# A STRATEGY FOR MAINTAINING AND SANITIZING CASSAVA PLANTING MATERIAL IN WEST AFRICA

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### Abstract

A significant constraint to cassava production in West Africa is the use of planting material that is insufficiently vigorous and is infested with pests and diseases. The constraint is compounded by a lack of knowledge of the appropriate criteria, and their dissemination, for the selection of healthy, vigorous material, and for its propagation and maintenance. Extension agents and farmers need a sustainable strategy for sanitizing cuttings. Such a strategy would (1) develop protocols for identifying, selecting, and propagating clean and vigorous planting material; (2) introduce sanitation procedures into existing national structures for the production of cuttings through training and on-farm trials; (3) develop methods of diminishing the spread of cuttings infected by African cassava mosaic virus in different ecological environments; (4) increase cassava yields, especially those of local cultivars, to prevent their disappearance and to ensure genetic diversity; (5) develop cultural practices that will maintain and produce vigorous planting material and limit the degradation of the genetic yield potential; (6) reduce the spread of common cassava pests and diseases; and (7) enhance national plant quarantine capacities. This strategy synergistically complements the philosophy of the Ecologically Sustainable Cassava Plant Protection (ESCaPP) project, which operates on a multidisciplinary, multi-institutional framework for developing and implementing sustainable cassava plant protection in West Africa. Responsibilities will be shared as bilateral activities among the NARS of the participating countries (Benin, Cameroon, Ghana, and Nigeria) to ensure integration of the limited multidisciplinary expertise available in the region.

## Introduction

Cassava is becoming increasingly important as a food source for the rapidly expanding rural and urban populations in Africa, especially in drier areas (El-Sharkawy 1993). Increasing production demands, coupled with limited agricultural resources, threaten the sustainability of cassava agro-ecosystems on the continent.

The Ecologically Sustainable Cassava Plant Protection (ESCaPP) project carried out countrywide, extensive surveys in four West African countries—Benin, Cameroon, Ghana,

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and Nigeria—focusing on plant protection practices. Preliminary results of the dry-season survey revealed that farmers' criteria for cassava planting material selection are limited to number of nodes, and the stem's thickness and age. They are not aware of the possibility of positively influencing these criteria and therefore make no effort to maintain or produce planting material. Because cassava is well known to grow on poor soils (Cock and Howeler 1978), it is often planted in degraded and marginal fields. Farmers frequently cited low soil fertility as a criterion for choosing a field for growing cassava (ESCaPP, 1992, unpublished results). This not only contributes to a generally accepted "fact" that cassava enhances degradation of natural resources, but also to declining vigour in planting material and, thus, most probably to the loss of yield in local germ plasm. Neither do farmers realize that a direct relationship exists between parameters of the physiological vigour of a cassava cutting (e.g., sprouting ability and drought tolerance) and the characteristics of its environment of origin (e.g., soil fertility, and harsh climatic conditions in hot and dry areas).

Cassava cuttings of poor vigour and infested with pests and diseases suppress the crop's potential from the beginning. Plant protection must begin with identifying, supplying, and maintaining clean planting material. Because cuttings are sold without leaves, farmers cannot control pest and disease infestations and do not realize that they can be transmitted through the stems themselves. Neither is any comprehensive protocol available to support and advise on sanitizing infected planting material.

This paper describes the development of a strategy to promote sanitation of cuttings through extensive research, implementation, and training activities within the existing ESCaPP project. Tools are assembled, tested, and developed for reducing the spread of plant pests and diseases, and for managing germ plasm to improve the quality and vigour of cuttings in targeted cassava-growing ecologies. This study aimed to provide a model that can be used in various parts of the continent to sanitize and maintain cassava cuttings.

#### Review

Cassava's ability to grow well on degraded and marginal fields (Cock and Howeler 1978), together with intensified production, often enhances the degradation of soils, which, in turn, leads to a gradual decline in cutting vigour. Planting material originating from fertile soils is not only more vigorous at plant establishment, but also yields significantly more than cuttings from poor soils (Lozano et al. 1977). Lozano et al. (1977) also suggested using 'strong' normal cuttings as planting material, which implies an origin in a favourable environment. High fertility can positively affect the control of pests and diseases, for example, by reducing the severity of attacks from the African cassava mosaic virus (ACMV) (Ogbe et al. 1993) or the cassava mealy bug (Neuenschwander et al. 1990).

