no longer be available. Thus, sometime within the next two years, the arrangements regarding the nature of the association

and financing of the PRC by these commercial companies should be concluded in such a way that the PRC would be of national service in these control programmes.

Such financial cooperation between the PRC and the oil palm estates is necessary to justify any form of technical and/or financial assistance from an external agency. Essentially, the cooperation between the IICA and the PRC is an association for strengthening the activities of the centre. It would therefore be unreasonable to expect any supportive or financing agency to allow a local counterpart financing source not to play its necessary and responsible role. It is more than likely that a formally structured arrangement betwden the plantations with their newly formed board and the PRC will be the catalyst for deriving both technical and financial support in this new phase of activity. Indeed, this relationship is one of the most critical to the exercise, as it has been before. Yet, without full recognition of its role as a beneficiary organisation, the absence of a Board jointly, with the poor direction of the past three-year programme of work, was responsible for the failure of IICA's cooperative inputs.

<u>Other infrastructural facilities; distribution of facilities</u>

The other infrastructural facilities needed for the programme of 1988 - 1990, relate to field experimentation for the development of hybrid stock for use against Spear rot disease. Such fields are available within a radius of 40 km. from the PRC. At Dirkshoop, in the district of Saramacca, apart from coconut trial plots, an area has already been set aside for producing oil palm hybrid stock. A similar site has been prepared at La Poule. However, the major site for the rehabilitation of the previously attempted hybridisation programme, about 15 years ago, is a 50 ha. farm at the OEMA Station, about 25 km from the PRC. At this site, there exists parent stock of <u>E. guineensis</u> together with <u>E. melanococca</u> with hybrids of these two

lines and some backcrosses. Rehabilitation of this field is expected to begin shortly in view of the expected seminar on Spear rot in March, 1988. This will be a major hybridization centre.

SUMMARY OF RESEARCH DONE PREVIOUS TO 1988 ON DISEASES RELEVANT TO THE PROGRAMME FOR 1988-1990

It was stated previously that control measures will be derived from the abundant scientific literature available on the pest and diseases considered here. One should now consider Hart rot disease at this time since a comprehensive review has already been given on Spear rot disease in an earlier section. Historically, Suriname had given the world some of the first information on Coronie wilt (Bor, 1969) which Drost, in 1908, had called Hart rot. Before 1975, however, it was being confused with Lethal Yellowing which had practically the same overt symptoms. Despite this, it was even mistaken by Ohler, in 1966, as a new disease called 'Broken leaf'.

There has never been any difficulty with the identification of the causal agent, the Trypanosomatid flagellate, (Parthasarathy et al, 1976) in Suriname. On realizing that the disease itself was not a rot as was indicated by Griffith (1977) who called it Cedros wilt, the same researchers (Parthasarathy et al, 1978) introduced the term "fatal wilt" into the literature in 1978. The disease now is generally called Cedros wilt or Marchitez de Cedros, but Hart rot still remains as the significant term in Suriname.

The actual classification of the species of *Phytomonas* which is causal to the disease has caused some conflict. Griffith (1980) continued to use the original name *Phytomonas elmassiani* since he had traced its origin from the milk-weed plant *Asclepias curassavica* to the coconut via the insect *Oncopeltus sp.* which lives mainly on the weed *Asclepias* and to *Pentatomid* bug *Mecistorrhinus sp.* which transmits the pathogen from a diseased coconut tree to a healthy one in Trinidad. The mutualistic bacterium associated constantly with the flagellate in *Asclepias* was utilized as an accurate tracer to locate the protozoan. On the other hand, McGhee, in his visits to Suriname (1977,1978), reclassified it as a new species, *P. staheli*, believing it to be obligate to palms and did not consider the weed to be important since, in his opinion, the chain of relationship might have been broken in antiquity. Griffith (1982) later showed that the same flagellate from the milk-weed *Asclepias* could in fact cause the disease on coconut palms. At this point in time, serological studies are being done to assist in the specific classification.

Several of the more recent Surinamese workers in the last three years (Kastelein et al, 1984, 1985, 1986) in attempting to cultivate the protozoan *in vitro*, ended up culturing only weed related flagellates which bore no reference to the coconut flagellate. They were not able to culture the protozoan from *Asclepias* either. Despite this, advances were made on the vector in Suriname, following the work of Griffith and Dollet (1982). Recently, Asgarali (1985) in the PRC, studied *Lincus sp*, *Pentatomidae*, as a possible vector in coconuts. Nothing so far is known in Suriname as to the vector in oil palms. From all appearances, however, it will be a *Pentatomid* of some kind, and more than likely *Lincus sp.* itself.

Control measures applied in Trinidad were basically the removal of the milk-weed plant Asclepias. Such control was possible because control measures for Red Ring disease normally removed any residium of the protozoa in diseased trees. All trees are poisoned with Silvisar 510. In the absence of the weed reservoir, or collateral host, the disease was easily controlled. In Suriname, however, control measures relate both to the poisoning of the diseased trees with Grammaxone and the use of Endrin around the palm to kill the fallen vector insects still developing on the branches on the ground. (Thomas, 1981, 1983).

A major conflict that presents itself with the interpretation of the disease in Suriname arose because of a poor understanding of McGhee's reason for changing the specific name of P. elmassiani to P. staheli. In the concept of P. staheli no weed is required for the transmission sequence. McGhee, the author of the new name, had also worked with P. elmassiani in Asclepias. He concluded that residual inoculum in the unattended coconut palms with the associated vector, a Pentatomidae, was all that was necessary to cause the disease to spread. This, of course, is possible as was shown in Guyana by me. However, over the last three years, much unnecessary work was done in Suriname on the search for weeds which housed P. staheli. For example, Segeren and Alexander (1984) studied the effect of weeding on Hart rot disease. This was followed by an inventory of weeds in eight coconut fields (Segeren et al, 1984).

In Trinidad, it is still certain that the milkweed plant is still only the source of inoculum and McGhee's claim was that, at the time, it was not possible to take flagellates from the milkweed, Asclepias, and place them in in the phloem of the coconut palm in order to demonstrate artificially Kock's postulates.

This was accomplished later. So, for all intents and purposes, the milkweed plant, Asclepias which abounds in the Coronie district, is still a credible source of inoculum. Eventually, with carefully organized control measures for the disease in coconuts, this fact will become evident. On the other hand, the control measures employed are effective in an estate without Asclepias. It will be very effective in the oil palm fields where the amount of shade inhibits the natural prolific development of Asclepias curassavica. One modification of the local method is early treatment to prevent leaf-fall with vector insects and the consequent added need for an insecticide. A chemical like 'Silvisar 510' will also kill the insects on the tree if it is injected in time.

A review of the literature on Cyparissius in Suriname

Some of the first work done on Cyparissius (Castnia) on coconuts in Suriname was by Van Dinther (1956). Later, mention was made of the pest in the literature of the Ministry of Agriculture in 1962. A considerable amount of time in the last three years was spent on life history studies, most of which was already known elsewhere. However, there was the perspective of a possible nematode parasite for Castnia which was studied by Segeren et al in 1984. Generally, control work was done using Furadan and BHC in the leaf axils or by injection into the stem of a liquid preparation. In oil palms, which are more seriously attacked, work was done in Brasil by Shuiling (1980) when the pest was considered there to be serious. In Suriname, ecological studies should be done in the oil palm estates while Furadan or BHC is used with studies on control.

