REPÈRES

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Centre de coopération internationale en recherche agronomique pour le développement, France

Science Publishers, Inc.
Enfield (NH), USA Plymouth, UK

Joint Publication: Science Publishers, Inc., USA
and CIRAD, France

Exclusive selling rights in Asia : Science Publishers, Inc.
Exclusive selling rights in Europe : CIRAD

CIRAD (Centre de coopération internationale en recherche agronomique pour le développement)
Avenue Agropolis
34398 Montpellier Cedex 5, France
Internet site : http://www.cirad.fr

ISBN (papier) : 978-2-87614-468-2
ISBN (pdf) : 978-2-87614-822-2
DOI : 10.19182/agritrop/00209

Translation of: *Les maladies des cultures pérennes tropicales,* CIRAD. 1999.
French edition : Copyright CIRAD
Updates made by the authors in 2001.

Translation Team : K. Thanikomoni
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Fichier préparé par Nicolas Perrier, société 4P
Imprimé pour vous par Books on Demand (Allemagne)

Foreword

Forty years of research and control of the most serious diseases affecting the major tropical tree crops are encapsulated here! Too long a period from the viewpoint of the evolution of socio-economic contexts, practices, methods and techniques, but the minimum or nominal for one or two crop cycles, rarely more. How to durably protect a resource essential for the economy of a number of developing countries from threats posed by diseases? This book deals precisely with this problem.

By compiling this impressive synthesis of studies, many of which are still unpublished, the authors have not only produced a compendium on diseases of tropical tree crops, but also provided an approach whose usefulness needs no demonstration: purposeful research proposing the scientific approach necessary for agricultural application, based on practical situations encountered in the field.

Moving clearly away from academic studies, D. Mariau and his collaborators do not propose an encyclopaedia of tropical pathogens. By avoiding the standard monographic presentation by species, they have shown how a thematic presentation can lead from a preliminary diagnosis to basic knowledge on the life-cycles of parasites, and implementation of protection strategies adapted to technical and socio-economic contexts in real situations.

The novel presentation, easy reading and willingness to consider application of the results are certain to attract protectors of perennial crops, be they researchers, technicians or producers.

Beyond the banal compilation of information on diseases and control methods, what struck me most while reading the manuscript was its comprehensive presentation of knowledge and methods, with hallmark beginnings of a reflection on integrated protection of perennial crops.

In this sense this book constitutes a reference base, similar to the one in insect pests* , on which new domains in the evolution of sciences can depend, be it cellular and molecular biology or sociology of agricultural practices, to obtain efficient and durable protection systems.

Michel Dron
Scientific Director, CIRAD

*D. Mariau (ed.). 1966. Integrated Control of Pests of Tropical Perennial Crops, Repères, CIRAD, Montpellier, France, 196 pp.

Preface

For several decades, plant pathologists of renowned research organisations (IRCC, IRFA, IRHO, IRCA, CTFT), amalgamated into CIRAD since 1985 (Centre de Coopération Internationale en Recherche Agronomique pour le Développement), have been studying the major diseases of tropical perennial crops, viz., avocado, coffee, coconut, hevea, mango, oil palm, papaya and tea, sometimes in collaboration with entomologists and often with breeders. To these crops must be added citrus, which also grows in Mediterranean type of climate, and tropical agroforestry.

The results of all these studies, in both field and laboratory, have been published in a number of articles in CIRAD's publications, as well as in international journals. Vast amounts of data are contained in papers presented at scientific meetings or in reports that are not easily accessible and therefore forgotten. These results and information are of varied importance and the objective of this book is to bring together the most significant among them. For purely geographic reasons, some diseases have been little or not studied by CIRAD. To make coverage as exhaustive as possible, these diseases have nevertheless been listed at the end of the book along with some brief information and important bibliographic references.

Several presentation formats were considered. The one we have used, less classic than plant by plant study, appeared to be interesting for more than one reason. It helps to compare pathogen types, several of which affect different plants and could be the subject of similar control methods. This thematic presentation also enables a better demonstration of the great importance given by researchers to the characterisation of pathogens and selection of resistant plant material, which is an important control method for plant pathologists. To facilitate reading of this work, Chapters 1 and 4 ('Symptomatology and Economic Incidence' and 'Pathogens') contain recapitulative tables listing the major diseases of plants, their symptoms and causal agents, while a table summarising the control methods per plant and per disease and maps showing the global distribution of these diseases are given in the Annexure. Lastly, the general index can be consulted.

