

Coffee Wilt: The Problem and the Project

*Those who cannot remember the past are condemned to repeat it.*¹

1.1 Introduction

During the last decade of the 20th century, an almost forgotten African fungal pathogen called coffee wilt disease (CWD) or tracheomycosis resurged to become the principal production constraint for Robusta coffee in Uganda and the Democratic Republic of Congo (DRC). Over the same period, a similar disease of Arabica coffee, present since the 1950s in Ethiopia, became a growing problem.

Why this happened is both a mystery and a tragedy – a mystery because we understand so little about the origins of the disease and a tragedy because such a major outbreak, which has cost hundreds of millions of dollars in lost earnings, could have been avoided.

CWD is of special significance because, unlike other major diseases such as coffee leaf rust (CLR) and coffee berry disease (CBD), it kills the tree. The first signs of it are yellowing of the leaves, which then wilt and develop brown necrotic lesions. The leaves then curl, dry up and fall off. This process may start on one part of the tree but eventually it spreads to the rest of the plant. The period between the infection by CWD and death of the coffee tree varies from weeks in young plants to 8 months in trees which are more than 10 years old, although most affected trees die 2–3 months after initial symptoms are observed.

In most cases, the symptoms start on one side of the coffee stem where the vascular bundles become blocked by a combination of fungal colonization and host responses. These symptoms are confirmed by scraping off the bark of the diseased stem with a knife. A resultant blue-black stain is characteristic of an infected coffee stem.

Once a tree is infected, there is no remedy other than to uproot the tree and burn it *in situ* to reduce the chances of spreading the infection. No new tree should be planted in the same place for at least 6 months because the remnants of the root system remain in the soil and retain viable spores of the disease.

Thus, the arrival of the disease suddenly changes the Robusta species from being, as the name suggests, a strong tree capable of withstanding attack from several diseases – a good bet for smallholder farmers with few inputs – into one that easily succumbs. It can turn coffee from being a source of ready seasonal cash for poor farming families into a liability that represents wasted time and effort.

Many smallholder farmers, if they control coffee diseases at all, are used to dealing with problems on a 'just-in-time' basis rather than a 'just-in-case' approach.

¹ George Santayana, 1905. *The Life of Reason*.

But by the time the farmer realizes that his plot is infected with CWD, it is too late to take remedial action to save any infected trees and other apparently healthy trees in the plot may already be infected as well. This makes the conventional approach to controlling coffee diseases – spraying on appearance of early symptoms – wholly inappropriate in the case of CWD. For this disease then, an entirely different, proactive (preventative) approach to disease management is abruptly required.

This report covers a series of projects that were developed towards the end of the 20th century, with funding from the Common Fund for Commodities (CFC), the European Union (EU) and the Department for International Development (DFID), to improve understanding of the disease and to help find lasting remedies for it. The report covers the history of CWD, the possible reasons for its resurgence, the various efforts to understand more about the disease, the present state-of-the-art for controlling it and what needs to be done next. For the uncomfortable fact is that, despite the best efforts of researchers in ten or more countries, CWD is still a problem which may still be spreading within DRC at least, and probably Ethiopia as well.

The report will also draw some general conclusions and lessons learned about the efficacy of the response to the problem. Further, it will comment on the state of coffee research and extension in Africa, which, it is no secret to relate, has declined concomitantly with the continent's 50% fall in coffee production over the last 20 years. Since coffee is the most economically important tropical commodity crop, this decline is no small matter, especially considering that coffee originated in Africa, a continent that gifted this iconic plant to the rest of the world.

1.2 A Short History of CWD

1.2.1 Origin - an unsolved mystery

Where the disease came from before it was found on coffee is a mystery. There exist no convincing reports of an alternate host that could act as a reservoir and source of variation. Molecular studies (Geiser *et al.*, 2005) now classify CWD as a member of a species complex, one that contains such diverse diseases. A close relative is *Fusarium udum*, the agent that causes pigeonpea wilt. It is possible that the disease has lived for generations on a wild species of coffee, but our state of knowledge of the genus is not yet sufficient to give any clear pointers to the origin of CWD. At present, all we can surmise is that through some mix of genetic mutation, recombination and exploitation of new terrain with new crops, a new disease form spontaneously emerged at a time of rapid expansion of coffee farming during the economic boom of the 1920s.