Cassava is increasingly cultivated in the drier areas of Africa (El-Sharkawy 1993), mostly as a food security crop (ESCaPP, 1992, unpublished results). The main production constraints (i.e., grazing cattle, high temperatures, and drought) reduce its spread and the opportunity to exploit its potential in these areas. In the dry savannas, higher temperatures and erratic rainfall demand considerable vigour from planting material (El-Sharkawy and Cock 1987) to ensure survival during the crucial establishment phase.

Poor establishment of plantlets leads to repeated planting, which means reduced planting intervals for the farmer and an unnecessarily high demand for already scarce planting material. Planting time also significantly influences the incidence of ACMV, cassava bacterial blight (CBB), and anthracnose (Pacumbaba 1988), and the ability to exploit potential yield (Nembozanga Sauti 1984). The crop cycle in the savannah averages 18-24 months, unless planted in wetter depressions. This makes planting material production and use difficult because harvest does not coincide with planting times, when planting material is needed, thus resulting in long storage, which reduces the quality, or even loss, of planting material. Stored planting material loses its physiological vigour as it loses moisture and carbohydrate reserves (Lozano et al. 1977). To optimize and promote sustainable cassava production in this harsh environment, researchers need to understand the physiology of cutting vigour.

As a vegetatively propagated crop, cassava is highly suitable for carrying pests, diseases, and even weeds from one field to the next. The pest, disease, or weed in question thus establishes early and so causes high yield losses. A combination of pests, diseases, and weeds can reduce cassava yield by as much as 50% (Herren and Bennett 1984). The impact of most biotic constraints can be controlled through chemical or biological intervention. The most efficient way, however, is to prevent their spread and exclude early infestations.

The visual selection of mother plants and effective sanitation of cuttings can efficiently reduce infection and spread through cuttings. Indeed, visual selection is the only known method for controlling some diseases, such as ACMD, but it can be combined with other methods, such as treatment with hot water to counteract mites (Lozano et al. 1984; Yaninek 1988). Clean planting material directly influences a crop's vigour and contributes to maintaining a broader genetic base by providing farmers more choice of cassava cuttings.

Pests and diseases also affect plant growth by reducing the photosynthetically active leaf surface, interrupting sap flow, and damaging stems and roots. The effect on final root yield (that is to say, yield loss) depends not only on the severity of the attack or infection, but also on the age of the crop (Cock 1978). As cassava has no crucial period of yield formation, the crop is said to be relatively tolerant of pests and diseases. An early infection during plant

establishment, however, can crucially affect the crop's development. Current recommendations for handling planting material therefore suggest reducing the spread of pests and diseases by visually selecting clean planting material (Lozano et al. 1977, 1984). Although various technologies and interventions clean infested cuttings (e.g., various pests can be treated chemically), not much is known about the vigour of a cleaned cutting originating from an infested mother plant.

The spread of ACMV in healthy cassava fields is rapid in Côte d'Ivoire. In contrast, in Kenya, it is easily controlled by planting disease-free cuttings, given the fact that, in this country, where wind reduces its dissemination (Fargette et al. 1985), *Bemisia tabaci* is a relatively inefficient vector, unlike in West Africa (Terry and Hahn 1982). In Côte d'Ivoire, using healthy cuttings is advantageous when:

- (1) They are planted in areas where cassava is not widely grown and where little vector infection occurs;
- (2) Adequate cultural practices are used to maintain healthy stocks (e.g., careful choice of planting date would significantly reduce disease severity and minimize disease escape); or
- (3) Accompanied by control of the whitefly itself (Fargette et al. 1990; Pacumbaba 1988).

The use of virus-free planting material as a plant protection measure to reduce ACMV spread was successful in Côte d'Ivoire (Fargette et al. 1990) and Uganda (Bock 1994).

Virus-free planting material can be produced under well-managed conditions in lowinoculum pressure areas. The nursery must be maintained virus free by roguing. However, plant protection of the cassava crop cannot be implemented as a single package, because different approaches are needed, depending on the agro-ecology, spread of the disease, and level of inoculum pressure (as in the case of ACMV).

Meristem-tip culture for cassava is an established technique among international centres and some national agricultural research systems (NARS). It is used mainly for research purposes, and, as this technique is accepted by quarantine services, for disseminating clean clones across national borders. The technique is sophisticated in terms of equipment needed but slow in terms of the amount of material being produced, hardened, and disseminated (mainly because of equipment constraints). The use of this technique on a larger scale, however, is too costly, although studies combining meristem-tip culture and heat treatment to eradicate ACMV have been successful (initials? Boher, 199?, personal communication; Frison 1994; Kaiser and Teemba 1979).

