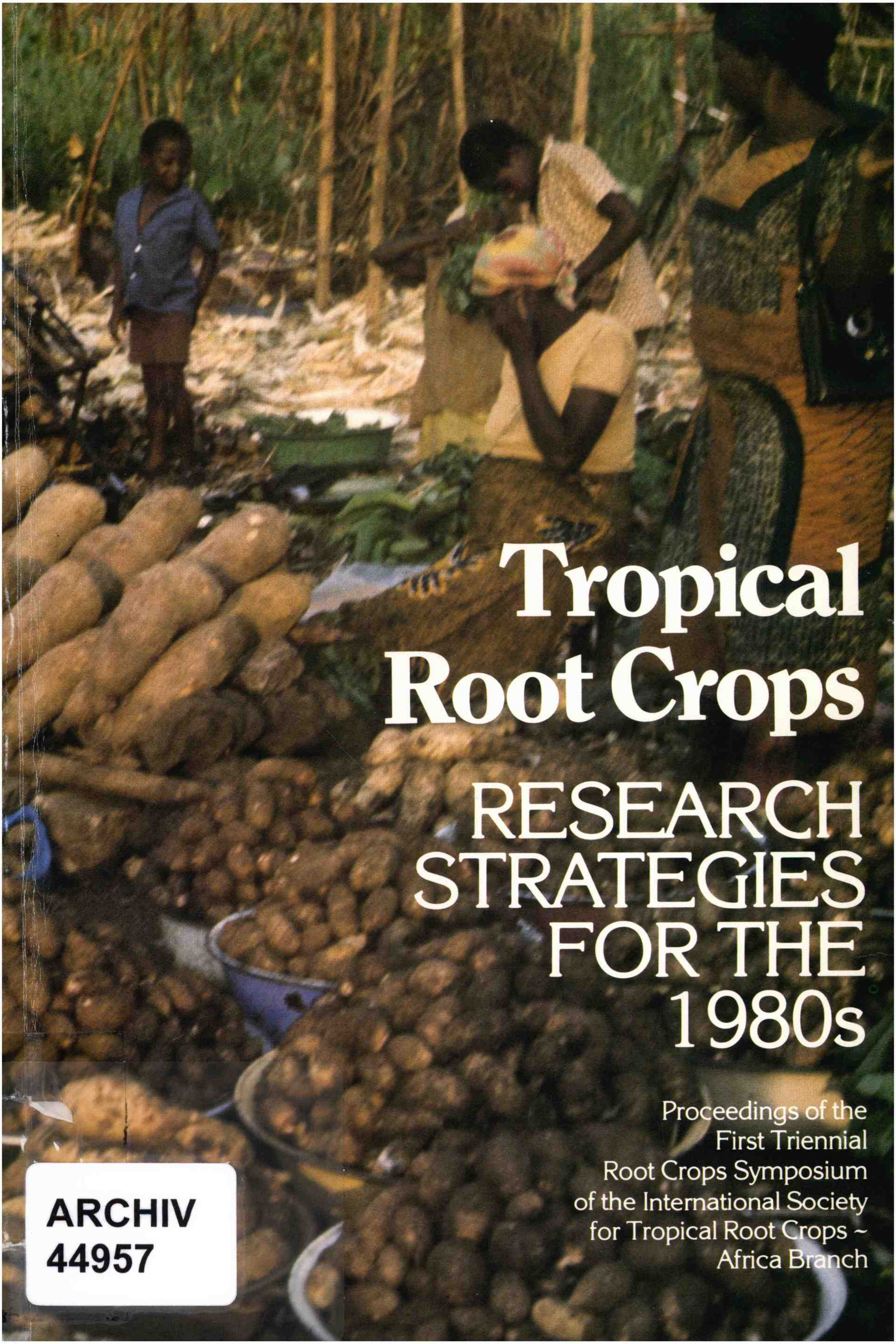

Tropical Root Crops

RESEARCH STRATEGIES FOR THE 1980s

Proceedings of the First Triennial Root Crops Symposium of the International Society for Tropical Root Crops ~ Africa Branch