It is always salutary for researchers to review their work so that the reflection and investigations of tomorrow are based on a good synthesis of yesterday's studies. It is therefore for them, their successors and their colleagues in other scientific organisations that the authors have made their contribution here.

This book was also written for teachers, and hence for their students, in such a way that their teaching can be supported by concrete examples taken from the field of tropical agronomy.

Lastly, the authors have also given thought to users in the wider sense of the term, because the vocation of CIRAD is to take the results of their research up to the agriculturist. In this book they will find that in the great majority of cases, solutions are offered—even if they are sometimes only provisional—for solving their problems concerning protection of their plants against diseases.

In the field of chemical control, recommendations for use of various pesticides should naturally be adopted in accordance with the phytosanitary regulations of each country and adapted following the advances made in their knowledge over the years.

We cordially thank Dr. M. Dron, Professor of Phytopathology and Scientific Director (CIRAD) for writing the foreword. We wish to express our gratitude to Drs. R.-A. Muller and E. Laville (Honorary Scientific Directors of ex-IRCC and IRFA) for reviewing the book and offering suggestions. Their wide knowledge, especially in the domain of the pathology of the plants studied by these institutions, was an important input for this book. Dr. J. Meunier, Deputy Scientific Director of CIRAD, after a long career at IRHO, and Dr. J.-C. Follin, Plant pathologist at CIRAD, also reviewed the manuscript. We are grateful for their invaluable comments. We also thank Drs. M-L. Caruana, M. Grisoni, M. Delabarre, O. Pruvost, J-M. Thevenin and Tran van Canh for their contribution.

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Introduction

Dominique Mariau

ECONOMIC IMPORTANCE OF TREE CROPS

During the last few decades, the cultivation of tropical tree crops has expanded extensively not only in Asia, but also in Africa and Latin America, generating a substantial revenue for these countries. To mention just a few examples: in 1997, in the Indo-Malaysian peninsula, about four to five million hectares were under oil palm cultivation, representing ten times the area planted in the early 60s. In 1996, the Ivory Coast produced more than one million tons of cocoa beans, i.e., twelve times more than the production thirty years earlier. In 1990, with a production less than the current production, cocoa represented 40% of the agricultural exports of this country. During the same period, coffee production in Colombia was nearly one million tons, representing almost 50% of the agricultural exports of the country. With a citrus production of one million tons, Morocco can expect a revenue of 1.3 billion dirhams corresponding to 20% of the food exports of this country. All these crops constitute the basic resources of tens of millions of families throughout the world.

In the majority of the cases, the wide expansion of these crops is at the expense of forests which have been too extensively and too rapidly exploited. In the last few decades, tens of millions of hectares of forests have disappeared in the tropical zones, and the reconstitution of a forest park, similar to that which could be done in some European countries in the twentieth century, would require considerable input from specialists. These pioneering fronts are being abandoned in several countries. It would be advisable to engage in replantation with plant materials which are more productive and more resistant to such and such disease, as has been done, for example, for oil-palm, instead of going in for new land clearing for cultivation. Moreover, the carrying capacity has often led some planters to embark on an intensification programme, enabling them to improve the competitiveness of their plantation.

IMPORTANCE OF PLANT SANITATION

At the global level, it is very roughly estimated that about 30-50% of the plant production managed by man is destroyed before or after harvest by insects,

diseases and weeds. Data are available for some major annual crops. To cite just two examples: 30% of the global production of rice, i.e., the equivalent of 300 million tons, is lost and we are quite aware of the impact of diseases and weeds on this crop. Similarly, the wheat lost is around 150 million tons, corresponding to three times the production of France.

Similar statistics are not available for tropical tree crops. However, we can cite a few figures which show the magnitude of the havoc caused by certain diseases. The lethal yellowing disease of coconut destroyed more than 5 million trees in Jamaica, while the *cadang-cadang* disease destroyed 12 million trees in the Philippines. Also, 150 million cocoa trees affected by the swollen shoot disease had to be uprooted in Ghana.

Ravaging insects can kill a tree, especially when it is young, as is sometimes the case with *Oryctes* (Coleoptera, Scarabaeidae), one of the major destroyers of coconut. However, most often the impact of insects as ravagers is only on production, either directly by attacking the fruits, or indirectly by reducing the foliar surface or weakening the plant. The situation is quite different when it comes to insect vectors of diseases, but that is a special case.

The effects of diseases are much more harmful. They may directly affect the fruits which, at the global level, is the case with the brown rot disease of cocoa pods, or they may affect the foliage, as in the case of *Phaeoramularia* cercosporiosis of citrus, with direct or indirect incidence on the production or plant growth.

