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The International Exchange and Testing of CASSAVA GERM PLASM in AFRICA

Proceedings of an interdisciplinary workshop
held at IITA, Ibadan, Nigeria
17-21 November 1975

Editors: Eugene Terry and Reginald MacIntyre

Cosponsored by the
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Contents

There is a wide range of variation in the characteristics encountered with the major cassava germ plasm collections. The suggested ideal plant type in Africa is one that carries its branches on about two metres of stem.

Foreword

This is the ninth IDRC report on cassava and the seventh recording the proceedings of a multidisciplinary workshop. Previous reports are listed at the end of this Foreword.

A similar workshop held at CIAT in Palmira, Colombia, in February 1975, was designed to establish guidelines for the international exchange and testing of cassava germ plasm with particular reference to Latin America and Asia. Because of the severe phytosanitary constraints posed by the presence of African cassava mosaic disease in Africa the only representation from that continent at the CIAT meeting was from IITA. This participation was planned with the idea of structuring a similar workshop for African cassava-producing countries and this report describes the proceedings of that workshop.

The meeting opened with a presentation from *Hahn*, the IITA Root Crop Program leader, who set the framework for the subsequent discussions and described how IITA perceived its role in the development of an international exchange and testing program for cassava germ plasm in Africa. During the next two days representatives from Sri Lanka (*Rajaguru*), the Camerouns (*Eckbeil and Lyonga*), Ghana (*Doku*), Liberia (*Henries*), the Malagasy Republic (*Rafiringa*), Malawi (*Edje and Chapola*), Sierra Leone (*Dahniya*), Tanzania (*Msabaha*), Togo (*Adam*), Uganda (*Nyiira*), and Zaïre (*Kabeya*) presented situation papers relating to cassava production in their countries.

The author of each presentation was requested to cover the following points: 1) cassava germ plasm available in his country; 2) state of the evaluation of this germ plasm, including the characteristics being noted; 3) the area devoted to cassava and whether this was principally single- or multiple-cropped and an estimate of whether this area was likely to increase in the future; 4) the status of research on the crop with a brief summary on the work in progress and plans for the future; 5) the human and financial resources devoted to research and extension on cassava; 6) the names and instances of the most important diseases and pests of the crop; and 7) the quarantine requirements for importing cassava germ plasm.

The information provided by the participants is presented in tabular form in this report. Following each presentation there was ample time for questions and comments. These discussion sessions brought out many useful points which are outlined in the Summary of General Discussions.

The participants made a tour of the IITA cassava fields and laboratories and spent one day visiting a major cassava-growing area near Warri, more than 200 miles from Ibadan. At this location IITA has a large-scale cooperative program with both the State Government and a Shell/BP community development program.

Country presentations were summarized by *Terry* after which four IITA staff members presented guideline documents relating to the testing and selection of cassava varieties. The initial paper by *Hahn* discussed the breeding aspects, followed by *Terry* who covered pathology, *Leuschner* entomology, and *Ezumah* agronomy.

The next item on the agenda was a panel discussion relating to quarantine regulations for cassava. The panel of *Addoh*, *Aluko*, *Lozano*, and *Terry* discussed this subject within the context of the suggested guidelines that had been drawn up at the earlier CIAT workshop. Following the panel discussions, a subcommittee was appointed to draw up reports on the agronomic and phytosanitary aspects of the international exchange and testing of cassava germ plasm. The subcommittee's report was presented to the full workshop for review and adoption and is presented in this report as Appendices 1-A and 2-A.

The final day of the workshop was given over to a panel discussion followed by a series of special papers. The panel discussion covered IITA's Training Program and was moderated by *Reeves* with *Arinzé*, *Adam*, *Ezeilo*, *Persley* and *Henries* participating. Particular stress was placed in the discussion on the role that IITA might play in training scientists in root crop research. *Flinn* then presented a paper on the possibilities for economic research into cassava production systems in Africa in which he stressed the need for greater agroeconomic knowledge of the crop in order to formulate sound research programs. He was followed by *Hahn* who provided a description of the breeding program being used for cassava at IITA. *Terry* then described cassava bacterial blight, a disease which was previously considered unimportant, but in the last few years has become a major source of losses to cassava producers in Africa. The final paper by *Nyiira* also dealt with a recent introduction, cassava green mite, from the neo-tropics to Uganda less than five years ago and which has already caused serious losses in both Uganda and neighbouring countries. The final item of the program was a demonstration of the rapid multiplication technique being used for cassava at IITA by *Howland*.

This report presents first the special papers followed by a table summarizing the country presentations and the "Summary of the General Discussion" on them. The latter part of the report comprises three appendices: Appendix 1 deals with agronomic aspects of the international exchange and testing of cassava germ plasm. This includes not only the report of the subcommittee on cooperative testing and selection but also provides notes on germination and pollination and a description of the rapid multiplication technique used at IITA. The fourth part of Appendix 1 presents guidelines for the establishment of a national cassava improvement program using a model from Zaïre. Appendix 2 deals with the phytosanitary aspects of the theme subject and presents the suggested guidelines as drawn up originally at CIAT and approved at this meeting plus a description and evaluation of certain major diseases and pests of cassava. The third Appendix is a short note on the Training Program at IITA.

This is the second workshop in this series that has been held at IITA. Throughout the meeting there was an excellent level of discussion and IDRC is indebted to the participants for the time, effort, and expertise that they contributed to making this meeting successful. Particular thanks are due to Drs S. K. Hahn and E. R. Terry who were responsible for most of the preparatory work associated with this meeting.