Because of repeated vegetative propagation over many years, the abiotic and biotic

stresses have reduced the quality of cuttings from some local cultivars. To keep a basic clean stock of local cultivars for germ plasm conservation, JC Lozano recommends (1990, personal communication) cleaning cuttings of local clones with meristem-tip culture. The resulting reestablishment of genetic expression thus helps conserve the materials under natural field conditions. However, yield improvement of cuttings from meristem-tip culture is considerable only in the first cycle, declining rapidly in the second and third cycles because the 'clinically' clean material is more susceptible to re-infestation (JC Lozano, 1990, personal communication). Treating plantlets additionally with beneficial bacteria ensures yield stability, initiates naturally acquired resistance, and improves the hardening of the fragile plantlets.

### Hypothesis and Objectives

Yield stability and environmental development of cassava are highly dependent on the quality of the vegetatively propagated planting material. Planting material (i.e., cuttings) with insufficient vigour and infested with pests and diseases limits production. The widespread use of such material reflects the lack of knowledge, and implementation, of appropriate criteria for selecting, propagating, and maintaining vigorous and clean cuttings. Protocols for identifying and eliminating pests and diseases and for promoting plant vigour in cassava cuttings are needed by NARS involved in plant quarantine and plant protection activities, as well as by extension agents and farmers who need to consistently select, propagate, and handle clean cuttings.

Such protocols must be part of a strategy to produce and maintain clean, vigorous cassava planting material for the specific requirements of the major cassava-growing ecologies in West Africa. The specific objectives of such a strategy would be to:

- (1) Develop a decision matrix for maintaining and sanitizing planting material according to the needs of specific ecologies
- (2) Disseminate the know-how of producing and maintaining vigorous planting material.
- (3) Develop protocols for identifying pests and diseases, as well as for selecting and propagating clean planting material.
- (4) Introduce sanitation procedures into existing structures (e.g., quarantine, research, extension services, and production systems) for the production of cuttings.

- (5) Preserve and increase cassava yield, especially of local cultivars.
- (6) Reduce the spread of common cassava pests and diseases.
- (7) Enhance national plant quarantine capacities.

## Implementation

## Diagnosis

The information presented here was taken from surveys at both village and farmer levels (260 questionnaires) (ESCaPP, 1992, unpublished results). Preliminary results from Benin, Ghana, and eastern Nigeria—which results have not yet been classified according to agro-ecologies or to individual countries—indicate that, when asked, farmers say that they select according to 'vigour' and tolerance of pests and diseases. Practice in the field itself, however, proved to be the contrary. This divergence may have resulted from a misunderstanding of the issue, because it was not confined to a specific variety. Of 112 villages analysed so far, no farmer pre-treated his planting material in any way.

Fields planted with cassava were selected for their high fertility levels in 69 out of 112 farms. Soil samples were taken from these fields to cross-check this subjective answer and to correlate planting practices and phytosanitary situations. Although farmers recognize that fertility levels can influence their root yield, none used fertilizer.

More than 90% of the farmers interviewed used their own planting material or stems obtained from a nearby neighbour or friend. Markets formed the source of planting material in only 5% of cases. Cassava stems were stored under shade in 40% of villages for 1-3 months, although 80% of farmers kept their planting material in the field for very short periods. This obviously relates strongly to requirements of the agro-ecological environment, as well as to growing period and planting time. Data are being analysed in this respect to set priorities.

Farmers' fields were also scored for pest and disease incidence and severity during both a dry and rainy season. The data, yet to be analysed, should reveal the importance of individual biotic production constraints according to agro-ecology. The farmers' perceptions of knowing about, recognizing, and appreciating the importance of biotic constraints are balanced with the inventory scored in the field to assess training needs for eventual intervention or technology transfer.

# Planning phase

In relation to agro-ecological differences, intervention strategies are prioritized into cultural management (i.e., vigour maintenance) and health of cuttings (i.e., visual selection or sanitation interventions). In all agro-ecologies, pest and disease prevention has high impact potential, even when using techniques as simple as visual selection of planting material. For ACMD, this seems to be the only approach possible for a farmer to keep the disease under control, unless fields are located in areas with low inoculum pressure.

