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Technical Centre for Agricultural and Rural Co-operation

Controlling African Cassava Mosaic Disease



John Guthrie

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Acknowledgements

The author would like to thank Dr D.L. Jennings for his helpful comments on the draft manuscript and Dr C. Fauquet for providing some of the illustrations (Frontispiece, 1, 5, 6, 7, and 8).

Edited and designed by Chayce Publication Services, UK

Printed by Ashley House Printing Company, UK

ISBN92 9081 *073* 4

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Introduction

Cassava (*Manihot esculenta)* originated in Central and South America (Rogers, 1963), but is now widely grown in tropical and subtropical regions, including those of Africa, Madagascar, India, Indonesia, Malaysia, Thailand and the Philippines. It was introduced into West Africa by the Portuguese in the late 16th century via Sao Tomé, Fernando Po and the Congo river, but its early spread was slow. For the following 200 years it was of little importance elsewhere in Africa and did not reach many of the regions where it is now widely grown until the present century (Jones, 1959; **Doku,** 1969). It was introduced to the island of Réunion from Brazil in 1736 and was recorded in Zanzibar in 1799. However, it was apparently unimportant in the East African hinterland before 1850 except around Lake Tanganyika, to which it had spread from the west.



Healthy cassava plant

Although the crop is often regarded primarily as a famine reserve, there has been increasing realization in recent years of its value as a high-yielding source of carbohydrates. Its cultivation has increased considerably during this century, and there is now a greater area under cassava in Africa than in all other cassava-growing areas of the world combined. The crop is grown in almost 40 African countries. The reported production of 56 million metric

tonnes, grown on 7.5 million hectares, represents 43% of the world total and is a major food item for at least 200 million African people (Food and Agriculture Organization, 1985).

The average yield of cassava in Africa — 7 to 8 tonnes per hectare — is far below the potential of the crop. The most important single reason for this is probably the almost ubiquitous presence of African cassava mosaic disease. In the first part of this booklet, the occurrence and effects of the disease are discussed. The second part deals with methods of controlling the disease, and includes a brief outline of other cassava disease and pest problems. The final part discusses cassava progagation methods.

African Cassava Mosaic Disease

African cassava mosaic disease (ACMD) is caused by a virus and, as its name implies, appears to be confined to Africa. A similar disease caused by a closely related virus occurs in India, but the virus which causes the disease known as cassava common mosaic disease, found in South America, belongs to a different group. It follows, therefore, that the original cassava introductions into Africa were free of the disease and were invaded by a virus present in some other host or hosts whose identity has yet to be established.

ACMD was first described in the late 19th century (Warburg, 1894) and is now found wherever cassava is grown in Africa. Ironically, it is because the disease is so widespread that its importance has received little attention — so many plantings contain few, if any, healthy plants that ACMD infection has come to be regarded as a normal condition of the crop. Consequently, it is not generally realized that ACMD causes serious yield losses.

Plants infected with ACMD are not killed but show pale green or yellow areas on the leaves, which are commonly small and distorted. Tubers are reduced in size and number. Stem diameter and overall size are also reduced. Yield reduction may be severe. Losses of up to 95% have been reported and the overall reduction in Africa may be as high as 50%. The virus which causes ACMD belongs to the gemini virus group, whose paired particles are visible only under an electron microscope. A number of strains of the virus have now been recognized (Bock and Harrison, 1985), but strain differences are not important for practical field control.

ACMD is spread in two ways: when the whitefly (*Bemisia tabaci)* feeds first on diseased plants and then on healthy plants; or when diseased cuttings are used to establish a crop. The relative importance of the two ways depends on several factors, but yield losses are greatest when plants are derived from infected cuttings (Briant and Johns, 1940).

The reduction in yield caused when a previously healthy plant is infected by whitefly depends on the stage of growth at which this occurs. There is no significant yield reduction if infection occurs more than 120 days after planting (Fargette et al., 1986) but of course cuttings taken from such plants will give reduced yields in the next crop.

Cassava has become the most important food crop in Africa because of its high yield capacity and its ability to grow in poor soils. Given the rapid

population increase in most African countries, particularly in urban areas, it seems likely that cassava will become still more important in the future. Every effort must therefore be made to bring ACMD under control.