SPECIFIC OBJECTIVES AND ACTIVITIES OF THE PROGRAMME

1. Technical objectives/activities for Hart rot

   a. To mount a national survey in order to determine the level or incidence of Hart rot disease in approximately 2,000 ha. of coconut holdings distributed throughout Suriname;

   b. To devise a national campaign to control the incidence of Hart rot disease throughout coconut farms in Suriname;

   c. To establish permanent procedures whereby the incidence of the disease can be monitored continuously beyond 1990.

   d. To pursue the identical operations (a) (b) and (c) in the oil palm estates in Suriname;

   e. To determine and compare the vector to this disease in oil palms with that in coconuts and to formulate plans to determine outbreak periods or patterns associated with the control measures applied over the 2-year period.

2. Technical objectives/activities for *Cyparissius daedalus*.

   a. To mount a continuous survey to determine accurately the damage done by *Cyparissius* in oil palm in an attempt to assess the effectiveness of the control measures being utilized at present.

   b. To determine the influence of seasons/wet and dry/ on the level of attacks;

c. Preliminary laboratory trials on the effectiveness of the fungus Metarrhizium anisopliae on larvae. (Similar trials can be done with Beauvaria sp.)

3. Technical objectives/activities for Spear rot.

These were already explained in the programme for Spear rot earlier for the staff of the PRC. However, for the division of Soil Fertility and Agrohydrology, the necessary soil/water relation studies would be made and correlated with the increase in incidence of the disease. It has been reported by Van Slobbe in 1984 that Spear rot incidence is highest where and when growing conditions are adverse. The literature in Africa concurs with this observation. There is, therefore, need to establish the nature of the stress factors which reduce the rate of leaf-growth (adverse conditions) and predispose the palms to infection by the pathogen.

Thus, the projects will be:

a. A comparison between the increase in incidence in Sprar rot with (i) soil/water relations (ii) levels of available nitrogen into the soil (iii) comparisons with similar criteria in areas without disease throughout the two-year period.

b. Studies of leaf-growth rate correlated with the onset of symptoms (Refer to literature by: A.D.S. Duff; Journ. WAIFOR.14. 176 - 190. (Appendix).

c. General soil analysis can be made over the two-year period to establish limiting nutrients in an attempt to assist the palm to resist pathogens of any kind and to produce more fruits.

4. Technical objectives/activities for the development of hybrids between Elaeis guineensis and E. melanococca.

The rehabilitation of the exisisting plots with E. guineensis and E. melanococca and the maintenance of the existing hybrids will be essential for the development of strains showing greater tolerance to the local eco-system. The result will be that selected palms would have greater freedom from risk of disease to the imported Bud rot or even Vascular wilt by Fusarium oxysporium which has come in from the old world to Brazil.

5. Non-technical objectives

a. The major non-technical objectives will be to develop a sense of commitment in local researchers to assume the responsibility for their own programmes while developing greater expertise and self-confidence in research. The programmes as organised are within the capabilities of the officers at present employed by the PRC, the Ministry of Agriculture and the technical support staff on the plantations.

b. The second major objective is to enable research staff of several disciplines to be able to organize work programmes and develop confidence in their ability to do so, especially now as facilities are limiting and expatriate staff are difficult to obtain.

c. To develop in young researchers the perspective of international standards and to train them to view their own results with objectivity and positiveness; especially when they are forced to participate in the more complex aspects of their own research problems.

CONDITIONING FACTORS TO ACHIEVE THE STATED OBJECTIVES

For the next two years, the activities of the staff of the PRC will be confined to controlling the two diseases and the pest mentioned. Further, there will be a lot of processing of data to be accomplished during that time in order to determine further directions. The Government, through the Ministry of Agriculture, has to employ the available staff and assist in developing suitably equipped laboratory.

Another local counterpart to the exercise is the three commercial oil palm plantations. These together will form a unified body and relate to the PRC so that it can be afforded added financial assistance in the absence of the Dutch aid. A primary role of this new association should be to outfit some of the laboratories, in phases, with the necessary basic equipment as previously mentioned. Most of the recurrent expenditure can come from the government budget.

The IICA has always been conceened from the inception with strengthening the PRC in any reasonable and tangible way for which its policy allows. A major role of the IICA in these initial two years of the programme should be:

1. To expose all the officers in the PRC to a continued process of short-term training;

2. To be a connecting link between foreign institutions in Latin America and elsewhere where pertinent research is being undertaken;

3. To assist in the initiation of the projects related to the programmes prepared with appropriate financial or direct aid in terms of equipment like a computer. And assist in the relevant training necessary for the staff

to be able to store and analyse their scientific information. In fact, the initial gift of a PC with printer and a plotter and programmes as Fortran and a simple data retrieving programme, will go a long way in restoring the confidence that might have been lost due to the misfortunes in the initial 3-year programme.

4. IICA's financial contribution to provide long-term consultancy and advise should be re-assessed, in this case, and the comparable funds re-directed to assist further in those above-mentioned ways.

A major conditioning factor, also, will be the role of the coconut farmers in the policy outlined by the joint association between the oil palm plantations and the PRC. There will be a need for a revival of the cooperative formed many years ago and a resurgence of political interest in the crop if the Palm Research Centre is going to proceed with its operations in coconut pests and diseases eventually. It would appear that a serious drive must be created to rehabilitate the existing coconut industry and modernising the factory. An appeal can be made to the FAO particularly, for a consultant, and eventually funds to assess the situation and make the necessary recommendations for the programmes of crop and factory development. Two thousand ha. of coconuts will not pose a serious problem to rehabilitate as long as a market is found for the factory products. The solution will revolve around small farmer development in coconut multiple cropping systems.

SPECIFIC RESPONSIBILITY AND DUTIES FOR AVAILABLE STAFF AT THE PRC AND ELSEWHERE

Coordinator and Administrator - Mr. Fung Ken Sang, W.

The major responsibility is for the administration and coordination of programmes with the PRC, the Oil Palm Plantation Board and the reformed Coconut Growers (Cooperative). He is responsible for ensuring that the various programmes keep on schedule and that goals are met. He is also responsible to ensure the smooth running of the joint-institutional activities and maintain an accurate check on expenditure of all kinds. He is thus accountable to the Director of Research or Supervising Board.

Technical Project Leader and Agronomist - Mrs. T.L. Nanden - Amattaran

The major responsibility is that of technical head responsible for directing and coordination of all major technical aspects of each programme. She is responsible for ensuring that the various programmes are accurately and efficiently executed. Apert from this, another major technical responsibility will be to coordinate the inputs of staff from the Research Division. She will chair the monthly meetings which will be held to ensure correct technical procedure and surmount difficulties experienced by any staff. She will be responsible for requesting training for staff and visits of experienced personnel to assist from time to time. Her specific input will be in the field of organiser for all control programmes, including Spear rot, and assisting in the agronomy of the rehabilitation of the hybrid plots to ensure their proper agronomic development. She will also relate to agronomic problems of small farmers in coconuts and assist in any rehabilitation efforts which might be needed.

She will be responsible for obtaining information on growth-rate studies on Spear rot disease in oil palms with Dr. Noordam.

<u>Hart rot Programmes and Vector Studies in oil Palm - Mrs. J. Asgarali</u>

The major responsibility is for the organisation and execution of the survey and control programmes on Hart rot in coconuts and oil palms. She will relate to the officers in the oil palm company to coordinate and assist in executing their programmes. She will relate to the Extension Services of the Ministry to train requested staff in the dissemination of information about Hart rot in coconuts. She will be responsible for the control campaign at the farmer level and be the executive officer in co-ordinating all information. She will be responsible for mounting a programme of research to determine the vector of Hart rot on oil palms. Since the vector for both oil palms and coconuts might be the same, the research would not be too difficult. She has already worked with <u>Lincus sp.</u>, the vector for Hart rot in coconuts. She will assist Mr. Rellum with studies in the control programme for <u>Cyparissius</u>.