While visual selection of healthy plants does not require an understanding of the basis of selection, sanitation procedures must be applied according to specific situations (e.g., CBB versus anthracnose). As this can be difficult even for the scientist, then farmer adoption of even simple technologies will be low. Recommendations should therefore address higher level functionaries such as extension agents and cooperatives.

Recommendations for intervention concerning cultural management basically consist of demonstrating the positive response of cassava to fertilizers of any kind, in terms of both root yield and "vigour" as defined by farmers' selection criteria. Depending on the agroecology, recommendations should include the wider component of environmental protection (e.g., sustainable shifting cultivation in rain forests or prevention of soil erosion in dry savannas).

### **Experimentation**

The above procedure of setting priorities led to an assessment of needs for research, adaptation of technologies, and their dissemination for implementation. For cassava pests and diseases, possible sanitation methodologies have to be compiled. This involves an extensive literature review by a wide range of experts.

To produce and maintain planting material, the identified priorities are transformed into strategic and on-farm research (OFR), following Tripp (1991). OFR is implemented for individual intervention methods in certain ecologies and/or against certain biotic constraints. They include all degrees of farmer involvement: researcher managed and researcher executed; researcher managed and farmer executed; and farmer managed and farmer executed. Farmers use their customary planting practices and traditional intercropping systems, adding only the new intervention.

Experiments include demonstrating, in the high-fertility plots within the fields of 30 farmers, the crop's response to fertilizer, in terms of root yield and, especially, physiological quality of stems produced. The fertilizer is expected to be replaced with organic manure at a later stage.

The objective is not to introduce high-input systems, but to demonstrate the effect of input, even though small, on the production of planting material. Other experiments include (1) the comparison of origins of planting material; (2) cultural control of ACMD; (3) definition of quality planting material for dry savannas; and (4) influence of pest- and disease-infested mother plants on the quality of cuttings.

For major pests and diseases in areas where plant protection procedures are unknown, strategic and adaptive research are implemented to produce planting material free of intrinsic or extrinsic physiological constraints.

Cuttings cleaned of pathogens and pests are tested in comparative yield trials in targeted ecologies. Plant vigour is defined as a selection criterion; the potential damage saved by using clean cuttings is estimated; and the benefit of the introduced criteria for selecting farmers' planting materials to the area's level of phytosanitation is assessed.

Clean planting material is tested in specific ecologies to investigate its resistance against early invasions by pathogens and pests of which it had been cleaned. On-farm demonstrations of clean materials, together with their associated plant protection measures, are then established in those selected ecologies. Socio-economic assessment of the need and/or demand for clean cuttings will be conducted. Proven packages and tools will be made available for incorporation into rapid multiplication and distribution networks with which the project will collaborate to bulk and distribute the clean materials.

Local cassava planting material must be kept clean and vigorous to maintain and ensure genetic diversity. Meristem-tip culture will be used to clean and evaluate reestablishment of the quality of the planting material.

# Assessment of individual technology adoption

Sanitation and maintenance interventions are tested for technical and socio-economic feasibility in the farmers' environments and adapted according to the resources needed in different ecologies. The various steps of these interventions are monitored for their sequence of adoption by farmers. Farmers' modifications to the technology are evaluated for further improvement.

# Strategy development

The final compilation of experiences in strategic and on-farm research will result in extensive recommendations. A unique feature will be their set-up as a decision matrix, including a priority setting for interventions according to the agro-ecology, the individual field diagnosis, and, eventually, the planting date. The output will be in a comprehensive form for extension agents and eventually farmers.

In-service training will be provided to village extension agents and participating farmers in all intervention techniques and in the implementation of the strategy. The basis for subsequent training of extension agents and farmers will develop from their knowledge and skills in diagnosing needs and identifying selection criteria for planting materials, the diagnosis of damaging pathogens and arthropods likely to be transferred through cuttings, and experiences in the handling and management of clean materials.

### Conclusions

The successful implementation of an appropriate, environmentally friendly, strategy for sanitizing and maintaining clean cuttings through trained national staff and progressive farmers should increase cassava yields by enhancing plant vigour and reducing undesirable pests and diseases, while protecting natural resources.

Production constraints, both biotic and abiotic, that influence the quality of a cassava mother plant and contribute to a reduced yield potential must be prioritized for different agroecologies and individual farmers. A decision matrix will support the intervention techniques to be applied. The intervention technologies will be compiled into comprehensive recommendations that meet ecological requirements. Extensive training on all levels is an essential part of the strategy, especially for farmers.

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