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# THE FUNGAL DISEASES OF CASSAVA IN THE REPUBLIC OF CONGO, CENTRAL AFRICA

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## ABSTRACT

**The main fungal diseases of cassava are listed. They include leaf spot diseases of minor importance caused by *Cercospora henningsii* Allesher, *C. caribaea* Chupp. et Cifferi and *C. vicosae*. They also include stem diseases represented by anthracnose of cassava whose symptoms are formed in two stages: (i) wounding by the bug *Pseudotheraptus devastans* (Distant) Het., Coreidae in parts of the stem that are not yet fully lignified. Wounding activity of *P. devastans* is influenced by numerous factors related to the genotype of the insect, the diurnal cycle and environment. Analysis of the results also shows that the saliva of *P. devastans* has a toxic or enzymatic effect on the cytoplasm and cell walls of cassava tissues, causing cell degradation; (ii) the wounds are infected by conidia of the fungus *Colletotrichum gloeosporioides* Penz. Among environmental factors, relative humidity plays a major role. Infection of cassava stems under experimental conditions is only successful with high relative humidity close to saturation and at temperatures of 24-28°C. Finally, there are two groups of root diseases referred to as root rots: (i) soft rots caused by *Phytophthora drechsleri* Tuck., *Pythium* spp., *Fusarium solani* Mart. and *Sphaerostilbe repens* B. et Br. The latter is the most widespread in the Congo; (ii) dry root rots caused by *Rigidoporus lignosus* (Klot.) Imazeki, *Rosellinia necatrix* (Hart.) Berk., *Botriodiplodia theobromae* Pat., *Armillaria mellea* (Vahn: Fr.) P. Kumm., *Armillaria heimii* and *Phaeolus manihotis* Heim. Rot caused by *A. heimii* is a problem that must be solved in the tropics.**

*Key Words: Cercospora henningsii, Colletotricum gleosporioides*, soft rots, wounding, *Manihot esculenta*

## RÉSUMÉ

**Les principales maladies fongiques du manioc ont été répertoriées. Il s'agit des maladies foliaires représentées par des taches foliaires dues à *Cercospora henningsii* Allesher, *C. caribaea* et *C. vicosae*. Ces maladies, sont de faible importance. Il s'agit aussi des maladies caulinaires représentées par l'anthracnose du manioc dont la formation des symptômes exige deux étapes: (i) Réalisation d'une blessure sur les parties de la tige non encore lignifiées par une punaise *Pseudotheraptus devastans* (Distant) Het., coreidae. L'activité du *P. devastans* sur la réalisation des blessures est influencée par de nombreux facteurs. Ce sont: le génotype de l'insecte, le cycle journalier et l'environnement. L'analyse des résultats a montré aussi que la salive du *P. devastans* exerce une action toxique ou lytique sur le cytoplasme et les parois cellulaires des tiges de manioc; (ii) Infection des blessures par les conidies de *Colletotrichum gloeosporioides* Penz.**

**Le rôle des facteurs du milieu notamment, l'humidité relative est prépondérant. L'infection des tiges de manioc ne réussit expérimentalement qu'en présence d'un taux d'humidité élevé proche de la saturation et de températures comprises entre 24°C et 28°C. Il s'agit enfin des maladies racinaires désignées sous le nom de pourridiés du manioc et répartis en deux groupes: (i) les pourritures racinaires molles: Elles sont dues à *Phytophthora drechsleri* Tuck., *Pythium* spp., *Fusarium solani* Mart. et *Sphaerostilbe repens* B. et Br. et parmi lesquelles la pourriture à *S. repens* est la plus répandue au Congo; (ii) les pourritures racinaires sèches: Elles sont dues à *Rigidoporus lignosus* (Klot.) Imaziki, *Rosellinia necatrix* (Hart.) Berk., *Botriodiplodia***

**theobromae (Pat.), *Armillaria mellea* (Vahl: Fr.), P Kumm., *Armillaria heimii* et *Phaeolus mahihotis* (Heim.). Le pourridié à *A. heimii* représente en milieu tropical, un problème à résoudre.**

***Mots Clés: Cercospora henningsii, Colletotricum gleosporioides*, les pourritures racinaires molles,realisation d'un blessure, *Manihot esculenta***

## INTRODUCTION

Of the root and starch tuber crops grown in Congo and Central Africa, cassava, by the sheer size of the area cultivated, ranks as the principal crop and main source of carbohydrates. In the various regions, diseases in general and fungal diseases in particular are serious constraints. These diseases may be categorised into different groups according to the part of plant affected, i.e., leaves, stem or roots. There are several pathogens which cause either wet or dry root rots. The groups of diseases vary in severity. This paper briefly describes each main group of diseases and considers the most important in some detail.