IDRC-163e

TROPICAL ROOT CROPS: RESEARCH STRATEGIES FOR THE 1980S

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CASSAVA ROOT ROT DUE TO *ARMILLARIELLA TABESCENS* IN THE PEOPLE'S REPUBLIC OF CONGO

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Armillariella tabescens is the pathogenic agent of cassava root rot in the People's Republic of Congo. Studies carried out in many areas have shown that cassava is attacked by external "subterranean" rhizomorphs and internal "subcortical" rhizomorphs. Agricultural practices, such as the use of stakes that are already infected and the often very long period (3–4 years) during which roots are preserved in the ground contribute to the maintenance of the disease. Farmers are receiving advice concerning measures aimed at reducing losses, such as harvesting roots and marketing them after 3 years. However, these measures are encountering problems deriving from marketing and road conditions and the farmers' reluctance to abandon traditional practices.

Armillariella tabescens (Fr) Sing est l'agent pathogène du pourridié du manioc en République Populaire du Congo. Les prospections effectuées dans de nombreuses localités ont montré que *A. tabescens* édifie dans le sol des rhizomorphes "subterranea" (organes infectieux) externes et des rhizomorphes "subcorticalis" internes, par rapport aux organes attaqués dans les tubercules. L'utilisation pendant les bouturages de boutures déjà infectées, la période de conservation des tubercules dans le sol souvent très longue (3 à 4 ans) sont des pratiques culturales qui contribuent au maintien de la maladie. Certaines mesures tendant à réduire les pertes et qui consistent à arracher les tubercules après 3 ans de conservation dans le sol, et les commercialiser sont conseillées aux paysans. Cependant leur application se heurte à des obstacles liés aux problèmes de commercialisation, à l'état de l'infrastructure routière et la psychologie des paysans.

In the Congo, cassava is the most widespread crop and the main source of carbohydrates among all the starchy tuber and root plants cultivated (cassava, sweet potatoes, yams, and taro). In cassava-producing areas, cultivation takes place in general in small plots, where other crops are sometimes grown along with it.

Several factors limit the production of cassava at present in the Congo, for example:

- The widespread distribution, in cassava-producing areas, of local varieties with low yields;
- The traditional methods of preparing the soil; and
- The presence of numerous pests and diseases either recently introduced (for example, the cassava bacteriosis caused by *Xanthomonas manihotis*), or long established, among which are the rots due to the genus *Armillariella*.

Because of its widespread distribution and the losses for which it is responsible, the *Armillariella* rot is the most important.

Armillariella rot has been observed in several areas in the southern part of the country. Plantations in the following localities and their periphery have been prospected (Fig. 1): Odziba Mbe, Kinkala Boko, Mindouli, Kindamba, Vingza, Madingou, Sibiti, Komono, Mossendjo Mayoko, Makabana, Mont-belo, the Mayombe Forest Massif, and Pointe-noire. In the savanna, farmers use the burn-beating (Makany 1976) technique of cultivation; in the forest, slash-and-burn. Where these two types of vegetation exist, both techiques are used.

SYMPTOMS

Symptoms have been observed on plants 2–4 years old. In general, when plants other than cassava are attacked by *Armillariella*, the aerial symptoms appear after one or more roots have been attacked. On cassava, the symptoms and their evolution vary according to whether the plant is a creeping or erect variety. On erect varieties, the symptoms appear when all roots (tuberous or non-tuberous) are attacked and destroyed. These symptoms begin with a yellowing of the foliar lobes, followed by desiccation and detachment of the petiole from the stalk. The stalk and branches

Fig. 1. *Localities studied in the southern section of the People's Republic of Congo.*

become denuded and then die. On creeping plants, these symptoms have not been observed, even on plants whose subterranean system is destroyed.

On the stalk the symptoms first appear on the neck; the skin cracks or splits and exposes blackish mycelial filaments that propagate in palmette-shaped forms. On erect plants, these palmettes progress along the stem up to 1 or 1.5 m from the ground (Fig. 2). On creeping plants, they colonize only the base of the neck and do not progress higher than 20 cm above ground. In the soil, near the neck of the plants numerous long cylindrical, branched ''subterranean'' rhizomorphs have been observed (Fig. 3). These rhizomorphs are either flattened against the stake or root and creep along it or have their base anchored on the stake or root and propagate in the soil apically. Transverse and longitudinal sections show a structure similar to that described by Townsend (1954) and Guillaumin (1967, 1968). During the rainy season, the mycelium at the neck level differentiates to produce the numerous carpophores set out in tufts and supported by annulus-free stems.