IDRC is also grateful to Dr W. K. Gamble, the Director-General of IITA, for making the Institute's facilities available for this workshop, and to Dr D. J. Greenland for his remarks of welcome at the start of the workshop. Particular thanks are due to Dr W. H. Reeves, head of IITA's Training Program, who was responsible for many of the meeting logistics and for looking after the participants.

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Other Cassava Publications

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Welcoming Address

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Since cassava was first introduced into the African continent at the end of the 16th century, it has been widely accepted, grown, and used as one of the most preferred staple foods in many parts of the continent. World production now amounts to about 100 million tons annually from about 11 million hectares, of which Africa produces 42 million tons from about 6 million hectares. This comprises about 40 percent of the production and more than 50 percent of the area devoted to this crop throughout the world. In Africa the trend in production shows a steady increase.

Cassava is potentially able to produce more food calories per unit area than any other food crop, owing to its high yielding ability, adaptation to diverse climatic and cultural conditions, and ability to survive long (4–6 months) dry seasons. It generally requires less labour, less cost of production, and less care in management than cereal crops. Both root and leaf are valuable as human food and livestock feed and the root is widely used for industrial production of starch and alcohol.

Some external factors could have significant influences on the role of cassava in tropical Africa. First of all, recent high price of cereals in the international markets has encouraged farmers to grow more cassava. As an example, both Sierra Leone and Liberia, which have produced and depended mostly on rice, are changing from major rice production to general food production with considerable emphasis on cassava. The acreage of cassava in both countries has been noticeably increasing in the last few years. Secondly, dried cassava is becoming an important source of carbohydrates in livestock feeds and feed industries, particularly in Northern Europe and Japan. Thailand, and to a lesser extent Indonesia and the South American countries, are exporting cassava for this purpose. Some African countries are attempting to start an export program of dried cassava. Lower prices of cassava relative to feed grains in the international market could lead to significant increase in demand for the cassava as livestock feed.

Since cassava is very tolerant to drought, its acreage in the drought-affected areas in Northern Africa has also been increasing remarkably. Many African countries which suffered from drought in the past are now emphasizing cassava cultivation. It should be pointed out that the cassava-growing area in India has had no famine problem even when it had a severe drought.

Though cassava has played an important role in Africa, and it has such desirable features, improvement in this crop has been given very little attention compared with other crops. The average yield of cassava in Africa is about 7 tons per hectare which is about half of that in South America. Cassava mosaic disease is present and serious only in Africa and India. Cassava bacterial blight disease has recently been identified as very serious in several African countries. It must be emphasized that the future development of the crop in Africa can make a useful contribution to the economy and to the quality of life on the continent.

This meeting on cassava is the first of its kind in the history of cassava production in Africa. It therefore affords a unique opportunity to discuss the current problems of cassava production in Africa and India and to lay down the future strategies to solve the problems.

The objectives of the workshop are: 1) to identify the constraints in production, research and development of cassava in Africa and India; 2) to explore ways and means of solving the constraints; 3) to improve ways of mutual collaboration among cassava workers and institutions; and 4) to establish a network for cassava improvement in Africa and India.

Promising new cultivars of cassava need to be tested under a wide range of ecological conditions. Here we see clean and healthy leaves which suggest a good yield in cassava roots.

Possibilities for Economic Research into Cassava Production Systems in Africa

J. C. Flinn

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Cassava is of as much interest to the economist as it is to the cassava breeder, physiologist, pathologist, entomologist, agronomist or food scientist working in the tropics. The economic importance and uses of the crop, the farming systems or regions in which it is grown, and its role in national markets or in international trade are discussed in April et al. (1974), Butler et al. (1971), Johnson (1963), Jones (1969, 1972), Nestel and MacIntyre (1973), and Phillips (1973). The objective here is to suggest some areas of economic research in cassava production which are complementary to that of the biologist, or which are useful to policymakers and planners to assess the impacts and trade-offs of alternative strategies for increasing the production of the crop.

Some features of cassava of particular interest to the economist include: (a) it is grown in farming systems ranging from subsistence agriculture to highly commercialized systems; (b) it is produced using hand labour alone or with some aspects of production being mechanized; (c) it can be stored in the ground for long periods of time, but when harvested deteriorates rapidly unless processed; (d) depending on type, it may be consumed with very little or very extensive processing; (e) processing may be labour-intensive or capital-intensive; (f) marketing channels may be traditional, or may be highly integrated, large-scale operations; (g) the potential markets for cassava products are very broad, and include human consumption, animal consumption, medicinal purposes, and industrial uses.

Thus there are choices available related to systems of production, processing, and marketing of cassava. These choices involve technical, economic, and social decisions. When evolving improved cassava production systems, one must be concerned not only with the economic gains from the technology but with the distribution of these gains as well. Thus social goals, politics, and government policies cannot be divorced from the technical and economic criteria used, in part, to evaluate "relevant" systems of cassava production. Indeed, government policies and infrastructural arrangements are just as vital as the technology itself when the objective is to increase the marketed surplus of a commodity.

A simplified production system

To help focus the following discussion, a highly simplified cassava production system is presented in Fig. 1 together with a number of the more important factors (and their principal linkages) which will influence the structure, conduct, and performance of the system in reality. Each of these decision or intervention points provide foci for collaborative research between the economist and other workers. There is no suggestion that the economist would be the principal researcher in each of these groups; obviously in some cases, he would be supportive of the biologist (e.g. on the impact of environmental factors on cassava production), the political scientist (policies and institutions), or the sociologist (human factors), depending on the nature of the study. The important point is that there is a need for cooperative, integrated research between scientists of various disciplines if cassava systems, in their broader sense, are to be quantitatively understood.