## LEAF DISEASES

Diseases affecting the leaves of cassava are seldom a serious threat and are mainly manifest as necrotic spots. Three sorts of symptoms may be distinguished depending on the size of the spots and their pigmentation. Those of the first type are very small with a diameter equal to or less than 2 mm and the dead tissue becomes whitish. Spots of the second type are circular and characterised by brownish dead tissues with a diameter of 4 to 7 mm. Spots of the third type are circular or oval. The brownish spots are larger than the whitish ones. The pathogens which cause these infections belong to the genus *Cercospora*: *C. henningsii, C. caribaea* and *C. vicosae*.

There are several other pathogens of relatively minor importance which cause leaf diseases and which have been identified by Boher *et al.* (1978).

## STEM DISEASES

The main stem disease is cassava anthracnose caused by *Colletotrichum gloesporioides*. It was first described by Hennings in 1893 (Chevaugeon, 1956) after being observed on petioles from Dar-es-Salaam, in what is now Tanzania. The pathogen identified was named *Gloeosporium manihotis* Henn. In 1904, working on cassava leaves from Brazil, the same author described *Colletotrichum manihotis* Henn. The disease was later described and the pathogen identified as: *Gloeosporium manihotis* (Bourriquet, 1946), *Glomerella manihotis* (Chevaugeon, 1956), *Colletotrichum manihotis* (Vandermeyen, 1962) and *Glomerella cingulata* (Irvine, 1969). Following the work of Arx (1970) who considered the systematics of the genera *Gloeosporium* and *Colletotrichum*, the majority of research workers now consider *Colletotrichum manihotis* which is a specialised form of *gloeosporioides*, as the pathogenic agent of anthracnose.

The symptoms are characterised by the formation in unlignified parts of the stem of oval or elongate necroses covered with acervuli, which are the asexual reproductive organs of the pathogen. The cassava stem disease develops in two stages. Firstly the formation of a primary necrosis or lesion caused by feeding of the bug *Pseudotheraptus devastans* (Distant) Het., Coreidae and secondly an infection of the insect-damaged tissues by the conidia of the fungal pathogen. *Pseudotheraptus devastans* is prevalent in Africa (Boher *et al.*, 1983) and its role in causing lesions in cassava was identified in Zaire by Dubois and Mostade (1973).

**Initiation of cassava anthracnose symptoms.** The initiation of a necrotic lesion by *P. devastans* is the first phase leading to the appearance of anthracnose symptoms. This phase involves the injection of saliva into the cortical tissues of cassava stems. The results obtained from lesions produced experimentally (Makambila, 1987) show that their size depends on the cultivar inoculated and the depth to which the inoculation is made. Cassava cultivars can be divided into two groups on the basis of the size of the damaged area caused by *P. devastans* and notably its length and width. Some cultivars are sensitive to attack, while others are less sensitive with primary necroses (lesions produced on the infected stems) of smaller size.

The primary sites most prone to infection by *C. manihotis* are those in the incompletely lignified portions of the stem.

The effectiveness of *P. devastans* in causing primary lesions is influenced by numerous factors such as the insect's genotype, the diurnal cycle and the environment. The saliva has a toxic or lytic action on the cell components of the stem leading to a collapse of the cells (Makambila, 1987). However, the saliva is only active when it comes in direct contact with the outer or cortical cells of the stem and saliva left on the cuticle has no effect. The cuticle may act as a protective barrier for the outer and cortical cells so that saliva can only enter the cortical cells through a lesion.

**Lesion infection by the conidia of *C. gloeosporioides*.** The second phase consists in the production of lesions or primary necroses and the development of the fungal pathogen. The conidiospores germinate and produce a germinative filament which in turn produces an appressorium giving rise to an infection hypha which penetrates the epidermal cell. It is unclear whether primary necrosis is necessary for the differentiation of these three organs by the fungus.