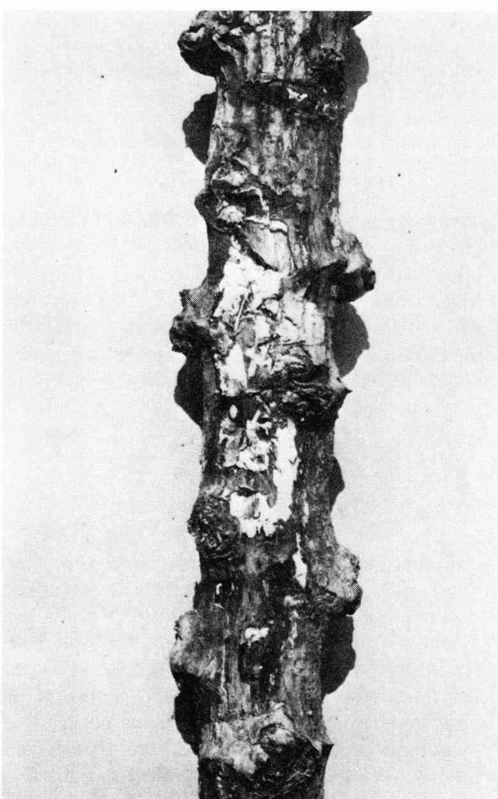

Fig. 2. *Cassava stalk with mycelium patches between skin and core.*

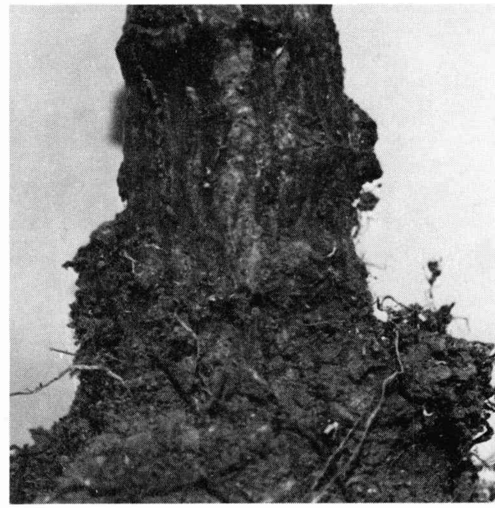

Fig. 3. *Cassava stalk (4 years old) with ''subterranean'' rhizomorphs.*

Diseased roots are covered with a network of brownish, branched ''subterranean'' rhizomorphs, the initiators of the infection (Fig. 4). On severely infected roots, it is possible to observe on the skin a network of black palmettes that develop in the central cylinder and emerge in a vertical fan on the root's surface. Their extremities are white initially, then turn brown, then black (Fig. 5). These organs constitute a sort of pseudosclerotia. The longitudinal section of a piece of infected root exhibits, in the central cylinder, many palmettes 0.5–2.5 cm wide, growing centripetally or centrifugally by the apex. In this central cylinder, black lines stretch over several centimetres or outline oval black surfaces that result from the discoloration of certain parts of the palmettes. These dark masses (Fig. 6), similar to those that develop on the skin, are said to be pseudosclerotia (Campbell 1934). In the central area of the cylinder, the palmettes differ from the white, ribbon-like ''subcortical'' rhizomorphs, which look like fine strands (Fig. 7 and 8).

INFECTION

The infection of the cassava roots may come from "subterranean" rhizomorphs according to a mechanism that has already been described (L. Roger, personal communication). The rhizomorphs first spread over the root and branch some undifferentiated mycelial filaments into the skin at various points, adhering by "anchor" cells. From the infection point, the mycelial filaments settle in the skin, then aggregate into palmettes. These palmettes then spread either between the skin and the periphery of the central cylinder or toward the centre of the central cylinder. The progression of the palmettes is accompanied by the release of chemical substances that degrade the surrounding tissues.