<u>Campaign for Spear rot at the Plantations - Mr. P. Rellum</u>

The major responsibility will be for the entire campaign for the control of inoculum by the measures already outlined. He will be responsible for obtaining all information to be presented at the monthly meetings with all technical staff. He will work in cooperation with Dr. D. Noordam, of the Division of Soil Fertility and Hydrology with regard to experiments in soil/water relations correlated with increase of incidence of disease. He will also cooperate with the agronomist, Mrs. T.L. Nandem - Amattaram, with respect to work on growth-rate data and susceptibility to infection by the Spear rot pathogen.

<u>Spore Trapping, Epidemiology and Microbial Laboratory Diagnosis in Spear rot Disease</u> - Mrs. M. Parsadi and Dr. F.E. Klas.

Mrs. M. Parsadi has had training in doing some microbial work under Mr. Kastelein and is capable of managing a microbiological laboratory to cultivate bacteria and identify them. She can be trained further to do inoculation studies both in the field and the laboratory. She will relate to Dr. Ferdinand Klas, a microbiologist/virologist who will coordinate the epidemiological and inoculation studies.

<u>Assistance and Training in all Microbial Techniques and Laboratory Management</u> - Dr. F. E. Klas.

Dr. Klas is an outstanding microbiologist who specialises in epidemiological studies. His support will be needed by Mrs. Parsadi in the setting up of her laboratory and the analysis of information collected in the field studies on spore trapping. Dr. Klas's other responsibility will be to analyse all epidemiological data and direct and coordinate the field experiments to be carried out by Mrs. Parsadi. He will assist in the determination of Kock's postulates.

<u>The Rehabilitation of the Hybridisation Plots</u> - Patricia Milton

The responsibility for this will be assumed by Ms. Patricia Milton, M.Sc. (Plant-Breeder). Her role will be to select particular varieties of <u>E. melanococca</u> and <u>E. guineensis</u> for hybridization studies. She will relate to other institutions abroad like IRHO or the West African Institute for Oil Palm Research (Nigerian Institute).

Studies on Cyparissius in Oil Palm - P. Rellum and Ms. J. Asgarali

This activity will be phased into the work of the oil palm protection staff and co-directed by Ms. Asgarali and Mr. Rellum. Ms. Asgarali, being an Entomologist, will be required to direct the programme with advice from the Entomologist at the Ministry of Agriculture. She will be trained how to utilize fungal cultures against insects either in Brasil or Trinidad.

LABORATORY FACILITIES

It has already been indicated that no facilities are available for laboratory work despite the fact that laboratory space is there. The immediate requirement is to outfit a laboratory for Spear rot work. The basic equipment needed are given as follows:

Research microscope	US$	1,500
Spore capturing apparatus for field studies	US$	2,000
Portable autoclave	US$	500
Transfer chamber	US$	1,500
Binocular dissecting microscope	US$	800
Miscellaneous chemicals/agents/reagents, etc.	US$	2,500
Test tubes/glassware/dissecting sets	US$	1,000
One single pin balance (o.eol gm)	US$	1,000
Sterilizing oven	US$	1,500
1 Incubator	US$	2,000
1 Rough scale (0.1 gm)	US$	600
TOTAL	US$	14,400

Laboratory equipment for the other research work in Hart rot and Castnia are not an emergency; thus, these may be obtained over the two-year period. However, field chemicals for control measures are necessary and a chain saw is required immediately to fell trees, now and during the campaign. A computer is an absolute necessity for the organising of all the data in farmer programmes. Apart from collected information for analysing, the names of farmers, their holdings etc., will be required as initial survey data. Thus, even before the actual campaign begins, a survey of farmers and the size of their holdings will be necessary and the information stored for accurate determination of the survey methodology.

REQUIRED TRAINING FOR STAFF

It has already been decided that a training programme be mounted in Trinidad for two officers for techniques on spore-trapping and analysis of epidemics.

A further training progamme is necessary for training in managing the Hart rot campaign.

Various short visits can be arranged to countries like Jamaica for an appreciation of breeding programmes in the Caribbean.

A visit should be arranged either to the West African) Nigerian Oil Palm Research Institute or IRHO in the Ivory Coast for the Agronomist and Plant Breeder.

TECHNICIAL ASSOCIATIONS WITH OTHER INTERNATIONAL INSTITUTION

The IRHO has been involved in technical work in oil palm breeding in Latin America. They have also been involved with pest and disease work in Brazil, Ecuador, Colombia. It would be useful to court their interests

in the oil palm hybridisation project specifically since most of their international expertise is in breeding of coconuts and now oil palms, instead of in controlling pests and diseases.

The FAO has contributed significantly in the field of coconut palm development and processing. It has a long and successful history in dealing with coconut development for small farmers. The PRC should associate itself with this organisation and seek urgent assistance for the rehabilitation of the coconut industry in Suriname. The exercise is a small farmer project which would eventually require a specialist with factory expertise also. Someone from the Philippines or Indonesia can be requested to work for a 2-year period with the farmers in Coronie.

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APPENDIX

WEST AFRICAN INSTITUTE FOR OIL PALM RESEARCH

THE BUD ROT LITTLE LEAF DISEASE OF THE OIL PALM

by

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Introduction

A diseased condition of the oil palm, *Elaeis guineensis*, in which the spear and bud tissue is attacked, called Bud Rot, has been known for many years and has been recorded from the Portuguese Congo (Wakefield, 1920), Indonesia (Wellensiek, 1947), Malaya (Bunting *et al.*, 1934), the Congo Republic (Conrotte, 1935), Dahomey (Alibert, 1944), Nigeria (Waterston, 1953) and the Moyen Congo (Bachy, 1954). Usually the disease is of occasional occurrence and is of little commercial importance. Losses in Nigeria are stated rarely to exceed 1% in plantation palms (Bull and Robertson, 1959), while the incidence is also low in the plantations in the Central Congo Basin. However, this disease has caused the death of large numbers of palms in the Kwilu/Kasai region of Congo where losses exceeding 30% are common. As the economic life of a plantation is of the order of 25-30 years, and most of the losses occur between the 5th and 12th year after planting (Bachy, 1954; Kovachich, 1952), when it is too late to supply the vacancies, the economic importance of the condition in this particular area will be appreciated.

Possible causal agents which have been suggested are unspecified fungi (Wardlaw, 1948), bacteria (Bunting *et al.*, 1934; Wardlaw, 1948, 1958), virus (Kovachich, 1952; Wardlaw, 1951), insect-borne eelworms (Ghesquiere, 1939), physiological upsets and unbalances of nutrients and growth substances (Bachy, 1954; Kovachich, 1952), minor element deficiencies (Broeshart *et al.*, 1957; Ferwerda, 1954, 1955; Kovachich, 1953) and insects (Bunting *et al.*, 1934; Vanderweyen, 1952; Wardlaw, 1948, 1958). In addition, *Bacillus coli*, (Alibert, 1944; Ghesquiere, 1935), *Phytophthora palmivora* (Ghesquiere, 1935; Vanderweyen, 1952) and *Thielaviopsis basicola* (I.N.E.A.C., 1948; Vanderweyen, 1952) have been more specifically cited. However, no one succeeded in producing the disease by inoculation with any of the organisms isolated from diseased tissue or by using the rotting tissue as inoculum (Kovachich, 1952; Robertson, 1960). Robertson, however, showed that the disease was actively pathogenic when he arrested the downward spread of the rot by surgical treatment.