Agroeconomic research

To a certain extent, the research undertaken at one point in time becomes the technology of the future which, by implication, will influence the future

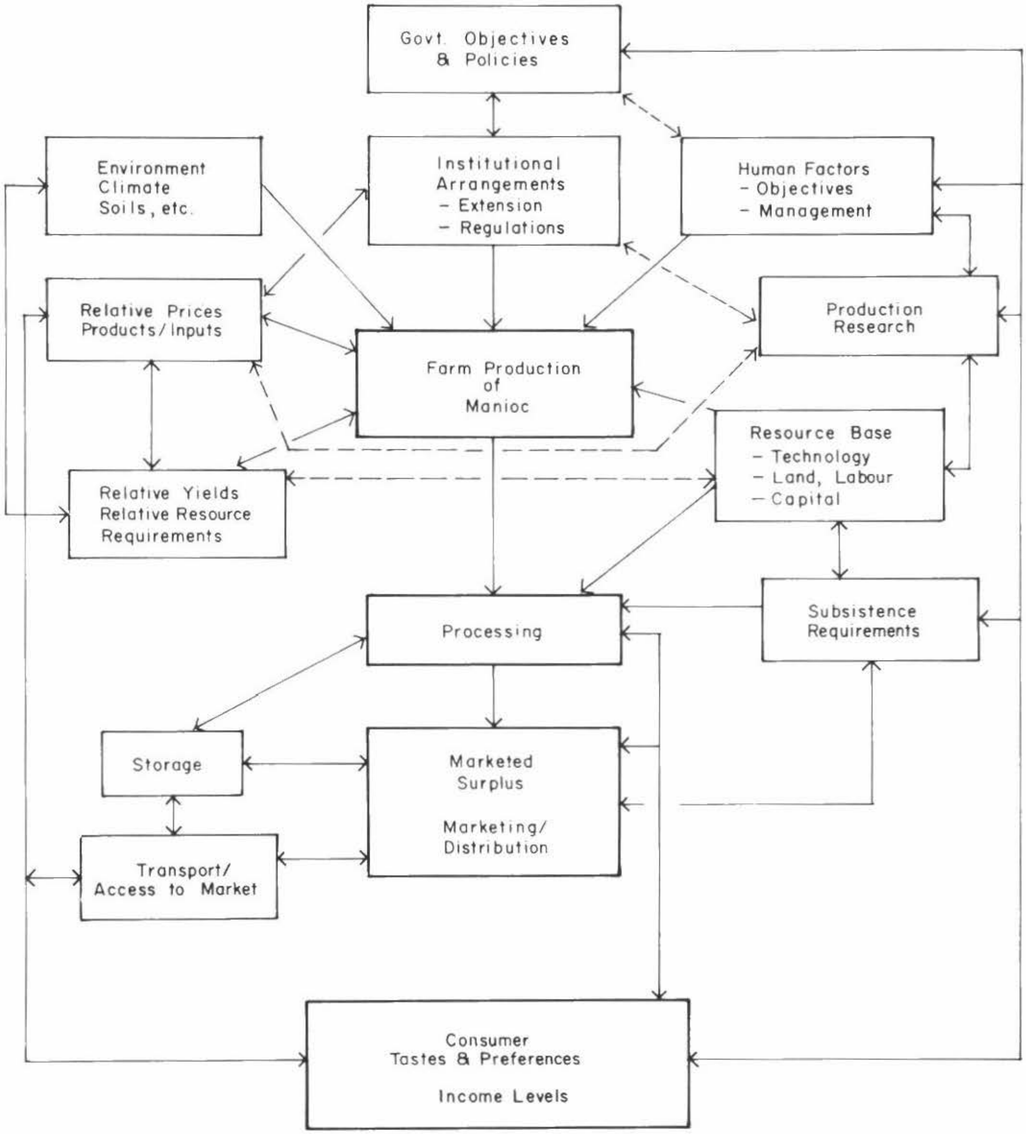

Fig. 1. A simplified cassava production system.

viability and social structure of the agricultural sector. Thus, a case exists for cooperation between the agronomist and the economist in the continuum from identifying research priorities through to the eventual on-farm testing of the subsequent agricultural technology. OECD (1964), Fishel (1971), and Andersen (1972) discuss and provide extensive references related to the identification, execution, and interpretation of cooperative agricultural research programs. There are, of course, obvious areas where the payoff from biological research is apparent and does not call for the input of an economist (e.g. breeding for resistance to CBB, CMD). However, when considering other breeding objectives (e.g. time to maturity of the crop, quality and storage attributes) there are economic trade-offs which will influence the relevance of the breeder's varieties to different target groups of farmers, processors, and consumers.

While the economist may interact with the plant breeder in defining breeding objectives (Ryan et al. 1974), he has a more obvious role when working with the biologist in defining the more economically important management factors that become components of the agricultural technology adopted by the farmer. For example, what are the economic combinations of inputs to use under various situations for "improved" cassava production? What are the appropriate methods of cultivation and land management? Which cropping systems are relevant to cassava production (e.g. sole versus intercropping, rotation sequences)? How often should the crop be weeded (hand weeding or chemical weeding)? How and when should the crop be harvested (hand or mechanically)? Valid solutions to these questions involve economic as well as technical and biological considerations, in addition to an appreciation by the researchers of the resource base of the farmer, his objectives, and management skills.

Cassava production systems

If researchers are concerned with identifying and solving problems of cassava production, it is necessary that they have a clear understanding of the role of cassava within farming systems. Also required are specifics of cassava production practices and how factors both within and beyond the control of the farmer impinge on his decisions to allocate his resources between cassava, other crops, and competing activities.