The other source of infection is infected planting material, the roots being attacked by simple generalization of the pathogenic agent from the stake planted in the soil. In humid conditions, the pathogenic agent reaches the root through its peduncle.

Rain and humidity contribute to the development of the pathogenic agent and the propagation of "subterranean" rhizomorphs in the soil. Infected roots collected during the rainy season are covered with many growing rhizomorphs of a brownish colour. During the dry season, infected roots have very few rhizomorphs showing growth activity. Further, my observations have shown that the disease propagates much more rapidly in areas where rain and humidity are constant, particularly in the forest zone.

Temperature, mentioned as a factor intervening in the initiation and development of rhizomorphs, does not appear to have much effect on rhizomorphogenesis. In the various prospected localities where rhizomorphs were observed on infected roots, temperatures range from 20 to 30°C during both dry and rainy seasons.

TOPOGRAPHY AND AGE OF PLANTS

In cassava plantations located on sloping terrain, the plants most infected are found at the foot of hills in areas most often very humid and badly drained in comparison with the slopes or hilltops.

The greatest damage has been noted in 3- or 4-year-old cassava plantations. Damage increases when the period of preservation of the roots in the ground extends to 4 years.

DISCUSSION AND CONCLUSIONS

Some of the cultivation techniques practiced in the cassava-producing areas effectively contribute to the maintenance of the pathogenic agent in the ground. Cassava cultivation is practiced over small areas where the usual practice consists in harvesting the roots when needed over a period of 2–4 years. A long period of preservation exposes the roots to infection. These infected roots constitute an important source of inoculum from which the "subterranean" rhizomorphs propagate in the soil and infect other organs. In humid conditions the use of stakes that are already infected allows the development and propagation of the pathogenic agent in

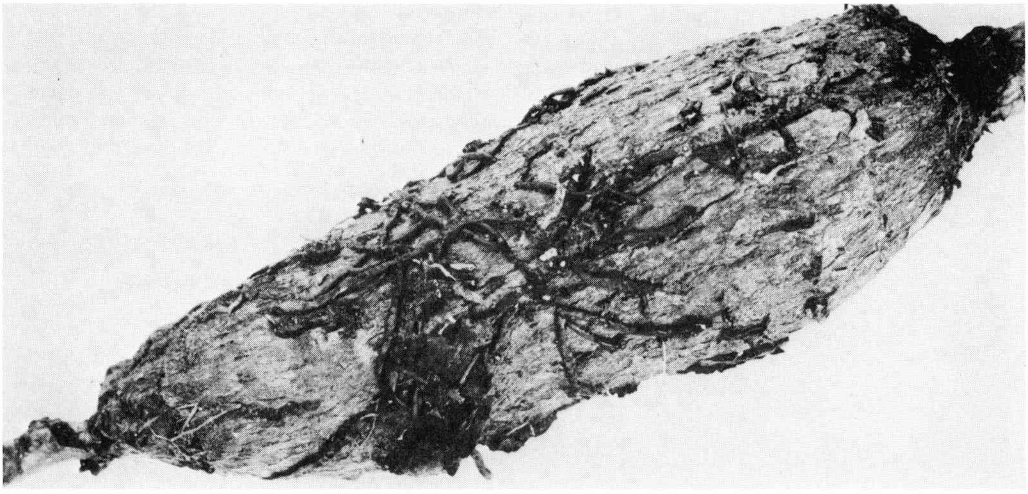

Fig. 4. *Network of "subterranean" rhizomorphs covering a cassava root.*

Fig. 5. *External surface of root infected with pseudosclerotia.*

new organs (tuberous or nontuberous roots) and in the soil.

My observations in various localities have indicated that at certain times of the year the genus *Armillariella* develops carpophores at the level of the neck of the stalk. The morphology of fructifications, particularly the absence of annuluses, suggests that these symptoms are attributable to *A. tabescens*. This species, previously unknown in Central Africa, has been recorded to a much greater extent in the Mediterranean area (Tunisia) on *Eucalyptus* (Delatour 1969); in the southern United States, on forest trees (Filer and McCracken 1969); on the pecan tree in Georgia (Takass et al. 1970); on *Citrus* in Florida (Rhoads 1948); and on the quinquina in Upper Guinea (Heim and Jacques Felix 1953).