The unspecified use of the term "Little Leaf" has been responsible for some of the misunderstanding and confusion surrounding the Bud Rot disease in the last 10 years. Little Leaf was specifically and correctly applied (Kovachich, 1952; Wardlaw, 1951) to the malformed leaves produced after a

PLATE 1. Leaves of the crown of an affected palm cut away to show the primary site of infection.

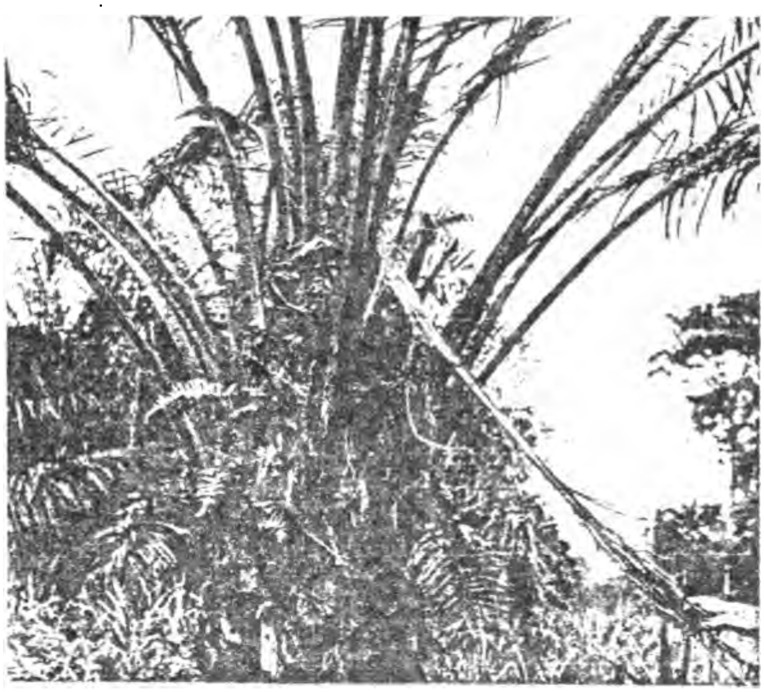

PLATE 2. A palm suffering from Bud Rot Little Leaf Disease. The spear has collapsed, dried out and is hanging down from the centre of the crown.

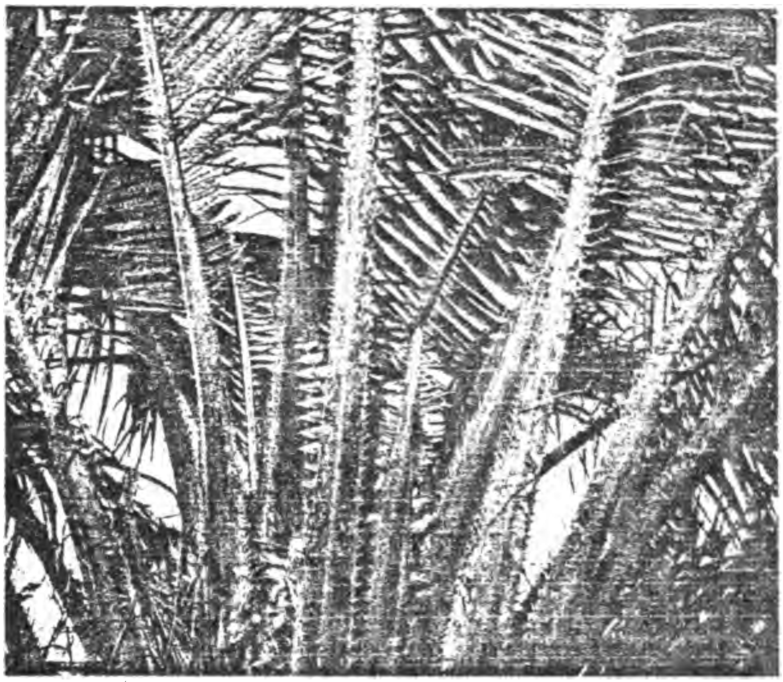

PLATE 3. · An affected palm, showing the production of little leaves.

non-fatal attack of Bud Rot. The bud tissue of a palm comprises the growing point, the young unopened spears and flowers, and the disease invariably involves the rotting of some or all of this tissue, followed by the death of the palm or the production of Little Leaves after a non-fatal attack. An appropriately descriptive name for this disease would, therefore, be Bud Rot/Little Leaf. Some other term may be required for foliar malformations of a physiological (nutritional) nature.

DISEASE SYMPTOMS

The first sign of an attack is the appearance of a wet and brownish rotting patch low on a spear, generally just at the point of emergence of the spears through the funnel formed by the older leaf bases. The rotting commences below this point (Plate 1). In very mild cases only the pinnae are affected and the attack may be continuous with the pinnae of successive spears becoming involved. This type of "tip rotting" may develop further, or the palm may grow out of the attack. In serious cases the rachis is involved and the spear collapses at the base while still green and hangs down from the centre of the crown, subsequently drying out (Plate 2). If the spears are pulled out of the crown, the affected tissue is found to be soft and pulpy and this will eventually disintegrate into a wet, structureless and evil-smelling mass. The rotting may spread downwards until the growing point is attacked when the death of the palm becomes inevitable. Alternatively the rotting may be arrested with the formation of a callus layer and the palm recovers, producing a variable number of "Little Leaves" (Plate 3), the number depending on how many young unemerged spears were partially destroyed during the attack. These Little Leaves are the basal portions of leaves left after their distal parts have been destroyed by rotting and they vary in size from a small length of rachis to almost complete leaves missing only some distal pinnae. "Stump Leaves" might be aptly descriptive of some specimens. Little Leaves are the result of and a recovery feature from an attack of Bud Rot, as pointed out by earlier observers (Kovachich, 1952; Wardlaw, 1951), and they do not precede rotting.

In many cases the palms look unhealthy before an attack of Bud Rot. Frequently there is a shortening in length of successively produced fronds (Alibert, 1944; Bachy, 1954; Broeshart *et al.*, 1957; Fraselle, 1953; Kovachich, 1952), abnormalities of the pinnae and meristematic tissue (Kovachich, 1953; Wardlaw, 1951), chlorosis (Ghesquiere, 1935; Kovachich, 1953; Wardlaw, 1958), premature drying out of the fruit bunches (Alibert, 1944; Wakefield, 1920) and a poor root system (Wardlaw, 1958). While these conditions may be observed, they are better regarded as general signs of ill-health in a palm which may subsequently be attacked, rather than as symptoms of Bud Rot itself. Palms may be attacked without showing any such features, though the main incidence of Bud Rot is in localities where such unthrifty palms are common.

INVESTIGATION AND RESULTS

Susceptibility and growth of the palm

A study of the growth of some 260 palms of different ages and genetical lines was made at Brabanta (Kasai, Congo). Over the period of a year, measurements were made of the total elongation of all the spears on each palm and of the average daily elongation per spear. The opening of each new leaf and the appearance of new spears was also recorded. Such growth measurements are considered to give a good indication of the health and vigour of the palms concerned.