From the results of histological studies the following roles can be attributed to the lesion. The initial development stages of the pathogen take place in the cells destroyed by either the *P. devastans* damage or simulated experimentally by heat. After analysing the various stages during which *C. manihotis* invades the cassava stem it is suggested that the lesion stimulates the differentiation of the infectious hyphae in the damaged outer or inner cortical cells. It then acts as trophic support for the ramifications formed from the infectious hyphae. The lesion serves as a means of penetration for the fungus. It can stimulate the differentiation of the penetrating filament and act as trophic support during the pathogen's initial development stages. It is notable that *C. manihotis* is at first saprophytic and then necrotrophic.

**Role of environmental factors (relative humidity and temperature) in the development of anthracnose symptoms.** Environmental factors play a major role. The infection of the stems can only take place in conditions of very high relative humidity. This interaction has also been noted with other fungal pathogens such as *Gloeosporium aridum* (Chand *et al.*, 1968; Ogowa *et al.*, 1977; Denham and Waller, 1981). Temperature also plays a role. Symptoms can only be produced experimentally at temperatures between 24° and 28°C. This temperature range is also conducive to the development of symptoms of coffee anthracnose (Walker, 1957; Nutman and Roberts, 1960). Similar results have been obtained with *Gloeosporium fructigenum* Berk. (Chand, 1968) and other species (Lauritzen *et al.*, 1933; Chowdhury, 1957; Leonard and Thompson, 1976).

## ROOT DISEASES

With cassava these mainly consist of root rots of which there are two major groups: wet rots and dry rots.

**Wet root rots.** These are minor diseases that occur in savannahs but more frequently in humid forest areas. The pathogens responsible are *Phytophthora drechsleri* Tucker, *Pythium* spp, *Fusarium solani* (Marti.) Sacc. and *Sphaerostilbe repens* B. et Br.. The root rot caused by *S. repens* is more frequently encountered than the rots caused by the other pathogens listed.

*Sphaerostilbe repens*, identified as the cause of cassava white root rot is widespread in Central Africa and particularly in the Congo. This disease was first recorded in Sri Lanka on papaya (*Carica papaya*), then in Malaysia on citrus, hibiscus. mango (*Mangifera indica*), cassava and avocado (*Persea gratissima*). In Africa it was noted in Uganda, Côte d'Ivoire, Ghana and Zaire, on rubber (Roger, 1951). A number of attacks by *S. repens* have also been observed on the roots of other starchy tubers, notably yams, in the Congo.

Bugnicourt (1935) studying *S. repens* determined the existence of coremia and rhizomorphs and described the perfect form. Goos (1962) noted the production of chlamydospores and described the structure of rhizomorphs differentiated by this fungus from examination of transverse sections. This study was supplemented by Guillaumin (1970 a, 1970b) who showed that *S. repens* produces two categories of asexual spores: conidia produced by undifferentiated mycelial filaments and stilbospores released at the apex of the coremia. The coremia and the rhizomorphs are closely associated and form an "aggregated unit". The most recent work of Botton (1980) focused on the morphogenic process of aggregated organs.

The symptoms observed on cassava are a rotting of the roots after spreading of rhizomorphs into the tissues which turn yellowish and rot. The bark turns black in places and is covered with coremia. The roots affected do not have rhizomorphs along the surface of the bark. The symptoms mainly develop where there has been some damage of the type often caused by rodents. The destruction caused by *S. repens* to cassava is seldom severe. Studies carried out in the cassava fields of the Mayombe forest patches of Congo showed that of 45 farms surveyed, less than 3% had infected roots and in affected farms up to 5% of the roots had the root rot due to *S. repens*.