The quantity of cassava produced by a farmer, and the amount that he may be induced to produce in the future, will be influenced by a complex of: environmental factors limiting yields (incidence of disease, soil type, drought, etc.); the prices of cassava, other crops, and inputs; the relative yields of cassava and other crops; his resource base, including the level of technology available; his management objectives (profit motives, attitudes to risk, concern for producing a supply of food over time, etc.).

The above class of information is best collected through empirical studies of farming systems—facts, not impressions, must be assembled. These farm-level studies of cassava production systems should be undertaken with a view to: (a) describing and quantifying present cassava production systems in the more important cassava-producing regions of Africa; (b) determining the technical, biological, economic, and management relationships which exist between cassava and other crops grown by the farmers; and (c) determining the effects of environment (disease, soils, etc.) on the output of cassava production systems. Such studies are multidisciplinary in nature and, for maximum effectiveness, require the cooperation of the economist, biologist, and soil scientist.

The major payoffs from such studies, in addition to helping the researcher understand the system in which changes will take place, include: (a) specification of the problem areas in cassava production which should have priority in biological research; (b) specification of the problem areas which need to be tackled through changes in institutional and marketing systems; (c) identification of constraints by priority which, unless removed, will impede the adoption of improved cassava technology; (d) identification of technology with a high expected rate of adoption; (e) estimation of the impact of new technology in terms of both economic gains and their distribution between farmers; (f) helping to identify the target group for the extension effort in cassava production; (g) enabling planners to predict resources and prices (credit, fertilizer, planting material) required for new technology to be adopted by farmers; (h) estimation of future demands for cassava products.

Examples of farm-level studies of cassava production systems are: Diaz (1973), Ezeilo et al. (1975), Pinstrup-Andersen and Diaz (1975), and Rankine (1972). Procedures and methodological issues involved in conducting farm-level production studies are found, for example, in Collinson (1972), Norman (1973), and Spencer (1972).

The present large discrepancy between biological or potential yield and economic yield (i.e. that portion of the cassava crop harvested by the farmer) suggests that if the price of cassava were more attractive, rapid increases in supply could be forthcoming. This, coupled with the advances being made by cassava breeders in identifying resistance or tolerance to a number of the more important cassava diseases, suggests that future yields may not be the most important limiting factor to increased cassava production. Problems are likely to occur in the areas of processing, storage, and marketing.

Cassava processing systems

Studies have shown that, within traditional farming systems, labour requirements for processing cassava (often the woman's job) may account for a third or more of the total energy required to produce a consumable or saleable item (Cleave 1974). In consequence, if it were technically possible to increase cassava production at the farm level due to the research endeavours of biologists, would the traditional processing system (both on- or off-farm) have the capacity to process the increased output? Where would the bottleneck lie? Would it be in (a) transporting the roots to the processing site? (b) washing/peeling the roots? (c) grating or other handling of the roots? (d) fermenting or retting the roots? (e) drying the product (energy supply?)? (f) storing the processed cassava?

If the processing subsector of the cassava system is likely to represent the effective constraint on an increased supply of cassava products reaching the market, it must be quantitatively understood before a solution is sought through research. Here the economist should cooperate with the engineer and food technologist in specifying the capacity, capital, and operating costs of cassava processing equipment that is more attractive to the processor than that presently available.

The distribution effects of proposed technology for cassava processing require equally careful consideration (e.g. "mechanized" gari production). Industrial plants capable of processing over 40 tons of roots a day are on the market (e.g. the Newell Dunford plant; Anon. 1974). Others of an "intermediate level" of technology are available which process up to 4 tons of roots per day (e.g. the "FABRICO" and "PRODA" plants in Nigeria; Ngoddy 1974). It is likely that while the large, capital-intensive plants are extremely efficient from an economic viewpoint, they could also create mass unemployment in the traditional, labour-intensive production sectors. From both economic and social viewpoints, design criteria for cassava processing plants should permit more efficient labour productivity than traditional systems without creating unemployment. This represents a challenge for the food technologist and engineer.

Cassava marketing systems

If cassava production increases beyond the point required to meet the increasing demands of an expanding population, what may be the consequences from marketing and price viewpoints? Several workers have suggested that the demand for cassava products for human consumption is rather income-inelastic in some countries of Africa, and quite income-elastic in others (e.g. Phillips 1973, p. 17), but that demand for cassava products is not very price-elastic (see Araullo et al. 1974 and Edwards 1974 for a review of industrial processing). Thus, in those countries where the income and price elasticities of demand for cassava are inelastic, if supply increases at a more rapid rate than does population it is possible that cassava prices may fall. The producer is then no better off than he was before he increased his production. Under such circumstances, programs aimed at increasing the national production of cassava above that required to meet the needs of an expanding population would have little chance of success, unless there was price intervention by government or unless alternative markets for cassava products were found. Thus in order for policymakers to assess the price effects of increased cassava production, and to estimate future demand, demand studies for cassava must be undertaken by marketing economists.