It was found at Brabanta that the spears of healthy palms elongate at between 2 cms. and 4·5 cms. per day depending on their age and genetical constitution. Figure 1* shows the growth of a healthy five-year-old field

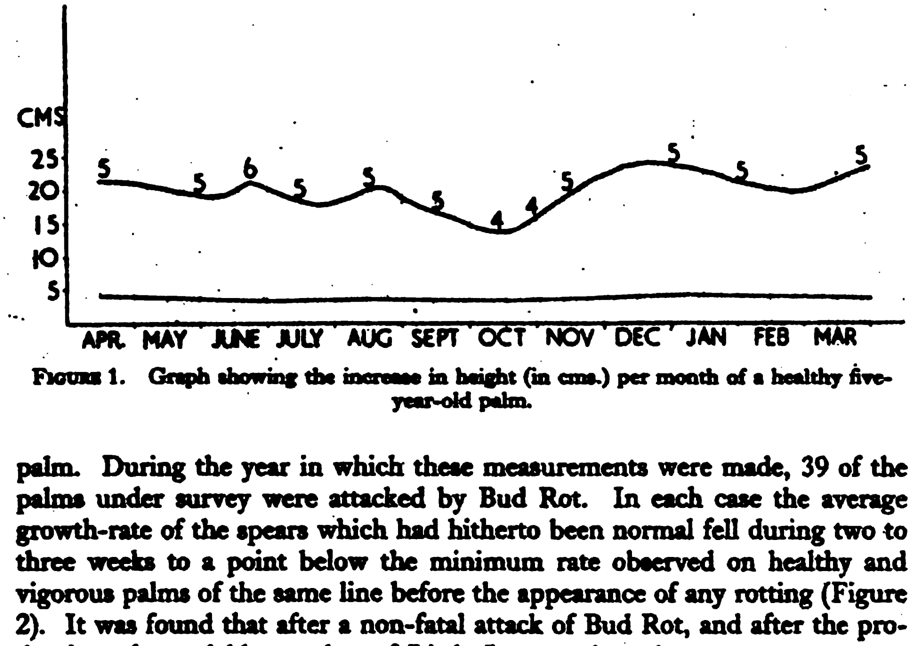

FIGURE 1. Graph showing the increase in height (in cms.) per month of a healthy five-year-old palm.

palm. During the year in which these measurements were made, 39 of the palms under survey were attacked by Bud Rot. In each case the average growth-rate of the spears which had hitherto been normal fell during two to three weeks to a point below the minimum rate observed on healthy and vigorous palms of the same line before the appearance of any rotting (Figure 2). It was found that after a non-fatal attack of Bud Rot, and after the production of a variable number of Little Leaves, the subsequent spears grew at a rate above what would be considered minimal (Figure 2) and if this rate was not maintained, a further attack took place.

In the same period, there were 17 cases of "tip rotting" which were also correlated with an antecedant fall in growth-rate and it might be argued that these palms were on the threshold of Bud Rot. Some of them subsequently developed Bud Rot following a further decrease in vegetative vigour but most

* In all the graphs, the upper line represents the total daily elongation of all the spears and is a measure of the growth of the palm. The figures refer to the number of spears involved and the lower line shows the average daily elongation per spear.

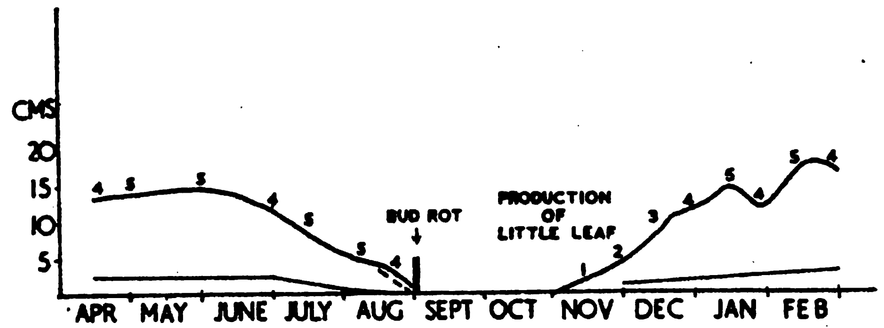

FIGURE 2. A graph showing the decline in growth rate of a palm prior to the development of an attack of Bud Rot.

of the attacks were of limited duration. The spears produced when the growth rate increased were free from attack (Figure 3). It would appear that there is a rate of growth, or growth level, above which the palms remained healthy and that attacks of Bud Rot are only found in palms in which the vegetative vigour has fallen to a critical level.

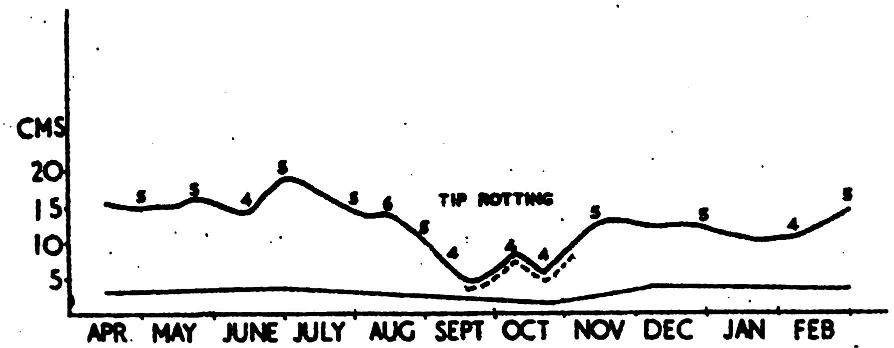

FIGURE 3. A graph showing the growth pattern of a palm which becomes affected by "tip rotting," a mild form of the disease.

Growth of the spears

Leaf primordia and leaves are formed in succession from the growing point of the palm, the older spear leaves elongating and emerging through the funnel and thereafter reaching maturity. During these phases of growth and development, the spear tissue passes through various stages of cell division near the growing point, cell elongation and finally cell maturation in older leaves. It is reasonable to suppose that because of the different stages of development, certain parts of a developing spear may be more or less susceptible to attack than other parts. If this is so, and if the Bud Rot disease is of an actively pathogenic kind, a decrease in spear growth-rate will expose the susceptible tissues to attack for periods longer than normal.

A series of measurements showed that all the spears elongated at approximately the same rate until the time that the pinnea began to open. Thereafter, the growth-rate of the spear decreased as the tissues matured to the base of the rachis until the spear occupied a position at the outside of the central group of unopened spears and its tissues became no longer immature.

In a young field palm, where the spears were elongating at 2·6 cms. per spear per day, dissection showed that the growing point of the trunk lay about 60 cms. below the point of emergence of the spears through the funnel. This point was taken as the datum and a spear was marked off in 10 cm. lengths, from the point of attachment to the trunk at −60 cms. up to +10 cms. above emergence. Measurements subsequently made showed (Table 1) that most of the growth took place in the lower portion of the spear, and that, after emergence, there was no further elongation.

TABLE 1. THE DAILY ELONGATION OF VARIOUS 10 CM. LENGTHS OF THE SPEAR.

Portion of Spear	Daily Elongation
cms.	*cms.*
Bud	
− 60 to − 50	0·9
− 50 to − 40	0·6
− 40 to − 30	0·4
− 30 to − 20	0·4
− 20 to − 10	0·2
− 10 to 0	0·1
0 to + 10	0

The causal organism

From young lesions, a bacterium of the genus *Erwinia* similar to *E. lathyri* (Manns and Taubenhaus) Holland was invariably isolated. It was also isolated from sap expressed from tissue in advance of visible rotting and was subsequently shown to be responsible for Bud Rot. Many other bacteria, fungi and insects invade the lesion at a later period.

A similar strain of *Erwinia* has also been isolated from the surfaces of spears and leaves of healthy palms, and seems to be widespread as part of the normal plantation microflora.