**Dry root rots.** This type of rot is caused by each of several pathogens:- *Fomes lignosus* (*Rigidiporus lignosus*), *Rosellina necatrix*, *Botriodiplodia theobromae*, *Armillaria mellea*, *Armillaria heimii*, and *Phaeolus manihotis*. They attack the root system and stem base of woody plants. These attacks lead to a destruction of the bark and wood and, eventually cause decay of the entire plant. Several types of root rot have been recorded in Africa. They occur much more in forest species and tree crops than in cassava. The main hosts identified are coffee, tea , cocoa, avocado, mango, pine, eucalyptus and rubber. The pathogens that cause the root rots observed on these various host plants have been identified by various authors (Bugnicourt, 1935; ; Gilson, 1960; Goodchild, 1960; Olembo, 1972). Three pathogens have been emphasised:- (i) *Armillaria mellea*, a Basidiomycete of the class of Tricholeometachia; (ii) *Sphaerostilbe repens*, an Ascomycete of the Nectriaceae, and (iii) *Phaeolus manihotis*, a Basidiomycete of the Polyporaceae.

According to available research on cassava root rot, *Armillaria mellea* is the principal pathogen (Makambila and Bakala Koumouno, 1986). The research workers above have seldom considered the taxonomy of the *Armillaria* spp. and, more precisely, the identification of the species present in Africa on the different hosts referred to above, including cassava.

**Root rot caused by *Phaeolus manihotis*.** The root rot caused by *Phaeolus manihotis* Heim is not widespread on cassava. Nonetheless, this pathogen is currently recognised as attacking *Pinus caribaea*, *Eucalyptus torreliana*, and *Eucalyptus cloeziana* in some areas and also cassava in the coastal zone of the Kouilou region of Congo. There is a lack of documentation on the description of the pathogen, but it is speculated that it is *Phaeolus schweinitzii* (Fr) which has not yet been confirmed in Central or West Africa. It is already known in South Africa, Australia, New Zealand and Cyprus where it is considered to be the most serious pathogen of coniferous plantations (Monchaux, 1980).

The symptoms are characterised by a degradation of the root tissue which turns yellowish. The pathogen is restricted to the bark on which mycelial cords are observed. The absence of fungal filaments in the root tissue demonstrates that the degradation of the root is due to an enzymatic or toxic activity of the pathogen. Although affecting cassava, this root rot is not a considerable problem on this crop in Central Africa and is more important on *Pinus* spp. and *Eucalyptus* spp. in Congo.

**Root rot caused by *Armillaria*.** Recent research on the taxonomy of African *Armillaria* has distinguished two groups of isolates. The first comprises those comparable to European Armillaria represented by *A. mellea.* The second group includes those from Congo which are responsible for the root rot observed on cassava and belong to the group *A. heimii.* The criteria used in making the distinction are biological and associated with the technology of molecular biology, particularly protein analyses, enzyme polymorphism and DNA extracts analysed using the RAPD technique (Augustian and Botton, 1992; Guillaumin, 1992; Intini, 1992; Mohammed, 1992). Although these studies have shed some light on the classification of African Armillaria, only a few of them, have attempted to determine the importance of *Armillaria* on cassava and the various other host plants attacked.

Cassava is known to be a host of *A. heimii* and an EU-financed project has been undertaken to assess the magnitude of the problem in Congo (Makambila and Bakala Koumouno, 1986). This study was carried out in the cassava producing region of Pool where the crop is grown in patches of cleared land in forest galleries or in the savannas. The aim of the study was to evaluate the importance of the root rot caused by*Armillaria* on cassava, and to determine the effects of crop age on incidence of infection. Of the 1066 cassava farms assessed 29 (22% of the total) were up to 1-year old, 689 (65%) were 1-2-years old and 139 (13%) were 2-3-years old. About half the farms were affected by root rot caused by *A. heimii*, but the proportion increased with age and the percentage of farms affected was 37, 48 and 69 of the total in each of the three age groups, respectively (Fig. 1).

The incidence of infection in each of the affected farms surveyed was also evaluated and four levels of infection were distinguished;

- Less than half the plants infected (<50%)
- Half the plants infected (50%)
- Infection more than 50% but less than total (>50%)
- All plants infected (100%).

A marked age effect was again apparent from the proportion of fields of each age in each category (Fig. 1B). The incidence of infection exceeded 50% in only 8% of the 1-year-old fields surveyed, compared with 23% and 53% for the 2- and 3-year-old fields, respectively (Fig. 1B).