Other bottlenecks in the cassava system may be found in transport and marketing. Johnson (1973) and Jones (1969, 1972) described the marketing systems for cassava in Africa in general terms. However, despite the importance of the crop, there is little quantitative information available on cassava marketing in the traditional sector. In many countries in Africa transport is poorly developed and costly. Programs aimed at increasing production of cassava may be to no avail if transportation to markets is not available. We need to assess the capacity of the transport systems to handle increased volumes of cassava and other products, and to determine what modifications are required to enable products to be moved at low cost.*

Marketing margins in developing countries (the difference between the price received by the farmer and the price paid by the consumer) are said to be excessive, and middlemen apparently make large profits at the expense of the producer and the

* It must be pointed out, however, that roads and other improvements of infrastructure do not guarantee greater consumption of cassava. It is possible that improved transportation could subject heretofore isolated producers to competition from imported commodities or commodities from other regions.

consumer. Is this a fact, or is the nature of the cassava marketing system small-scale and high-cost in nature with the individuals providing services within the marketing systems, like the farmer, making modest incomes? Many marketing studies (Thodey 1968) suggest this is the case, but policymakers often argue otherwise. Obviously, work is required to measure the prices of cassava products, the volume of flow at various points in the marketing system, and the cost of providing such services before statements relating to the efficiency of the marketing systems can reasonably be evaluated. Such information will also help to evaluate the distribution consequences of alternative forms of cassava marketing (e.g. government marketing boards, produce marketing cooperatives, etc.).

Policy and planning

While political and social decisions will influence policies related to cassava production and marketing (e.g. objectives of self-sufficiency, the role of the public versus the private sector) it is important that the social costs and the distribution of the benefits (and penalties) from alternative policies are known to the policymaker. The micro- and macroeconomic studies already identified provide part of the information required by government to assess the relative merits of alternative means of achieving their food production objectives.

Once objectives have been defined it then becomes the responsibility of the planner, economist, and technologist to identify the nature of the institutions, policies, and programs which will most efficiently contribute to the attainment of the political objectives. Informed programs, whether they are in agricultural research, extension, input infrastructure, marketing, or pricing, cannot be formulated, or embarrassing consequences avoided, without a quantitative understanding of the various components and links within the cassava-based system.

Summary

When considering cassava improvement in Africa, it is vital that the components of cassava production, processing, marketing, and policy, be studied as an integrated system. The ramifications of a possible change at one point in the system may be magnified, dampened, or wiped out by a reaction or bottleneck in another. To understand the true consequences of an objective to increase cassava production at the farm level requires an understanding of the linkages between the various subsystems, a task which requires the cooperation of the biologist, social scientist, and planner. In general, cassava systems in many parts of Africa are not well understood or documented. Cooperative research projects should be initiated to reduce this gap in knowledge.

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Improvement of Cassava at the International Institute of Tropical Agriculture

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The major biological constraint to cassava production in Africa is disease, especially cassava mosaic disease (CMD) which exists only in Africa and India, cassava bacterial blight disease (CBB), and anthracnose disease. Insects (e.g. green mite recently introduced into East Africa, and mealy bug, recently identified in Zaïre and the Congo) are potentially serious pests in Africa. Most of the local cassava cultivars are susceptible to these diseases and yields are low, being about 5–10 tons of fresh yield per hectare in 12 months compared with potential yields of more than 20 tons.

Although cassava is a very important staple food crop in tropical Africa, and has very serious problems, improvement of the crop had been given very little attention. Realizing this, the International Institute of Tropical Agriculture (IITA) established the Root and Tuber Improvement Program in 1971. This program covers cassava, yams, sweet potato, and cocoyams, with cassava receiving the highest priority. The broad objectives are to develop improved cultural practices and varieties with high stable yields, high quality, and plant characteristics suitable for efficient cropping systems. The ultimate goals and interactions among the disciplines are presented in Fig. 1.

Program objectives

The specific objectives for cassava improvement at IITA are: 1) high yield in terms of dry matter production per unit of land and time in both monoculture and mixed cropping systems; 2) resistance to, and cultural control of, economically important diseases and insects; 3) improved quality in terms of consumer acceptance, nutritional value, and processing characteristics; 4) improved plant type: canopy and root characteristics; and 5) adaptation to a wide range of environments.

At IITA a large germ plasm has been assembled in seed form from Africa, Latin America (especially from Brazil and CIAT), and Asia. This has been evaluated for resistance to the major economic diseases and for agronomic traits. Sources of resistance to the diseases including CMD, CBB, and anthracnose disease have been identified. Resistance to both CMD and CBB showed a positive genetic relationship.

Extensive hybridizations among selected parents are made and about 100,000 seedlings are raised and screened for disease resistance and root characteristics every year. About 2000–4000 seedlings are selected annually in five different locations in Nigeria and 19 different locations in Zaïre for cloning, and for further evaluation for resistance to diseases and lodging, for root and plant characteristics and for high yield potential. Promising clones have been put forward for advanced yield trials and the most elite clones from these trials have been tested in three different ecological areas. A few clones which have shown consistently superior performance over the years in terms of disease reasistance, yield, resistance to lodging, and plant characteristics have been multiplied and planted in farmers' fields in Nigeria. We can then observe performance under local conditions and farm practices, and test farmers' reactions to improved materials thereby making the best clones available to farmers. Some selected seedlings have also been evaluated on farms in Zaïre.

Significant progress has been made in producing improved cassava clones with resistance to diseases (especially CMD and CBB), higher yield, improved root characteristics, and resistance to lodging. Their gari quality has been tested and is acceptable.