Growth of the *Erwinia* was poor on Potato starch/Dextrose and Dox Agars, but was excellent on a medium made of Oxo/Peptone/Sucrose.

Inoculation of spears

Since it appeared that susceptibility to Bud Rot was conditioned by predisposing factors and could be correlated with growth rate and vigour, the first infection experiments were carried out on detached spears which were

obviously incapable of further normal growth. The un-inoculated spears remained fresh for over a week. These spears were obtained from two-year-old palms and were excised at their point of attachment to the trunk. In these palms, the bud was about 35-45 cms. below the funnel.

In a preliminary series of inoculations in which various organisms isolated from Bud Rot were used, it was established that only *Erwinia* sp., was capable of causing a typical rot of the spear tissue. The inoculations were made both by hypodermic syringe and by applying the bacterium as a suspension without damage to the spear. Typical lesions were produced by both methods of inoculation although rotting commenced slightly earlier after infection by syringe.

The effects of applying the bacterium to spears of the same and different ages and at various points above and below the datum were examined. When a composite series of spears was used, it was selected from palms with growth rates as similar as possible.

Figure 4 is representative of a composite series of spears taken from two-year-old palms and shows the extent of rotting of spears of different ages six days after inoculation. The spears were superficially inoculated with

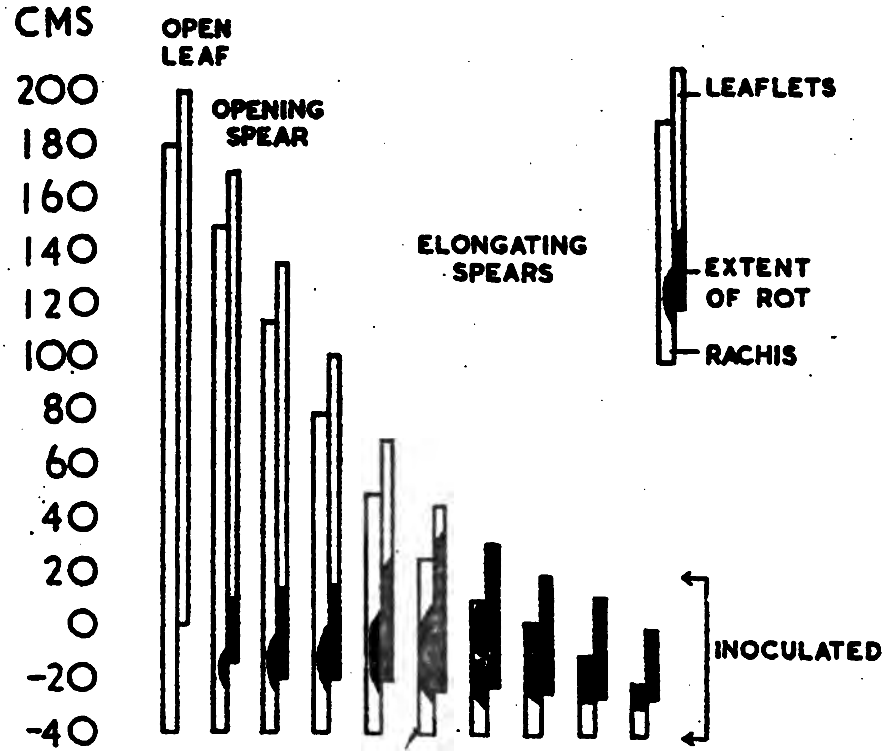

FIGURE 4. A representation of a composite series of spears taken from two-year-old palms. The extent of rotting on spears of different ages is indicated.

bacterial suspension over the area +20 cms. to the bud. Figure 5 shows the extent of rotting of three series of spears of different ages, six days after inoculation at different points with a single needle puncture. The inoculations were made through the leaflets and into the rachis.

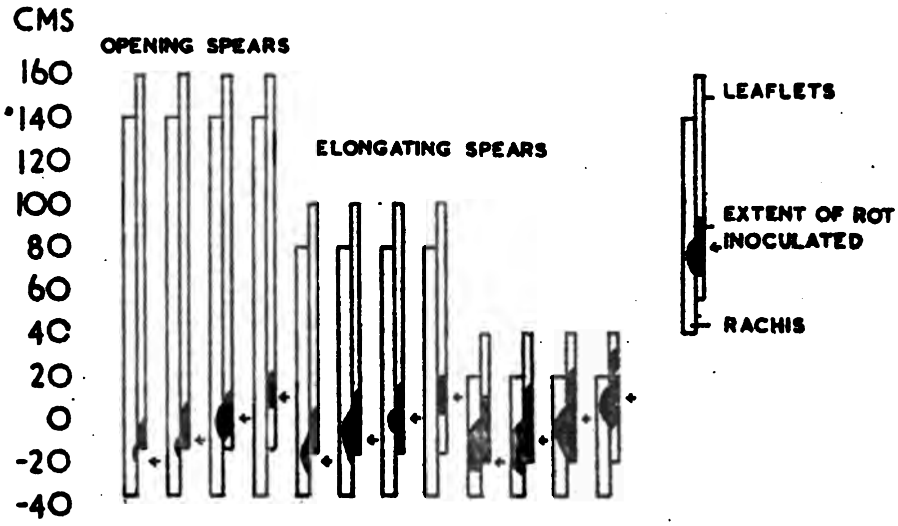

FIGURE 5. Extent of rotting after six days, of three series of spears of different ages, inoculated at different points with a single needle puncture.

These tests show that the most susceptible point of the spears of young palms is in the region −10 to −15 cms. On older palms which have been planted out for five to six years and where the bud lies at approximately −90 cms., the most susceptible point is found to be about −20 to −25 cms. These are the points at which the tissue is changing from active elongation to maturation (Table 1), and it would appear that attacks only occur when the palm is incapable of rapid growth when the spear tissue is passing through this susceptible stage.

The Figures (4, 5) show that an open leaf is not affected and an old spear, on the point of opening, is resistant to all but a rotting of the unexpanded leaflets. The rachis of a young spear, on the other hand, is susceptible to about +10 cms. and this is closely comparable with what occurs in the field. Very young tissues nearest to the bud, are comparatively resistant; and although a spear may be completely collapsed and rotten over the area 0 to −20 cms. within five to six days, the youngest tissue would not rot for a further four to five days. The relative resistance of this tissue possibly explains why all attacks of Bud Rot are not fatal.

Inoculation of growing palms

Growth studies showed that rotting of spear and bud tissue was always preceded by a reduction in the growth rate of a palm. If the susceptible areas

of the spears are exposed by removing a few outer leaves immediately there is a reduction in growth rate, no rotting is found. The rot begins about a fortnight later. So consistent is this that it was found possible to open palms exhibiting a fall in the growth rate and so demonstrate the beginning of an attack before any rotting was externally visible (Plate 1).

If palms are inoculated immediately after there is a reduction in growth rate, small but expanding areas of rot can be produced in as little as three days and the subsequent development of the disease is identical with that of a natural attack.

Rotting has been induced on palms which have remained on the apparent threshold of susceptibility for considerable periods but without succumbing to it. In these cases, the attack never developed as far as complete Bud Rot but continuous "tip rotting" developed after inoculation (Figure 6).