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Cassava leaf showing mild symptoms of African cassava mosaic disease

3



Cassava leaf showing severe symptoms of African cassava mosaic disease

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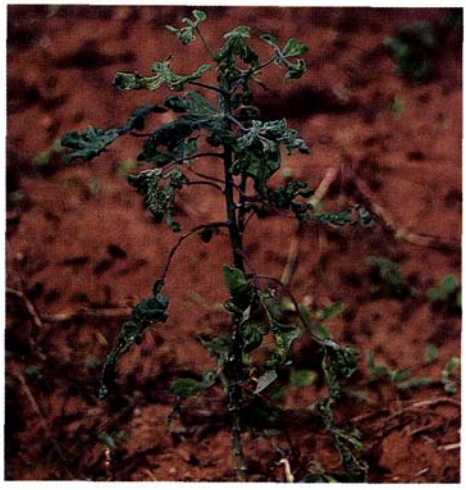

Cassava plant severely affected by African cassava mosaic disease

Controlling the Disease

There are two main methods for controlling ACMD:

- using varieties which are resistant or tolerant to the disease;
- using sanitation techniques, which involve taking cuttings only from healthy plants and subsequently removing any plants which become diseased.

The two methods are not mutually exclusive; both have a place in a practical control programme. Indeed, sanitation is easier to apply to varieties which have a degree of resistance, and its use during the first stages of propagation is often essential.

Control of the whitefly vector is not practicable under field conditions.

Varietal resistance

Cassava varieties differ in their susceptibility to ACMD.

Several workers have attempted to identify resistant material within local or introduced varieties of *M. esculenta,* and to increase resistance by making crosses with other *Manikot* species, especially the tree-like *M. glaziovii.* A major programme was conducted by Storey and his co-workers in East Africa from 1937 to 1957 (cited in Beck, 1982), and another is now being undertaken by the International Institute of Tropical Agriculture (IITA), at Ibadan, Nigeria (Hahn et al., 1980).

The IITA programme has made extensive use of the East African material, but has also incorporated germplasm from South America and India to improve quality and increase yield. A wide range of other *Manikot* species has recently been added to the programme. Material from IITA has been distributed to more than 20 African countries. The level of resistance or tolerance is generally satisfactory (a plant is said to be tolerant if it becomes infected but suffers relatively little loss of yield). However, it has often been difficult to meet local preferences in taste, texture and agronomic characters. It is hoped that the breeding work currently being conducted at IITA and by several countries participating in the IITA programme will remedy these deficiencies.

Quarantine regulations and general prudence dictate that international transfers of cassava cultivars are now made by means of meristem cultures. This ensures freedom from disease, but calls for adequate facilities and expertise in the recipient country to carry the material forward to field production. These are not always available.

Resistance to ACMD has been shown to operate in several ways, including resistance to inoculation, resistance to multiplication and diffusion of the virus in the plant, and resistance to the insect vector (Fauquet et al., 1986). These factors complicate breeding strategies, but they also increase the possibility of achieving effective disease resistance by combining different forms of resistance in a breeding programme.

Sanitation methods

Resistant varieties have made a useful contribution to the control of ACMD and there is potential for improvement, but breeding is time-consuming and expensive and does not cater easily for local consumer preferences. Consequently, attention has also been given to the use of sanitation methods.

Control of ACMD by sanitation is very simple in principle. It relies on visual examination to select healthy planting material, and the subsequent elimination or 'rogueing' of plants which show ACMD symptoms in the field.

Even in heavily infected cassava plantings, there are almost invariably a few mosaic-free plants from which to begin bulking healthy material. ACMD infection is not always systemic, so it is sometimes possible to use a healthy branch from an otherwise diseased plant. Meristem tip culture and heat treatment of diseased material have been used to obtain virus-free material (Kaiser et al., 1979), but such techniques are relatively difficult to use. Simple field techniques are generally adequate.

Once selected, healthy planting material is multiplied, either by taking cuttings in the normal way or by using rapid multiplication techniques. The clean material is planted in the field and is examined at frequent intervals during the early stages of growth. Any plants showing symptoms are uprooted immediately. This rogueing should be carried out at least once a week for the first 2 to 3 months. ACMD symptoms are obvious from the outset and rogueing takes very little time. Whiteflies will not feed on wilted leaves; uprooted plants need not therefore be burnt but can be left on the surface to dry out. Plants removed in the early stages can be replaced with healthy cuttings, but even if they are not, loss of yield from gaps in the stand

is less than would be expected because adjacent plants benefit from the reduced competition and give higher than average yields.