1.2.2 Outbreak and spread

CWD was first observed in 1927 in a plantation of *Coffea excelsa* near Bangui in CAR, the Central African Republic, then known as Oubangui-Chari (Figueres, 1940). At first, the disease developed slowly but by 1942 it had become a serious problem throughout the country and by 1945 it had destroyed most of the country's Excelsa plantations (Saccas, 1951), and indeed it seems that CWD is chiefly responsible for the permanent collapse of Excelsa as a commercial crop. Later Saccas (1956) also found the disease on *C. canephora* and *C. neo-arnoldiana* in parts of CAR.

In 1939, Steyaert discovered it on Excelsa in plantations in DRC (formerly Zaire and Belgian Congo), close to the border with Sudan at Aba (Fraselle, 1950). Initially it caused little trouble but, as with CAR, it later reached epidemic proportions (Fraselle *et al.*, 1953) when it spread to Robusta. Subsequently, it was found to have extended to Haut-Uélé, North Kasai and Katanga (Kalonji-Mbuyi *et al.*, 2009).

Between 1938 and 1945 the disease became established on Excelsa in Cameroon, causing complete destruction of plantations in the east of that country. Then, in 1947, it was discovered on *C. canephora* in Côte d'Ivoire and major losses were incurred there into the 1950s, with more than 50% of the coffee-producing areas being destroyed in both Côte d'Ivoire and, by then, DRC too. In 1958, the disease was reported in Guinea and spread quickly to most of the coffee-producing areas, causing coffee production to fall by nearly 50% (Chiarappa, 1969).

Initially, several fungi were implicated as the causal agent, but in 1939 Steyaert (1948) isolated a species of *Fusarium* and called it *F. xylarioides*, which is the asexual form of the disease. Then, in 1956, Saccas reported that the pathogen produced perithecia on the bark of affected trees. The perithecia represent the sexual stage of the fungus which, according to taxonomic convention, was given another name – *Gibberella xylarioides* (Heim and Saccas, 1950). Confusingly, therefore, for those who are not mycologists, the disease has two different scientific names, one for the sexual form and the other for the asexual form.

1.2.3 Control and decline

As the epidemics of CWD developed, it became apparent that some varieties or lines of Robusta coffee exhibited at least some level of field resistance. However, the picture was complex, for instance, lines of *C. excelsa* showed some level of resistance in Côte d'Ivoire but were completely susceptible in CAR, possibly due to climatic factors or the presence of different physiological races. Moreover, some cultivars of Robusta (derived from the DRC), which had some level of resistance in Côte d'Ivoire, were found to be susceptible in the DRC. Figure 1.1 shows a Robusta coffee tree killed by CWD.

At an international conference held in 1956, recommendations were made for the systematic elimination of infected plants, and for the development of host plant resistance. Accordingly, from the late 1950s, a control programme began to: (i) systematically uproot and destroy affected coffee plants over vast areas; (ii) relocate coffee production to new locations; and (iii) replant with resistant *C. canephora* germplasm. This strategy proved highly successful in eradicating the disease from Côte d'Ivoire and DRC (Saccas, 1956; Meiffren, 1961). To this date, the former country remains free of the disease, a remarkable testament to the effectiveness of the programme.

Overall, the implementation of these recommendations led to the status of CWD being reduced to that of a minor disease of Robusta coffee. *C. excelsa*, on the other hand, never recovered as a commercial crop.

1.2.4 A new outbreak

A significant development came in Ethiopia in 1957, when symptoms similar to those of CWD were documented on *C. arabica* for the first time. Subsequent breeding programmes proved ineffective however (Lejeune, 1958; van der Graaff and Pieters, 1978; Pieters and Van der Graaff, 1980).

Figure 1.1: A Robusta coffee tree killed by coffee wilt disease (CWD).



As we see later in this report, the Arabica CWD is genetically distinct from the disease attacking Robusta, and because of its isolation from the West African outbreaks, it seems very probable that this new endemic originated in Ethiopia, through a similar process to that of the original Excelsa outbreak. In other words, the most plausible theory is that a similar concatenation of events occurred in Ethiopia in the 1940s or 1950s, as in CAR in the 1920s, that led to the spontaneous evolution of a new variant from an unknown species of *Gibberella* growing on another host plant in the vicinity of a coffee plantation.