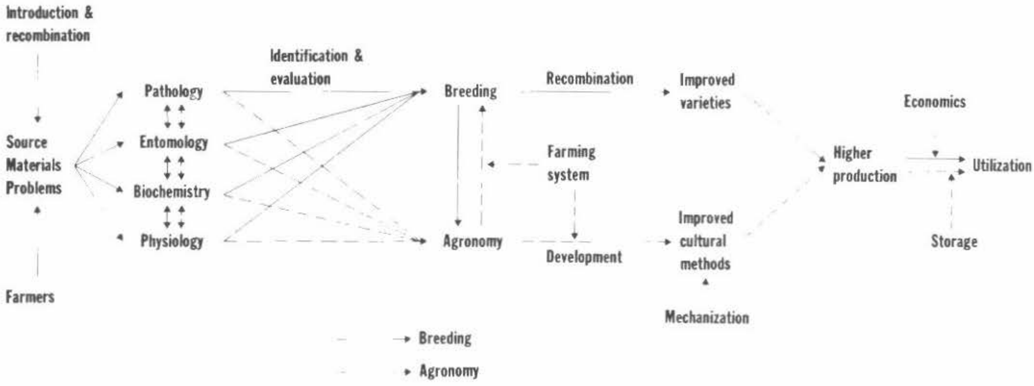

Fig. 1. A flow diagram showing the interactions between disciplines and the goals of the program.

Our disease-resistant (CMD, CBB) cassava in Nigeria maintains its resistance when planted in Zaïre. Resistance of our material to CMD was also confirmed in Sierra Leone, Liberia, and Togo. Our material showed a high level of resistance to anthracnose disease in Zaïre where the disease is a serious problem.

Cassava from exotic sources has been successfully improved for resistance to CMD, CBB, and lodging without sacrificing desirable agronomic traits.

By continuous selection for three generations, cassava has been improved for low HCN and many low HCN clones have been selected.

Many seeds containing sources of resistance to CMD, CBB, and anthracnose and possessing desirable agronomic characters have been supplied to countries in Africa and Asia.

IITA's headquarters site in Ibadan is an excellent place to evaluate breeding material for resistance to CMD, because of a large population of the white fly which is a vector of the disease. Also, because the area has a relatively high rainfall, resistance of cassava to CBB can be readily evaluated. Environmental conditions at IITA are fairly representative of the major cassava-growing areas in Africa.

A large number of cassava seeds can be successfully germinated without scarification by sowing them directly in the field during the dry season, when soil temperature is very high, followed by daily irrigation. The key factors for good seed germination are high soil moisture and a soil temperature of between 30 and 35°C. This germination method has enabled the program to deal with large plant populations. The breeding method which we have successfully used is a half-sib family selection method in combination with a polycross method. It has been possible to incorporate genes associated with resistance to diseases and lodging and good root characteristics. This method also makes possible the introgression of exotic sources into our breeding populations. Methods of selection have been developed based on some genetic information.

The key factors which have made cassava improvement work successful are favourable environmental conditions for evaluation, large population sizes, appropriate breeding methods, and good teamwork among the relevant disciplines.

A number of national cassava workers from many countries in Africa and Asia have spent time at IITA to become better acquainted with our cassava improvement technology. Most have returned home with improved seeds and have established national cassava improvement programs in their own countries.

The Root and Tuber Improvement Program now consists of a core program at IITA and two cooperative cassava programs in Nigeria and Zaïre. There are 13 professional staff and several postdoctoral fellows within the program. Through staff visits and the exchange of information and material, the program has established cooperative links with many national programs and institutions in Africa, Asia, and Latin America (particularly CIAT).

Cassava Bacterial Blight in Africa

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Cassava is grown throughout the lowland tropics of the world, producing an estimated 100 million tons of roots annually, some 42 million of which are produced in Africa. The largest cassava-producing countries in Africa are Zaïre (10 million tons/year) and Nigeria (7.3 million tons/year; FAO Production Yearbook 1971), where approximately 100 million people depend on the crop for a major portion of their caloric intake. In addition, 38 other African countries also utilize cassava as a primary, secondary, or supplementary staple food. Cassava is a particularly valued crop because of its drought tolerance, its ability to grow on poor unproductive soils, and the high yield potential of some cultivars.

Within the last 5 years, serious outbreaks of cassava bacterial blight caused by the bacterium *Xanthomonas manihotis* have been reported in Zaïre (Hahn and Williams 1973), Nigeria (Williams et al. 1973), and Cameroon (Terry and Ezumah unpublished data). This disease is considered the most devastating of several bacterial diseases of cassava in Africa since it often results in total loss of both yield and planting material under conditions favourable for its development (Lozano and Sequeira 1974b).

The potential for further spread of the disease by movement of infected planting material is high, and the resulting cassava crop losses could affect the nutrition and economy of millions of people in Africa. This review of the disease in Africa highlights some relevant facts that may serve as a basis for checking its spread and eventual control.