Other species of the same genus have been recorded in Central Africa and might well exist in the Congo. *A. elegans* with annulus (intermediate between *A. mellea* and *A. tabescens*) has been recorded on the coffee tree in Madagascar and Cameroon (Dadant 1963; Heim 1963). *A. mellea* with annulus has been recorded on coffee and tea in Tanzania (Wallage 1935); on tea, cocoa, and hevea in Uganda (Hansford 1937); on coffee in Malawi (Leach 1932, 1937); and on tea and conifers in Kenya (Goodchild 1958; Gibson 1960; and Olembo 1971). The others, *A. fuscipes* and *A. luteobubalina*, have not yet been described in Africa. The absence or presence of the annuluses as a feature for classification does not seem sufficient for systematic discrimination of the species. Other morphologic and cytologic features of the thalli should complement it. This would enable one to see whether species that are at present little known in Africa (*A. fuscipes* and *A. elegans*) have not been mentioned under *A. mellea*.

In some cases, the aerial symptoms usually described on plants attacked by rot have not been observed. The creeping varieties of cassava do not exhibit any aerial symptoms, despite the deterioration of their root system. Among such plants, new roots are grown above the neck and actively nourish the aerial part.

In the various localities I studied, I observed rhizomorphs on infected roots — a finding indicating that *A. tabescens* is capable of initiating "subterranean" and "subcortical" rhizomorphs on infected organs in equatorial and tropical climates.

Does temperature affect the initiation and development of rhizomorphs in tropical and equatorial climates? According to some authors, outside a range of 15 to 25°C, the initiation of the