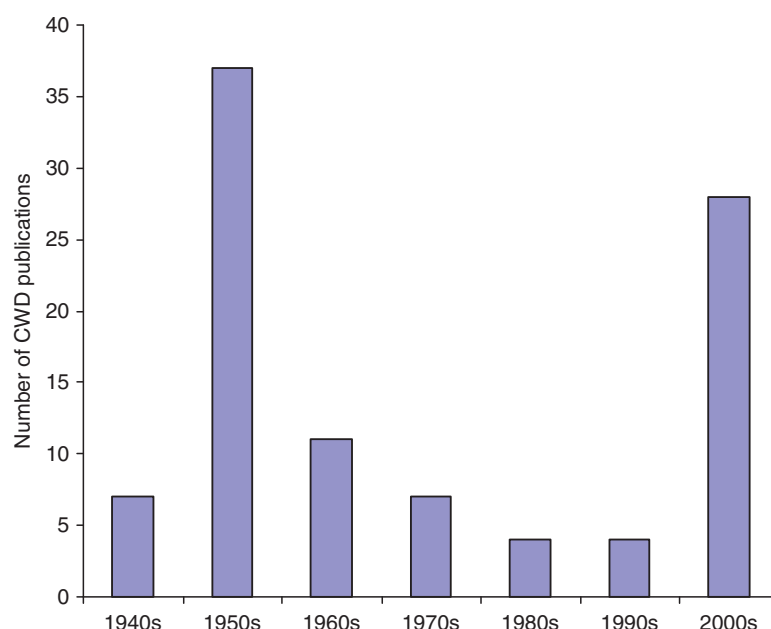
1.2.5 Resurgence

Through the 1960s and 1970s, the status of CWD declined to become a minor disease. However, this picture began to change in the late 1970s with occasional reports of the resurgence of CWD in DRC on abandoned farms near Isiro in Haut-Uélé, a central eastern region of Oriental Province. The subsequent pattern of spread strongly suggested that the new outbreak had indeed started from the Haut-Uélé region (an area previously infested in the 1950s).

This focus of disease caused many farmers to abandon their coffee plots. By the late 1980s, the disease had become widespread in the Oriental Province, spreading south towards North Kivu. Surveys carried out during this time showed that disease incidences of 30% or more were not uncommon. Currently, the disease is very widely spread in Oriental, North Kivu and now extends as well to Equator Province.

By 1993, CWD was reported in Uganda (in Bundibugyo district neighbouring DRC); by 1997, it had spread to Eastern Uganda (Birikunzira and Hakiza, 1997). In subsequent

Figure 1.2: Total articles and reports referring to coffee wilt disease (CWD) in the CAB International abstracts database, by decade.



years, Ugandan coffee production has fallen by about 50% and much of this decline can be directly attributed to CWD.

The disease was next found on Robusta in north-western Tanzania in 1995 (Kilambo and Kaiza, 1997; Mohamed *et al.*, 2000), though the spread and intensity of the disease in this latter country is to date much less than has been the experience in Uganda or DRC.

Hence, a disease that was thought to have been consigned to history, that was hardly covered in scientific literature (Figure 1.2), broke out and caused hundreds of millions of dollars worth of damage to coffee. Can this disease be brought under control again in a similar fashion to the 1950s, or will African coffee now always suffer from this problem?

This report will suggest that if the disease is to be effectively controlled, a distinct, long-term and proactive strategy will be needed to suppress it in the future. The present project aimed to carry out a number of diverse studies and activities to supply knowledge and materials to facilitate this process.

1.3 The Regional Coffee Wilt Programme: Five Projects to Achieve the Programme Objectives

In 1996, at the request of the International Coffee Organization (ICO) and coffee-producing countries in East and Central Africa, CAB International undertook preliminary surveys of coffee farms in DRC and Uganda.