The obvious limitation of the sanitation method is that the selected material, although free from disease, is no more resistant than the stock from which it came. In areas of high disease pressure, therefore, the rate of reinfection may be high and the benefits of sanitation reduced, possibly to a point at which the method is of no practical value. This is most likely to be true in lowland forest areas with high rainfall. Sanitation is not generally advocated for such areas.

However, sanitation has provided good control in both East and West Africa (Bock, 1983; Fargette et al., 1985). Although to date it has usually been conducted only on a pilot scale, there is good reason to believe that it would succeed over larger areas. Indeed, the greater the area of healthy material created, the greater the chances of success, as reinfection depends partly on the proximity of diseased cassava. Yield increases of 100% and more have been achieved by the use of sanitation under plot conditions. On a field scale, successful control of ACMD was achieved over a 10-year period in Uganda (Jameson, 1964).

Sanitation techniques are particularly applicable to material produced by breeding programmes. Few, if any, resistant varieties will remain entirely free from the disease under field conditions. A progressive build-up of infection will probably occur and will result in decreasing yields, although the rate of decline will be slower than in less resistant material. An organization established for the multiplication and distribution of cassava material resulting from a sanitation programme will be equally necessary for handling material coming from a breeding programme.

In this instance, a small nucleus of healthy material is obtained from an external source, and the role of sanitation is to rogue the few diseased plants that occur during propagation so as to build up a larger population. Once a large population is obtained, the infection pressure is considerably reduced or removed altogether, and the sanitation procedures can be relaxed, but not discontinued. The need for sanitation is inversely related to the resistance level of the variety, but all resistant varieties require sanitation to some extent in areas where infection pressure is high.

A suggested procedure for a sanitation programme is given in Box 1 (*page* 9)

There is nothing in the sanitation approach to cassava improvement that farmers cannot do for themselves at little or no extra cost in money or time, provided they understand the underlying principles. Nevertheless, research and extension services can play an important part in increasing national

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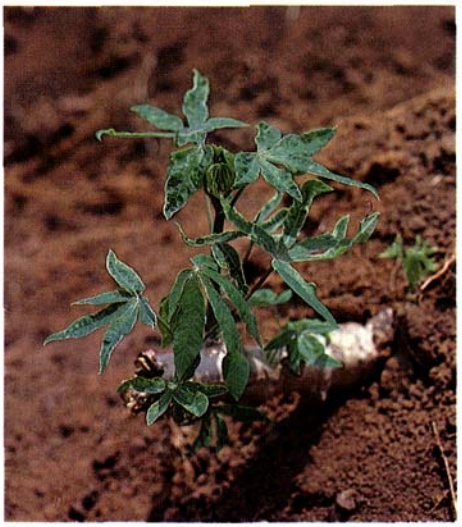

Young plant grown from an infected cutting; this plant should be rogued

cassava production by establishing collections of healthy clones, identifying the best of them in yield trials, and passing material and information on to farmers. A programme conducted by government organizations should serve as a catalyst in persuading farmers to adopt sanitation procedures in their own interest.

If sanitation procedures are neglected, disease-free material will gradually become reinfected, even in the most favourable areas. Yields will fall, and the sanitation concept will then be discredited and rejected by the farming community.

The advantages and disadvantages of the breeding and sanitation approaches are summarized in Box 2 (*page 10*).

Procedure for a sanitation programme

1 Identify a small number of research or extension stations which have the necessary staff and facilities These stations should, if possible, be in areas where cassava is an important crop Work at stations in high-rainfall areas is important when resistant varieties are being introduced, but it should be borne in mind that sanitation procedures alone are more likely to be effective in controlling ACMD where rainfall is medium or low

2 At each station, establish healthy clones of the more important local varieties. To these can be added the best varieties from other regions and, when available, material obtained from organizations such as IITA. From now on, inspect and rogue all material frequently.

3 Bulk promising material, either by conventional methods or, where appropriate, by using rapid multiplication techniques.