In a large number of diseases, the irreversible evolution of symptoms leads to the death of the tree and these losses may extend over vast areas. Such is the case of the disease called heart rot of oil palm in South America which has wiped out, or greatly endangered, a large number of plantations over several thousand hectares in at least five countries. Before the development of tolerant plant material—most probably the only solution to this problem—this disease greatly restricted the development of oil palm cultivation in many regions as investors could not take ill-considered risks. The same is true in the case of citrus greening which is a major problem in Asia and continues to spread in Africa.

Similarly, large rubber (*Hevea*) plantations were rapidly eliminated in South America after the Second World War. The cultivation of rubber is confined to zones that are often marginal and represents only a few thousand hectares in the whole of South America compared to the millions of hectares in South-East Asia. Such vast areas could have been planted in the greater Amazon region (which is after all the area of origin of *Hevea*), but the presence of the fungus *Microcyclus ulei* has prevented such expansion until now. This example shows that the presence of a disease can also have an indirect effect on production by limiting or even prohibiting the development of a crop.

Lastly, implementation of pioneer fronts and sedentarization of crops have resulted in stronger disease pressure, which often becomes a limiting factor at the time of replantation.

IDENTIFICATION OF PATHOGENS

Development of a control method first of all requires very good knowledge of the causal organism which has to be characterised precisely, first by its taxonomic position and knowledge of its life cycle, and then in a more detailed manner by using biochemical techniques such as enzyme electrophoresis, as well as molecular biology techniques for studying the genome. Species which cause a disease showing the same or almost the same symptomatology in all the countries, could exhibit an extremely variable degree of aggressiveness. This is the case, for example, with *Phytophthora* disease of cocoa: the losses resulting from the disease caused by *P. megakarya* in Cameroon is unacceptable, whereas the damage caused by the fungus *P. palmivora* in the Ivory Coast is more tolerable. Similarly, for developing an appropriate control method it is important to know if the *Phytomonas* species observed in coconut trees affected by hartrot disease are the same as those detected on euphorbias growing in the same coconut plantation, and which should be eliminated if they act as storage hosts.

A consequence of the stopping of pioneering fronts and the sedentarization of crops is greater disease pressure, which is often a limiting factor during replanting.

VARIETAL SENSITIVITY TESTS

For a good number of diseases, we have recourse to the selection of tolerant or resistant plant material, which means conducting tests that are as quick, simple and precise as possible. Hence these researches often require good knowledge of host-parasite relationships. Considering the wide variability that can be observed among pathogenic organisms, it is very important that these tests are conducted outside cultivated zones in order to study the virulence of strains of different origins, operations that are naturally prohibited in producing countries. The results of these tests should of course be confirmed later in the field under natural environmental conditions, all the more because we are sometimes obliged to perform a test on a plant part which is not normally affected by the pathogen.

CONTROL METHODS

Whenever we speak of control methods, we think first of chemical control, and until very recently the use of chemical pesticides was widely favoured. Without ignoring the usefulness of these precious tools, researchers are striving very hard to restrict their spread in time and space and to retain only the least

toxic and most specific active materials in the most appropriate doses in order to limit their impact on the environment as much as possible. The recommendation of a rational chemical control is now widely accepted.

With or without the support of chemical control, agronomists have worked a great deal on cultural techniques with the constant aim of limiting the impact of pathogens or modifying the environment in such a way that the physical conditions of the environment become unfavourable for the development of the pathogen.

In the domain of biological control, the means available to entomologists are much more varied than those available to plant pathologists. They can, for example, use indigenous or introduced parasitoid insects in order to regulate the populations of a ravager, favour the development of an entomopathogenic disease as specifically as possible, disturb insect behaviour by using certain substances, etc. In plant pathology, and especially in Mycology, we can envisage using a hyperparasitic fungus, but application of this method is still very limited. Nevertheless, it offers a path that should not be ignored.

The royal path of plant pathologists remains, with the cooperation of geneticists, the selection of more or less resistant plant material. However, this involves long term researches which, as we have seen, require good knowledge of the pathogens and perfecting tests to evaluate behaviour. Moreover, this material will be available only for future plantations and in the meantime the existing crops have to be protected, even if it is by means of provisional control techniques, without forgetting that in the domain of tropical perennial crops what is provisional could last a few decades. For some diseases, this selection process is obligatory, for example, fusarium wilt of oil palm in a number of cases in Africa, but tolerant plant material is available. It is the same for the foliar disease (leaf blight) of *Hevea* caused by *Microcyclus* in Latin America, but in this case planters have to still wait for some more years.