The gravity of the disease was recognized by the Inter-African Coffee Organization (IACO), which recommended holding a workshop to draw up strategies for containing the disease and formulate a project for funding by the international community. In February 1997, a meeting of representatives of ICO, CAB International and Centre

de Cooperation Internationale en Recherche Agronomique pour le Développement (CIRAD) agreed that the regional workshop be held in Uganda from 28 to 30 July 1997, under the coordination of Coffee Research Centre (COREC) Uganda. The regional workshop was funded by the EU, and attracted more than 60 participants representing 15 African countries including the DRC, Uganda, Ethiopia, Tanzania, Rwanda, Kenya, Angola, CAR, Guinea, Equatorial Guinea, Benin, Congo, Nigeria, Côte d'Ivoire and Cameroon. Two European countries were also represented, the UK and France, as were five international organizations: ICO, IACO, CIRAD, CAB International and ASIC.

As a result of consultations during the regional workshop, a draft proposal for a project on the improvement of coffee production in Eastern and Central Africa by the control of CWD emerged. It was resolved that Uganda and DRC should be the focus for the project's activities and agreed that a project proposal be formulated by CAB International as project executing agency (PEA) in collaboration with participating countries and with CIRAD as assisting agency. CAB International, together with the National Coffee Research Systems of seven African coffee-producing countries, developed a proposal for an RCWP, under the auspices of the Coffee Research Network (CORNET) of the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA).

The original regional programme proposal, which was for a single, large project, with ICO as the supervisory body, CAB International as the PEA, and CORI, ONC, EARO, TACRI, ISAR, CNRA and IRAD as collaborating institutions, was submitted to two potential donors: the CFC and the EU in 1998.

The proposal was subsequently revised into a fully integrated programme of activities addressing different facets of the disease and its management, to facilitate funding of discrete activities, expedite work on the ground as quickly as possible and make tenable financial arrangements. The revisions resulted in the establishment of four interrelated and interdependent projects, each dealing with specific components of the epidemiology and control of CWD, collectively referred to as the RCWP. It took 3 years to progress from the initial proposal in 1998 to the launching of the RCWP in February 2001 in Nairobi, Kenya.

Figure 1.3 shows the structure of the RCWP comprising four projects when it was launched in 2001. An additional project, which investigated the possibility of using remote sensing in monitoring CWD in Uganda using ground and airborne data, was added to the programme at a later stage. The activities and results of the original four projects will be covered in this report.

The RCWP was coordinated by the CORNET, under the auspices of ASARECA, with CFC, DFID and EU as the donors. CORNET was coordinated by CAB International Africa, and its responsibilities included: establishing linkages between partners, standardization and harmonization of CWD activities, planning and hosting programme meetings, monitoring and evaluation and programme administration. Objectives of each project within the RCWP are shown in Table 1.1.

The national coordinating partners for the programme were:

- Coffee Research Institute (CORI) of the National Agricultural Research Organization (NARO), Uganda;
- Jimma Agriculture Research Centre (JARC), Ethiopia Institute of Agriculture Research (EIAR), Ethiopia;

Figure 1.3: Relationship between revised projects, partners and funding sources of the Regional Coffee Wilt Programme (RCWP).