Etiology and symptomatology

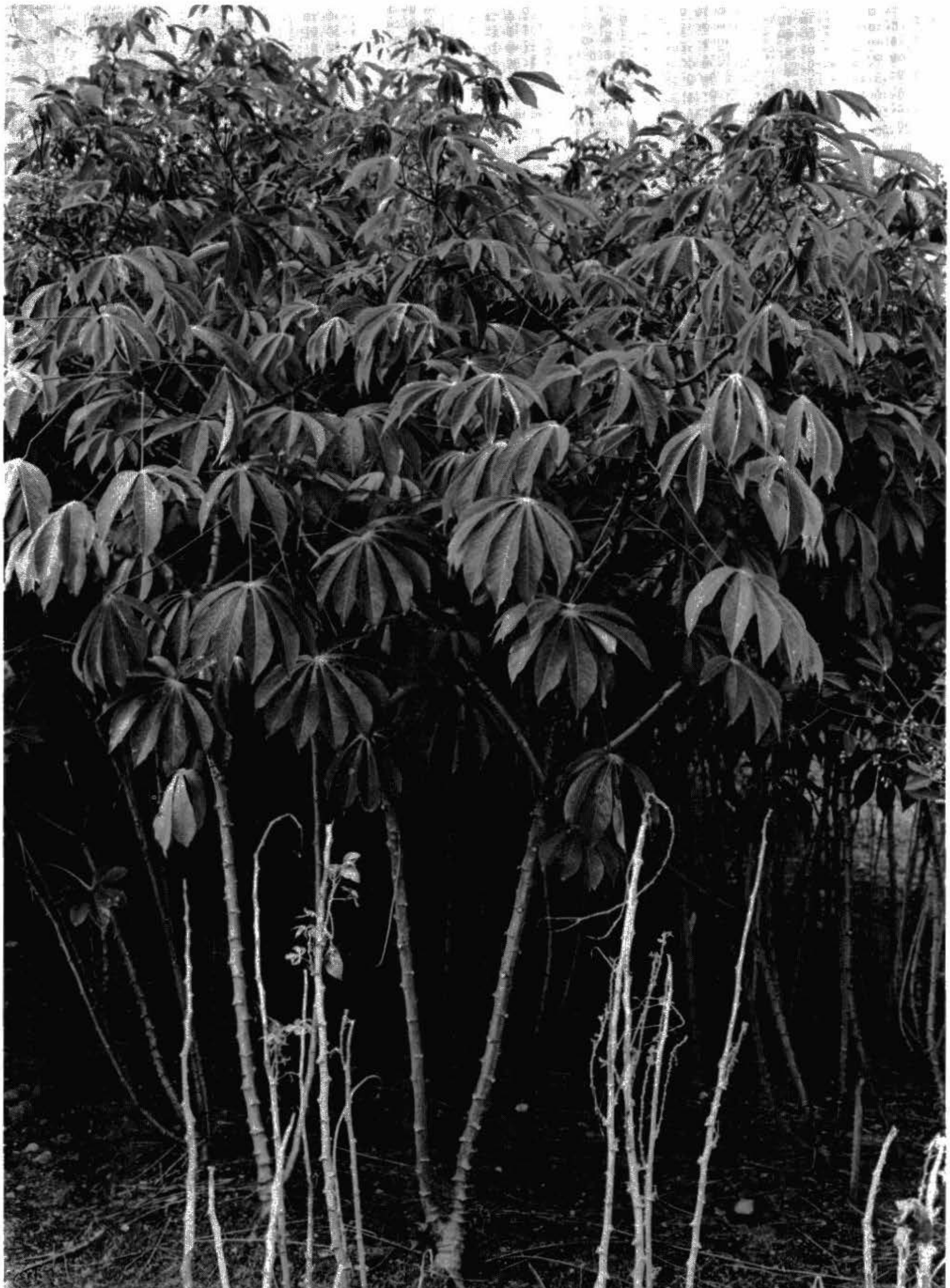
The cassava bacterial blight pathogen *Xanthomonas manihotis* is a gram-negative, motile, slender rod, with a single polar flagellum (Lozano and Sequeira 1974a). The bacterium penetrates via the stomata or through wounds in epidermal tissues of leaves and young shoots, invades the vascular tissue, and causes extensive breakdown of parenchimatous tissue.

The characteristic symptoms include (a) angular, water-soaked leaf spots which are small initially but later enlarge, coalesce, and eventually turn brown. The affected leaves become blighted and dry and eventually abscise; (b) degrees of leaf wilt ranging from one wilted lamina lobe to a large number of whole leaves; (c) yellow-orange gum exudation on the leaf petiole and young shoots; (d) severe defoliation; and (e) tip dieback resulting from vascular necrosis and death of the growing points.

Geographic distribution

In Zaïre, the disease was first noted in 1969–70 in the Gungu region of Bandundu province (Hahn and Williams 1973) and later recognized throughout that province as well as Bas-Zaïre and Kasai provinces (Maraite and Meyer 1975). In Nigeria it was first observed in 1972 in many locations in the central and southern regions (Williams et al. 1973). The highest incidence was observed in the East-Central and Mid-Western states where 100% crop losses were recorded (Terry unpublished data). In the Cameroon, incidence has so far been reported in 1974, only in the Northwestern, Western, and Littoral provinces (Terry and Ezumah unpublished data).

It should be emphasized that the disease incidence surveys made have as yet been very fragmentary, and because of the ease of spread of the disease, more comprehensive surveys may likely identify other locations in Africa where the disease has not yet been identified and reported.



Cassava bacterial blight (CBB) is a deadly disease of cassava in certain parts of Africa, and can cause total crop failure. The plants shown in the background have been bred at IITA and are resistant to both CMD and CBB.

Epidemiology

The incidence of the disease is highest during the rainy season, and rain-splash is the most important means of spread over short distances. Thus, although scattered leaf spotting and wilt have been observed during the dry season in Nigeria, the incidence of these symptoms increases significantly during the rainy season. Disease incidence in Colombia is highly correlated with amount of rainfall, and the locations in Africa where the most severe incidence has been observed are also high rainfall areas (Kikwit, Zaïre, 1600 mm; Warri, Nigeria, 2600 mm; Bambui, Cameroon, 2540 mm).

Dissemination from one area to another occurs largely through infected planting material (Lozano and Sequeira 1974b). The bacteria may also be disseminated by movement of soil during farm operations and by the use of contaminated tools. It is also possible that the practice of manually removing young cassava leaves for cooking may play a role in disease spread.

Insects have been suggested as possible agents of dissemination, but no supporting evidence has been presented. However, at the onset of the rainy season in Nigeria when there is a particularly high incidence of blighting and wilting, there are also large populations of the variegated grasshopper *Zonocerus variegatus* colonizing infected plants. It is known that grasshoppers' mouthparts and appendages become contaminated with moist bacterial exudate (Terry 1974a), and it seems likely that they may aid in spreading the disease.