4 Test clean material in comparative yield trials; this will also serve to check reinfection rates. Plantings of infected material should be isolated from the main plots of healthy material to reduce infection.

5 Organize demonstration plots on selected farms. These plots will also serve as sources of material and information

6 Distribute healthy planting material This must be accompanied by instruction on the principles of sanitation, as this approach to the control of ACMD will work only if farmers realize the importance of selecting clean planting material and practise rogueing at all stages

7 The rate of reinfection with ACMD should be monitored at all stages It may be necessary to discard varieties which show a high rate of reinfection, although these may be maintained in a collection for subsequent use in breeding

2 A comparisan of breeding and sanitation approaches to cassava improvement

Breeding	Sanitation
*Advan*tages	
Resistance more effective and durable, especially if combined with sanitation in the early stages of propagation	Quick results
	Low cost
Centralized programme may serve large multinational areas	Simple, effective at district or farm level
	Consumer acceptability assured
	Products available for further improvement by breeding
Disadvantages	
Trained scientists needed	Requires continuity
High cost	Ineffective in areas of high disease pressure
Slow progress	
Consumer acceptability requires careful selection and evaluation	Several small local programmes needed (this is not necessarily a disadvantage)
Complete resistance unlikely	

Other cassava disease and pest problems

Apart from ACMD, cassava is subject to many other diseases, as well as to a number of damaging pests. The most serious disease is cassava bacterial blight (CBB), while the two major pests are cassava mealybug and green spider mite. It is important that these should be recognized, but even more important that material used for propagation is as healthy as possible.

Cassava bacterial blight

Caused by *Xanthomonas manihofis,* CBB produces angular, water-soaked leaf spots; this is followed by wilting, shoot die-back and the production of leaf exudates. Similar symptoms are produced by *Xanthomonas cassavae* (Persley et al., 1976).

It is possible that CBB was introduced into Africa from Brazil in the early years of this century. Its occurrence was limited and sporadic until 1970, when it became prominent in Zaïre. Thereafter, it spread rapidly to many other areas and now causes major yield losses. Varieties differ in their susceptibility to CBB. Control measures are based on use of the more resistant varieties and selection of healthy planting material. Resistance to CBB is associated with resistance to ACMD in many of the new varieties which have been developed by IITA.

Cassava mealybug and green spider mite

Cassava mealybug (*Phenacoccus manihotis*) and green spider mite (*Mononychellus* spp.) were both accidentally introduced into Africa from South America in the early 1970s. In the absence of natural enemies they spread rapidly, and have caused serious yield losses in many areas. A major biological control campaign is now being conducted to overcome these pests by identifying and releasing their natural parasites and predators (Herren, 1987).

Cassava mealybug attacks the plant's shoot tips, which become stunted and distorted. Leaves are small and curled, internodes short and tuber yields much reduced. Tubers may rot. Mealybug infestations are easily recognized.

The green spider mite feeds on young leaves, which are much reduced in size and show severe chlorosis. In severe infestations, the apical shoot dies and, as with mealybug, heavy yield losses result.

6



Shoot tip infested with mealybug

7



Cassava plant infected with cassava bacterial blight

8



Cassava plant infested with green spider mite

9



Symptoms of green spider mite attack on a cassava leaf

Propagation of Cassava

Although cassava plants flower and set seed, germination of the seed is difficult under most conditions and is normally of interest only for research purposes. However, African farmers often keep volunteer plants and have sometimes obtained superior varieties in this way.

Cassava is normally propagated by means of stem cuttings, which is satisfactory for commercial production but has the disadvantage that the rate of multiplication is slow, giving only a ten- to twenty-fold increase per growing cycle. For the rapid increase of elite material, it is desirable to use other methods. A number of rapid multiplication techniques have been developed for this purpose.

Propagation by stem cuttings

Care in the selection and preparation of cutting materials is of great importance (Centro Internacional de Agricultura Tropical, 1977).It is not generally realized that the quality of cuttings has a marked effect on the eventual crop yield. Cuttings are normally taken from 12 to 15 month-old plants. It is important to select plants free from ACMD, blight and other major diseases and pests. Cutting material should be neither too woody nor too soft. Woody cuttings give poor and delayed germination, while green cuttings are prone to attack by bacteria, fungi and pests. Very thick or very thin cuttings also germinate badly, and as a general rule the diameter of the pith should be less than 50% of the stem diameter in cross-section. The number of nodes is also important for good germination; a cutting 20 cm long should have at least six nodes.