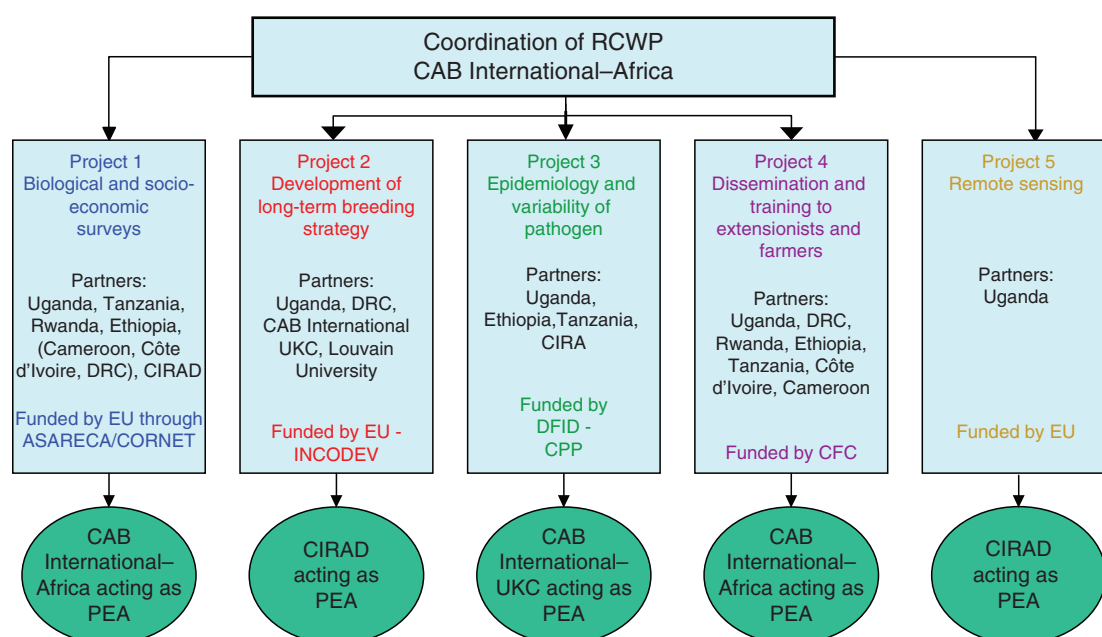


Table 1.1: Objectives of each project in the Regional Coffee Wilt Programme (RCWP).

Project 1: Surveys to assess the extent and impact of coffee wilt disease (CWD) in Eastern and Central Africa	
PEA: CAB International Donor: EU (EDF) through CORNET Partners: CORI (Uganda), TACRI (Tanzania), ISAR (Rwanda), EARO (Ethiopia), CAB International and CIRAD Start: February 2002 End: March 2003	Objectives <ul style="list-style-type: none"> ▪ Gather baseline information on environmental, physical and agronomic parameters affecting CWD incidence and severity ▪ Identify socio-economic factors influencing the occurrence, impact and management of CWD
Project 2: Development of a strategy based on genetic resistance and agronomical approaches to manage coffee wilt disease (CWD)	
PEA: CIRAD Donor: EU (INCODEV) Partners: CORI, ONC (DRC), CIRAD, CAB International and University of Louvain (Belgium) Budget: €720,000 Start: November 2001 End: October 2006	Objectives <ul style="list-style-type: none"> ▪ Establish pathogen variability ▪ Screen coffee germplasm for resistance ▪ Conduct field epidemiology studies ▪ Conduct resistance inheritance studies (pre-breeding) ▪ Coordinate project

Continued

Table 1.1: Continued.

Project 3: Epidemiology and variability of <i>G. xylarioides</i>, the coffee wilt disease (CWD) pathogen	
PEA: CAB International Donor: DFID Partners: CORI, TACRI, EARO, CIRAD, CAB International Budget: £110,059 Start: August 2002 End: December 2004	Objectives <ul style="list-style-type: none"> ▪ Determine pathogen variability including variation in aggressiveness ▪ Elucidate disease epidemiology through fieldwork and molecular techniques ▪ Determine resistance of <i>Coffea</i> germplasm to a range of pathogen isolates ▪ Formulate suitable disease management strategies
Project 4: Training of farmers and extension officers and dissemination of research findings on the management of coffee wilt disease (CWD)	
PEA: CAB International Donor: CFC Partners: CORI, TACRI, EARO, ISAR, ONC, CAB International Budget: Total Project Cost US\$8,951,587 Of which, CFC financing US\$3,516,888 Co-financing US\$3,212,329 Counterpart contributions US\$1,085,920 Start: 2001 End: 2007	Objectives <ul style="list-style-type: none"> ▪ Improve knowledge of extensionists on CWD management ▪ Train farmers on CWD management ▪ Package and disseminate research findings
Project 5: Remote sensing	
PEA: CIRAD Donor: EU Partners: CORI Start: November 2001 End: February 2002	Objectives <ul style="list-style-type: none"> ▪ To detect coffee plots and monitor CWD in a Ugandan landscape using remote sensing

- Tanzania Coffee Research Institute (TACRI), Tanzania;
- Institut des Sciences Agronomique du Rwanda (ISAR), Rwanda;
- Office National du Café (ONC), DRC;
- Institute for Agricultural Research for Development (IRAD), Cameroon;
- Centre National de Recherche Agronomique (CNRA), Côte d'Ivoire.

Other national institutes that took part in project implementation through the national coordinating institutes were:

- The Uganda Coffee Development Authority in Uganda;
- The University of Kinshasa, DRC;
- Institut National des Etudes et de la Recherche Agricole (INERA), Ministry of Agriculture, DRC.