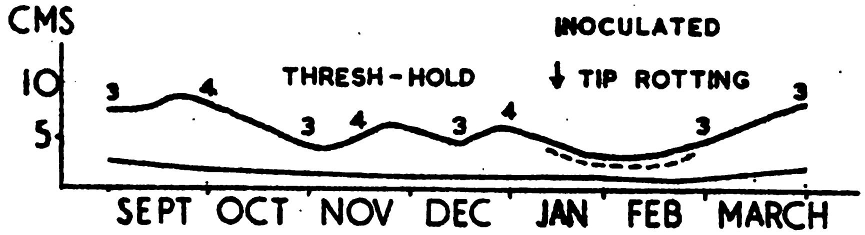

FIGURE 6. Tip rotting induced by inoculating a palm which is on the threshold of susceptibility.

Rotting occurs much earlier after inoculation than in nature and this is probably due to the massive inocula administered. This would explain the "tip rotting" induced in palms which grow at the threshold of susceptibility without becoming attacked. Healthy and vigorously growing palms have been inoculated but these have invariably remained free of disease.

Induced susceptibility

In order to test the hypothesis that the decrease in growth-rate renders a palm susceptible to attack, the normal growth of a number of palms was artificially retarded. Kovachich (1952) had reported that when the roots of five to six year-old palms were cut at a distance of 50 cms. from the base of the trunk, four out of seven palms so treated displayed an active rot of the central spear four months later. This experiment was repeated on palms for which full growth records had been kept and which were known to be vigorous and non-susceptible at the time by their failure to develop any rot following artificial inoculation. The roots of seven palms were cut at a distance of 50 cms. from the base and to a depth of two metres. On a further four palms, the roots were cut at a distance of one metre and to the same depth. All the palms treated showed an immediate reduction in growth-rate, and two of the palms cut at 50 cms. developed attacks of Bud Rot six and 11

weeks later (Figure 7). In the other palms, growth increased again, never reaching the apparently critical level. On examination, it was found that these had developed new roots. Twelve weeks after the initial cutting, the roots of these palms were cut again at 45 and 95 cms. respectively and there was again a reduction in growth-rate. Active rotting developed in three palms while the remaining palms exhibited a temporary reduction in growth. If the experiments had been started in the dry season instead of at the beginning of the rains, most of the palms would possibly have succumbed at the first cutting.

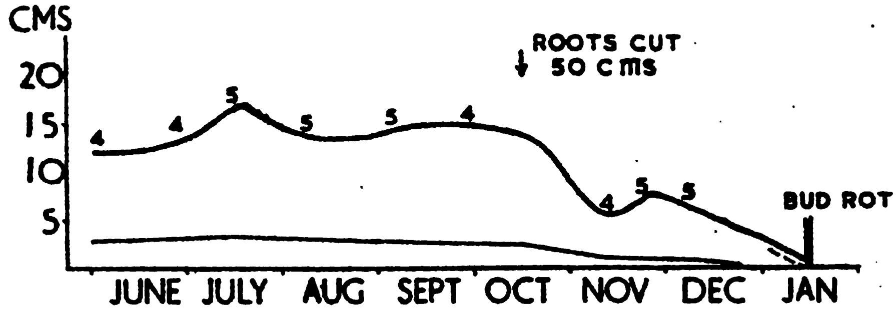

FIGURE 7. Bud Rot induced by cutting the roots of a palm to a depth of two metres at a distance of 50 cms. from the base of the palm.

The effects of leaf cutting were also investigated on similarly healthy palms. All but the spear leaves of six palms were removed and during the period of the experiment each spear was removed as it opened. Following this treatment, there was an immediate reduction in daily growth and all the palms developed Bud Rot in periods of three, six, seven, nine, 11 and 15 weeks (Figure 8). The period over which the attacks took place might perhaps be attributed to the differences in the food reserves available in the palms at the beginning of the experiment. It was noted that the spears produced after pruning were opening shorter than those produced before the treatment.

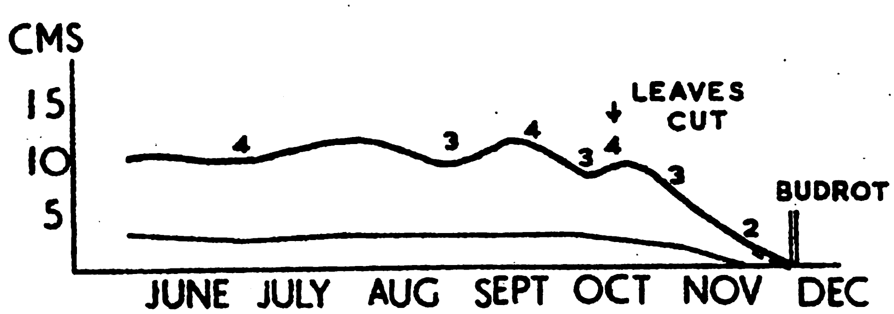

FIGURE 8. Palm induced into susceptible stage by leaf cutting. Bud Rot symptom developing as a result of this treatment.

In further experiments it was shown that a tourniquet applied low to a young spear renders it susceptible to rotting, but only above the constriction and, if a spear so constricted is inoculated, rotting and a typical collapse of the tissue takes place in six to eight days. If the natural bacterial population is allowed to act, the spears take 12 or more days to collapse.

From the results of these experiments, it is apparent that susceptibility to Bud Rot is conditional on the physiological state of the palm and that attacks take place on palms of which the vigour, as measured by growth-rate, has been impaired. Environmental factors such as availability of water and nutrients and attacks by other diseases may be involved, as well as the interplay between environment and genetical constitution.

Discussion

Predisposing factors—Water

Alibert (1944) considered the disease to be most prevalent at the end of the dry season, while Kovachich (1953) concluded that "Little Leaf" in the South of Congo was most severe at the end of the rains. However, the collective symptoms with which Kovachich was dealing might have included foliar malformations in a fertilizer experiment. Fraselle (1953) found the disease throughout the year and concluded that seasonal effects were negligible, while Van Daele (1946) reported that rotting was most frequent at the end of the dry season and at the beginning of the rains. This observation is in full agreement with experience at Brabanta. There, the dry season lasts for three to four months in the period June/September and the effect of this can be seen as a marked reduction in growth in even the most vigorous lines during this period. While it is true that attacks occurred throughout the year, most of the cases (28 out of 39) in the surveyed palms occurred during the dry season and at the beginning of the rains. In the majority of cases the onset of the disease started at the end of the dry season when growth is at its minimum. In the same dry season, a 6% attack occurred in a young extension planting which had until then been healthy.

In each of two adjacent lines of palms of the same age, B31 (*tenera selfing*) and B32 (*tenera* × *pisifera*), 20 palms were surveyed, and while there were five palms infected in line B31 there were no cases of infection in B32. These attacks all commenced towards the end of the dry season. When the average growth of the healthy palms of these lines was compared (Figure 9), it was

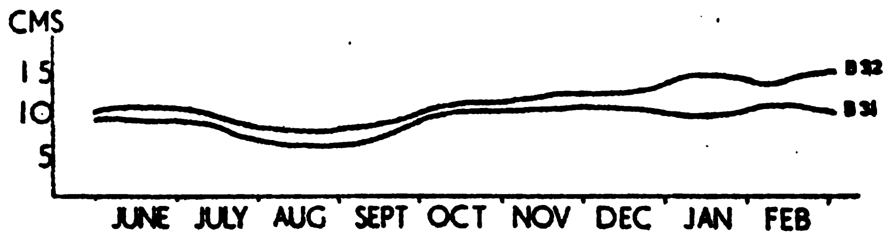

Figure 9. A comparison of the growth rate of two lines of adjacent palm—see text.

seen that not only was B32 more vigorous in general but also that the dry season effect was more pronounced on B31 than on B32. The dry season effect is also shown in Figure 3 where the reduction in growth led to Tip Rot.