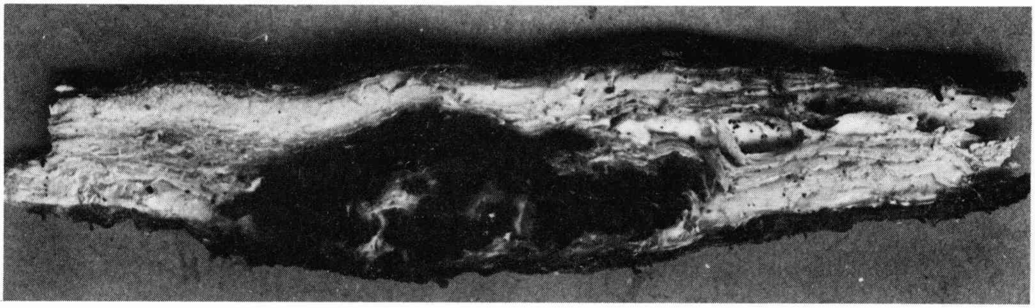

Fig. 6. *Longitudinal section of the root (TUB) showing pseudosclerotia (PS).*

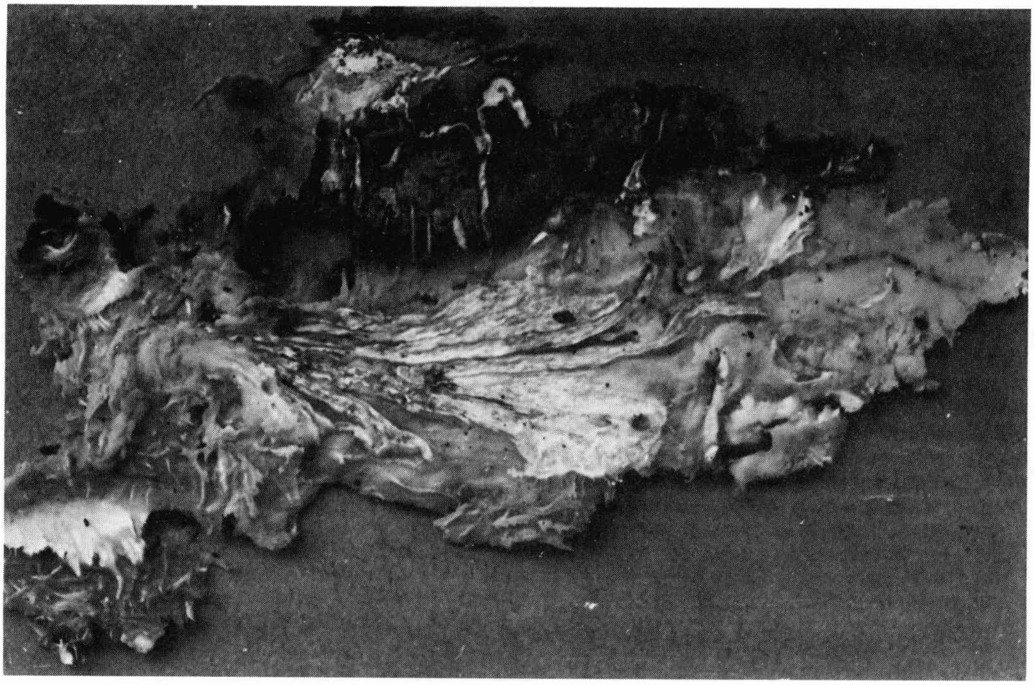

Fig. 7. *Mycelium aggregated in palmettes in central cylinder.*

rhizomorphs is slow in the soil and is inhibited at 30°C (Rishbeth 1963). According to others, the temperature has an influence on the number of rhizomorphs. According to them, the number of rhizomorphs initiated at 15°C is greater than at 25°C, but the total dry weight of the rhizomorphs is little changed (Redfern 1973). Swift (1962) mentions that the Armillaria does not differentiate rhizomorphs in tropical regions. These observations, which are quite different from mine, should be considered with a great deal of caution.

Cassava root rot due to *A. tabescens* presents a serious problem for cassava cultivation. It extends over large areas of most of the cassava-producing forest regions and is maintained by the cultivation methods traditionally practiced in these areas. Methods for combatting it (curative methods), which consist in the use of products such as

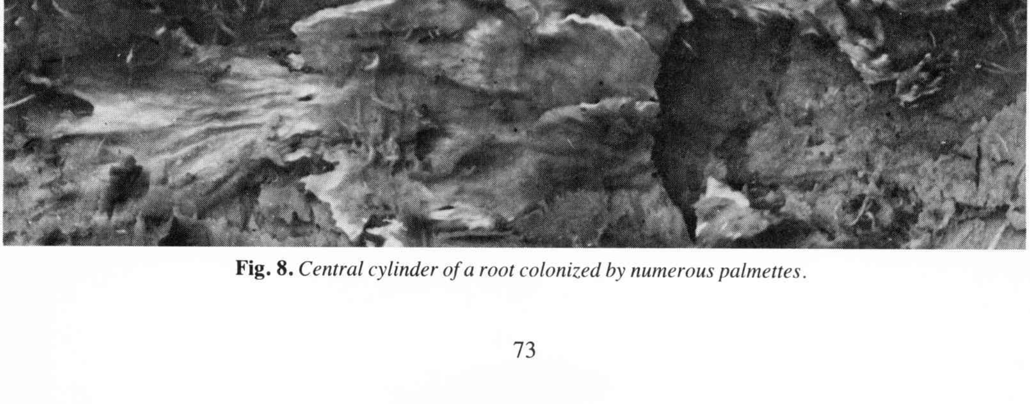

Fig. 8. *Central cylinder of a root colonized by numerous palmettes.*

Bordeaux mixture, mercuric chloride, etc., are unknown in these regions. Their application is plagued by many difficulties, and they are very expensive.

Preventive methods using genotypes that have been improved to withstand bacterial blight and mosaic disease have not yet been introduced in any program of prevention of cassava root rot due to *Armillariella* in Africa.

To reduce the most severe losses, farmers could harvest the roots earlier than is the present practice; therefore they have been asked to shorten to 2 or 3 years the period during which the roots are kept in the ground before being marketed. The advice, however, has not been widely accepted for several reasons. The farmers, whose cultivation practices are part of their heritage, cannot easily abandon them. Those who have attempted have encountered problems in routing the harvested cassava to the large urban centres and marketing it. To all this must be added the difficulties presented by road conditions, where some of the roads are barely passable at certain times of the year.

This paper was originally French; with the author's permission, it was translated into English for inclusion in these proceedings.