Due to the length of the vegetative cycle of tree crops, researches have to be conducted over a long period of time. Development of tests meant for measuring the resistance of varieties to pathogens should often be made on plant parts in order to avoid cluttering, which are not necessarily affected under natural conditions. Furthermore, the permanence of the crop leads to a quasi-constant selection pressure of the pathogenic organisms which could theoretically circumvent resistance more quickly than with an annual crop. The stability of resistance is therefore of very great importance. Acquiring it necessitates long and delicate studies on the genetic determinism of host resistance as well as on the diversity of pathogen populations.

Plant pathologists thus have a certain number of means at their disposal for controlling the numerous diseases affecting tropical tree crops. Perfecting the most appropriate method requires very long and extensive researches in the field as well as in the laboratory, which should be carried out in perfect harmony.

1

Symptomatology and Economic Importance

Jean-Luc Renard

The term disease applied to a plant expresses an abnormal state of the whole or a part of the plant due to the influence of the environment. Parasitic diseases, in contrast to physiological diseases which are caused by physical factors (especially soil and climate), are caused by the aggression of an organism which is both parasite as well as pathogen. This change, which may be temporary, permanent or fatal depending on the case, has the potential of becoming contagious and developing into an epidemic. This phenomenon is the result of direct contamination, gradually getting closer and closer, or through the mediation of a vector of the pathogen. Fungi, bacteria, phytoplasmas, trypanosomas, viruses, viroids and nematodes are responsible for causing the diseases presented in this work.

The tropical environment, with its hot and humid seasons, which may be more or less prolonged depending on the regions, is favourable for the development of parasites, especially fungi and bacteria. These organisms go into the resting stage in various resistant forms (chlamydospores, oospores, cysts, etc.) during dry periods. When the conditions become favourable again, the parasite resumes its activity and sporulates profusely. These spores are easily disseminated by wind and rain at a time when the plant is also extremely susceptible to infection (liquid water on the surface of the leaves, open stomata, etc.). In contrast to annual crops which are absent during a part of the year, perennial crops remain standing and constitute a permanent storage host of the parasites, which serve as the primary inoculum when infection recommences with the onset of rains, Regions without a real dry season are particularly favourable for the development of pathogens.

Symptoms of parasitic diseases are of various kinds: necrotic spots, rots, wilts, blights, etc. They depend on the type of parasitic activity and the part that is infected. Disease incidence on the production is variable. It depends on the part that is affected, intensity of the symptoms and the pathogenic ability

of the causal agent organism. Death of the tree is the ultimate stage in the evolution of symptoms. It may be sudden or result from a slow and general decay. In both cases the damage caused to the productive capital is irreparable. Infection of fruits results in low yields and often changes the quality of the produce. Diseases of leaves and branches reduce the vigour of the plant and affect the yield. In some cases, repeated infections on the leaves weaken the plant and ultimately lead to its death.

Thus, the heavy investment made by the agriculturist by planting a tree crop, whichever it may be, could be quickly compromised or even wiped out.

This is why a planter should be specially vigilant with respect to the health of the crop, so that he can do everything possible to arrest the development of an epidemic at the right time. Moreover, he should ensure that the plant material selected by him has, as much as possible, all the characteristics for resistance to a disease present in the region under consideration.

The first part of this chapter will be devoted to the description of the various symptoms caused by pathogenic organisms on tropical tree crops. The consequences of the disease on the vegetative growth of the plant and on its production will be indicated in function of the symptoms expressed. Because of the diversity of the pathogens as well as of the concerned crops and for a coherent presentation, the affected plant parts are presented in the same order throughout this chapter.

GENERAL DECAY

These diseases inevitably lead to the death of the plant more or less quickly. All kinds of pathogens may be responsible for general decay.

Diseases caused by fungi

In the quasi-totality of cases, the pathogenic organism grows in the soil. It attacks the plant through the roots or is transported through the vessels which get blocked; nevertheless, it can still be transported to different parts of the plant.

Rot diseases

The causal pathogens have similar life-cycles and attack the roots and then the trunk of a large variety of trees.

White root rot of rubber tree

The name of this disease is derived from the white mycelium filaments or rhizomorphs which the fungus, *Rigidoporus lignosus* (Klotzsch) Imaz (Basidiomycetes, Polyporaceae), commonly called *Fomes*, produces in the form of a network on the roots and collar of rubber trees. It is possible to see this on an