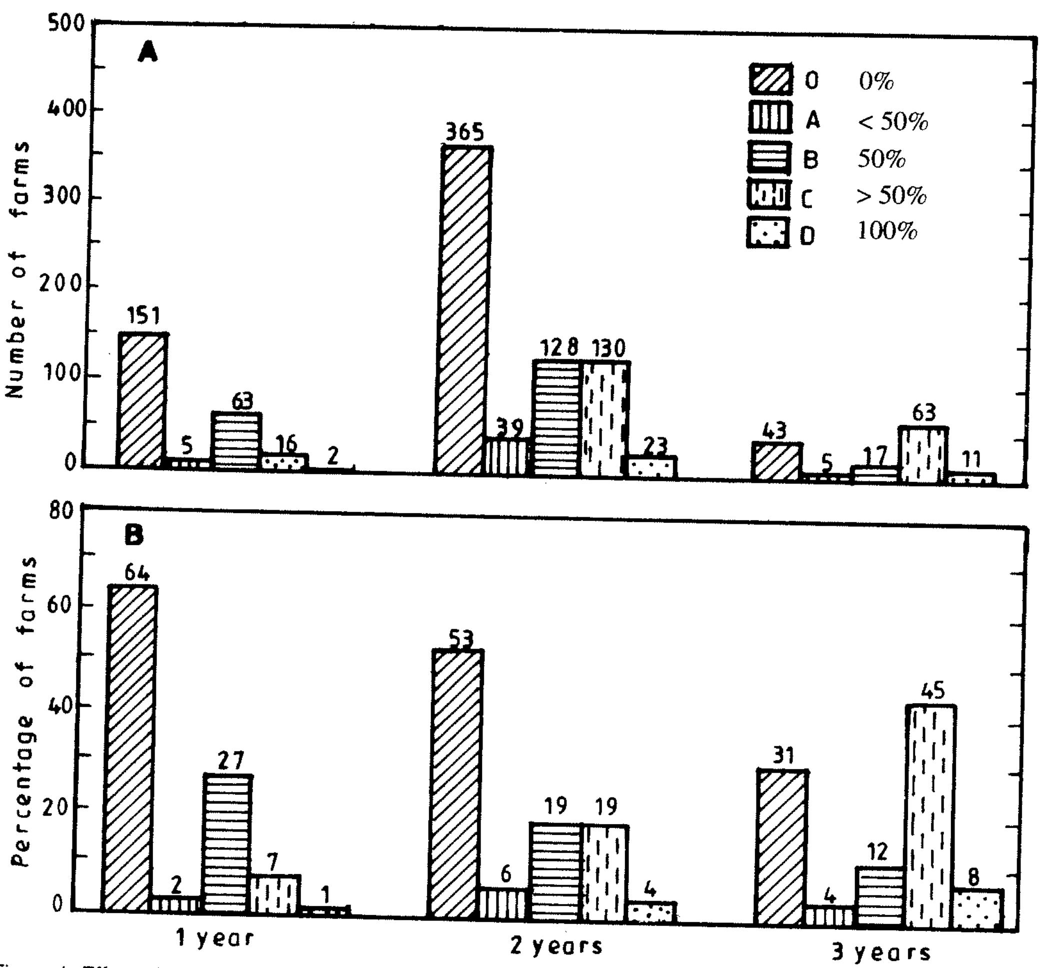


Figure 1. Effect of cassava crop age on incidence of *Armillaria heimii*

## CONCLUSION

In assessing the different diseases considered here it is concluded that some are of little importance, whereas others such as the root rots caused by *Armillaria* spp. have a considerable impact and justify control measures. Anthracnose caused by *Colletotrichum gleosporioides* seems to be of little concern since on several farms observed less than 10% of the stems were infected. In the humid tropics the cassava root rots, in particular those caused by *Armillaria heimii*, cause a serious problem that needs to be resolved. Several measures are required to restrict their incidence: (i) Research activities on *A. mellea* and *A. heimii* in different hosts and staff training; (ii) Research activities should lead to an improved understanding of the taxonomy. Studies based on host-parasite relationships should provide information on the behaviour of each cassava variety in relation to the groups of isolates of *A. heimii* recognised as the predominant types in Central Africa and in Congo. It is possible to assess the aggressiveness of the pathogens using the inoculation methods already developed; (iii) Education and training activities for farmers to enable them to recognise root rot and to reduce the survival of cassava roots in the soil to less than 3 years could contribute to reducing the incidence of cassava root rot in Central Africa, particularly in Congo.

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