Mechanical damage to cutting material should be avoided, as bruising and breaking of the outer tissues of the stem allow the entry of micro-organisms which will affect the health of the young plant. Delay between harvesting the cutting material and planting it reduces germination in many areas. If delay is unavoidable, the cutting material should be stored in a cool, moist, shady place.

The material selected for cuttings should be cut to length using a sharp blade or saw. A cut at right angles leads to more even rooting than a diagonal cut. A short section from the ends of the stem should be discarded, especially if these ends have dried out during storage. Cuttings should be 20 to 30 cm long.

10



Cuttings: too young (left); ideal (centre); too old (right)

11



Cuttings: too few nodes (left); ideal (right)

Once prepared for planting, cuttings should if possible be dipped in a combined fungicidal/insecticidal solution for 5 minutes. The materials used will depend on local availability; a mixture such as Dithane/Malathion is suitable. Cuttings treated with toxic chemicals must be handled with care. Chemical treatment may not be possible under subsistence farming conditions for reasons of cost, availability and health hazards.

Cuttings may be planted vertically or at an angle. Horizontal planting should be avoided, since it usually results in excessive numbers of shoots and reduced yields. Spacing between plants varies with local conditions and practices, but a spacing of 1 m within and between rows is usually satisfactory, giving a population of 10000 plants per hectare. Farmers in dry areas or in areas with poor soils may prefer to use wider spacing.

Rapid multiplication techniques

Propagation by stem cuttings is satisfactory for normal farming purposes, but rapid multiplication techniques are appropriate when the need to obtain a faster increase in the available material justifies greater expense and expertise. Two such techniques are described here. A publication by the Centro Internacional de Agricultura Tropical (CIAT)provides a more detailed description of these techniques (CIAT, 1982).

Two-node cuttings

These cuttings are planted closely in a soil-sand mix in humid chambers. The small shoots which develop are cut off immediately below a bud after 2 to 3 weeks and placed in water, where they develop roots. After approximately 15 days, the resultant plantlets are planted in the field, where they must be under shade and given adequate water until established. Using this method it is possible to obtain between 12000 and 24 000 cuttings, sufficient to plant 1 to 2 hectares at normal spacing, from a single mother plant within 1 year.

Axillary bud method

This technique involves cutting the mother plant into units consisting of a leaf, a petiole and an axillary bud, together with a small portion of stem. After cutting off most of the leaf lamina, these units are placed in trays of sand in a moist chamber. Rooting normally occurs within 2 weeks, and the plantlets are then transferred to small paper or plastic pots containing a suitable potting mixture, and kept in the shade. After a further 7 to 10 days, the plantlets are ready for planting in the field, where they must be given adequate water until established.

Multiplication by this method is extremely rapid and can produce up to 15000 plants from a single mother plant in less than 6 months. If the process is then repeated, 250 000 plants, sufficient for 25 hectares, can be obtained within 1 year.

Conclusion

In view of the growing importance of cassava in a continent in which there is an urgent need to increase food production on a sustainable basis, it is essential that ACMD is brought under control. Athough current breeding work is addressing the need to reduce yield losses and ensure that healthy material is available for propagation, it offers only a partial solution. Cheaper and equally effective sanitation methods must also be used. Applied in suitable areas, with care and dedication, there is good reason to believe that the application of sanitation to the control of ACMD could make a major contribution to food production in Africa.

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The Technical Centre for Agricultural and Rural Co-operation (CTA) operates under the Lomé Convention between member States of the European Community and the African, Caribbean and Pacific (ACP) States.

The aim of CTA is to collect, disseminate and facilitate the exchange of information on research, training and innovations in the spheres of agricultural and rural development and extension for the benefit of the ACP States.

Headquarters: 'De Rietkampen', Galvanistraat 9, Ede, The Netherlands

Postal address: Postbus 380, 6700 AJ Wageningen, The Netherlands

Tel: (31) 8380 60400
Telex: (44) 30169 CTA NL
Telefax: (31) 8380 31052