A corollary is found when recovery from non-fatal attacks of Bud Rot is examined. During the period under review there were 25 recoveries. Only one took place in the dry season when normal growth started in July, but 17 palms recovered during the first three months of the rains.

Soil and nutrients

It was reported from Dahomey (Alibert, 1944) that the incidence of Bud Rot was most severe on poor acid soils. This is similar to findings in the Congo, where the disease is only significant in the south and the soils are poor acid sands of low fertility.

At Brabanta, the incidence of Bud Rot is highest on the higher ground, where leaching of nutrients and the water availability to the palms would be poor. This is in accordance with the findings of Bachy (1954), who reported that the disease was bad on the hill tops and less severe in the valleys. Fraselle (1953) could, however, find no such relationship.

Ferwerda (1954, 1955) and Broeshart *et al.* (1957) have directly linked "Little Leaf" with boron deficiency, and from agronomic experiments, Kovachich (1953) concluded that the condition was caused by a deficiency or unbalance of nutrients. It is unfortunate that there are no data on the incidence of Bud Rot from these experiments because the count was masked in the term "Little Leaf" which in their papers obviously covered not only Bud Rot/Little Leaf but also other foliar abnormalities.

To determine the actual effects of major and minor nutrient elements on the incidence of Bud Rot, large scale field trials incorporating irrigation treatments would be necessary.

Other diseases

An analysis of the continuous health observations recorded over a period of six years from an agronomic experiment showed a highly significant correlation between the distribution of Wilt Disease (*Fusarium oxysporum*) and Bud Rot. In these records, Wilt Disease almost invariably preceded Bud Rot in time.

Sudden and severe attacks by the Wilt Disease fungus and another undiagnosed disease were often observed to precede an attack of Bud Rot. While this occurred only twice in the surveyed palms, in both cases the growth pattern prior to attack was typical. However, Wilt Disease need not be followed by Bud Rot and in cases of chronic Wilt Disease and Plant Failure it was observed that while overall growth was low, there were fewer spears involved (Figure 10), and a non-susceptible growth average was maintained. This growth should be compared with B10 in Figure 11 which shows the average for healthy palms of the same line.

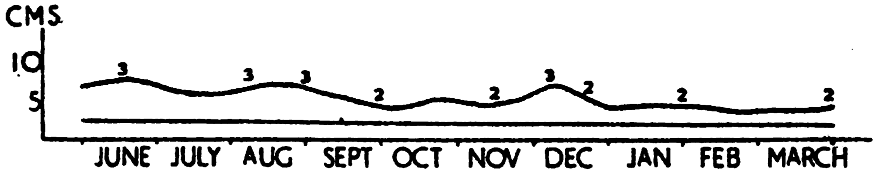

FIGURE 10. Showing the typical growth rate for palms suffering from chronic Wilt Disease or Plant Failure.

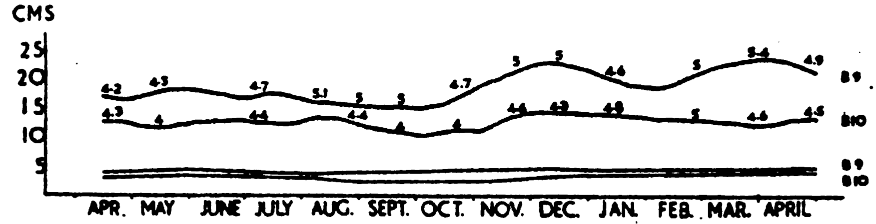

FIGURE 11. The growth average of palm in adjacent lines—see text.

Nursery Bud Rot has been known for some years (Kovachich, 1957; Wardlaw, 1958). An attack in which there have been a number of deaths with typical rotting of the spear and bud tissue has recently been seen in a nutritional investigation at Yaligimba. Different applications of fertilizers were given to the nursery palms, but the attacks could not be related to any particular treatment. On examination, each of the attacked plants showed typical lesions of Blast on the roots, but the severity of attack was not such that symptoms of Blast were evident on the aerial portions of the plants. A bacterium, seemingly identical with the *Erwinia* Sp. found at Brabanta, was isolated from the Yaligimba seedlings. Robertson (1959) has mentioned non-fatal attacks of Blast in which extensive rotting of the spear leaves occurred, recovery was slow and typically malformed Little Leaves were produced.

Genetic constitution and vigour

Bachy (1954) was the first to produce evidence that different genetical lines of palms had different susceptibilities to Bud Rot, and he showed that these lines maintained their respective susceptibilities in different localities in Bud Rot areas. Kovachich (1952) thought that *dura* was more resistant than either *tenera* or *pisifera* palms. In a survey carried out at Brabanta in 1961 on two blocks of *tenera* × *tenera* palms planted in 1942, 43·75% of the palms were found to be dead. While it is appreciated that not all the deaths can be accounted for by Bud Rot, the records indicate that this was the major factor. If it is assumed on a normal genetical basis that the original planting contained 25% *pisifera*, 50% *tenera* and 25% *dura* palms then 88% of the *pisifera* palms (mainly steriles) have survived, 65% of the *dura* and 36% of the *tenera* palms. This may perhaps be associated with the strain on the metabolism of the palms imposed by fruiting.

In the genealogical block at Brabanta wide differences in the health and vigour of similarly-aged lines of palms of different breeding can be seen. The growth averages of healthy palms in the adjacent lines, B9 and B10, are shown (Figure 11). These are both *tenera* selfings, planted in 1956. In 1961, of the 37 plants in B10, there were two dead palms and seven cases of active Bud Rot, while in B9 there were no deaths and only two cases of Bud Rot. In a younger planting, 20 palms were surveyed in each of three adjacent lines. During the period under review, there were two, nothing and five cases of Bud Rot in these lines, which was again reflected in the differences in vegetative vigour found in them.

Spread in the field

The mechanism of spread of the causal bacterium has not been worked out. Some observers considered that there was an insect association, or that insects were responsible for Bud Rot. While this is not so at the earliest stages of an attack, there invariably develops on the rotting tissue a large and varied insect population which must assist later in the dispersal of the bacterium. However, as already stated, the same organism or a strain of it, can be isolated readily from the surfaces of leaves of healthy palms. Thus, it appears that the bacterium may already be present throughout the plantation and that palms are infected while they are still non-susceptible. This aspect of the disease clearly needs more exploration.

Conclusions

It has been shown that the rotting of the spear and bud tissue of the oil palm is caused by a bacterium and that an attack can only take place on palms which have become, or have been made, susceptible. Growth and health records show clearly the differential effects of the long dry season on palms of various genetical lines and that the more vigorous lines are less frequently attacked. Interference with normal growth and attacks by other diseases may result in the development of Bud Rot. It may be inferred that anything interfering with vigorous growth can render a palm susceptible. In particular, lack of water during a long dry season may be a major factor. In the Congo, the incidence of Bud Rot is high only in those areas where growing conditions are comparatively poor but even there, wild palms in which presumably natural selection has been operating, are rarely seen to be infected. The occurrence of vigorous and highly productive palms in devasted areas of estates and the great differences to be found in the genealogical blocks indicate that Bud Rot could be overcome by breeding and selecting for vigour under adverse growing conditions.

Summary

The Bud Rot/Little Leaf disease of the oil palm, *Elaeis guineensis*, is shown to be caused by a bacterium of the genus *Erwinia*, similar to *E. lathyri*

(Manns and Taubenhaus) Holland. The bacterium is only capable of attacking palms in a weakened condition. Vigorous palms are not susceptible. It has not been possible to elucidate all the factors which may render a palm susceptible, but some indications are considered.

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