In Zaïre, it was reported that the disease was more severe on poor sandy soils (Hahn and Williams 1973), and observations in Nigeria support this observation. In Cameroon, however, severe incidence was observed on volcanic soils (Terry and Ezumah unpublished data).

Control

The most promising method of controlling cassava bacterial blight is to utilize disease-resistant cultivars. Most of the local and improved cultivars in Nigeria are highly susceptible, but screening for resistance has been carried out at this Institute. Observations for 3 years have revealed a large number of clones which show high tolerance in high-rainfall areas favourable for disease development; 202 local cultivars tested at the same location showed no tolerance.

Slower spread of bacterial blight by pruning most of the above-ground portions of infected plants has been reported (Lozano and Sequeira 1974b). The disease can also be controlled by careful selection of disease-free planting material and a successful method for producing bacteria-free plants has been developed (Lozano and Wholey 1974).

Crop rotation has been suggested as a means of control, but the survival potential of the pathogen in Africa in not known. A possible mode of survival of *Xanthomonas manihotis* is in the form of dry, bacterial pellets, each of which may contain 100,000–1,000,000 viable cells (Terry 1974b).

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Some cultivars are highly susceptible to pests and diseases. Grasshoppers are a major threat to cassava leaves, sometimes causing complete defoliation as shown here (foreground).

Advances in Research on the Economic Significance of the Green Cassava Mite (*Mononychellus tanajoa*) in Uganda

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The green cassava mite *Mononychellus tanajoa* was probably accidentally introduced into Uganda during recent years. The first documented outbreak was around Kampala (Nyiira 1972). Since 1972 the pest has covered wide areas including Kenya, Congo Brazzaville, Burundi, and possibly Rwanda.

Prior to its discovery in Uganda there was little concern over mites as pests of cassava, although existence of the pest was recognized.

Nyiira (1975a) shows that spider mites infest cassava in South and Central America, the Caribbean Zone, Asia, and Africa. The species include: *Tetranychus urticae* (= *T. telarius*), *T. bimaculatus*, *T. cinnabarinus*, *T. timidius*, *Mononychellus tanajoa*, *M. carribeanae*, *M. planki*, *M. chemosetosus*, *M. bondari*, *M. planby*, and *Oligonychus gossypii*. Together, they form what is now known as the cassava mite complex.

Although all have been recorded on cassava, some are of minor economic consequence. *Mononychellus tanajoa* is considered a potential threat to cassava cultivation throughout the African tropics. Other *Mononychellus* species and *T. cinnabarinus* could attain economic pest status as cassava becomes more widely cultivated.

Economic importance

Mononychellus tanajoa feeds on the undersurface of the cassava leaves. The infested leaves develop mottling, and a bronzed, mosaic appearance. On close examination, the bronze mosaic appearance is due to the yellow spots resembling pin-point pricks inflicted by the mite's feeding. The damage is chiefly to top leaves, although under severe infestation, stems get scarified and die back. Severely infested leaves drop off while the young cassava stems damaged by the mite turn rusty and rough. The damage to leaves and stems interferes with photosynthesis activity of the plants, and that, combined with the dropping off of leaves, may lead to reduced tuber yield.

Host range

Host plants of the green cassava mite in Uganda include the following: *Manihot* species: *esculenta*, *utilissima*, *glaziovii*, *dichotoma*, *heptaphylla*, *piauhyensis*, and *cartagenesis*. In Brazil, the green cassava mite also breeds and multiplies on *Manihot apii*. The mite is apparently restricted to *Manihot* species. It is possible, however, that its hosts may include other Euphorbiaceae.

Natural enemies

The most common natural enemies of the green cassava mites in Uganda include *Oligota* (Staphylinidae) and *Stethorus* (Coccinellidae) species and the Phytoseiidae mite complex. Other predators include *Syrphus* (Diptera: Syrphidae), *Chrysopa* (Neuroptera: Anthocoridae), *Thrips* (Thysanoptera: Thripidae), *Geocoris* (Hemiptera: Chrysopidae), *Orius insiduous* (Hemiptera: Lygaeidae), and spiders (Aranea).

A brief look at the potential of predators as control agents of the green cassava mite showed them to be effective and favourable.

In Trinidad, the Commonwealth Institute of Biological Control carried out a similar survey. They identified *Typhlodromalus limonicus* and *T. rapax* as abundant and important predators of general *Mononychellus*. They also encountered *thrips* and *cecidomyiids* (probably *Feltiella* sp.) associated with *Mononychellus*.

These initial findings suggest that natural enemies of *M. tanajoa* are of sufficient importance to merit further investigation for application of control of the green cassava mite.

Life history

The green cassava mite is very small (average length 350 μ). Its egg is about half the size of the adult. Adult females lay the eggs on the undersurface of the leaves. Initially, the eggs are deposited along the midrib and along the veins. As the female population increases, the eggs are deposited at random.

The eggs when first deposited are transparent and spherical. As incubation progresses the eggs look glassy and eventually the colour of pale straw just before hatching.

The number of eggs laid per female varies, the average at an uncontrolled mean temperature of 23°C being 3.4 per female per day. The incubation period is 4–5 days at 16–32°C. The hatchability percentage ranges from 25 to 100%. The nymph period at Kawanda Research Station (at 16–20°C) is 8–13 days.

The egg-laying life span averages 19 days in the laboratory at uncontrolled temperatures, and the mean longevity of females is 30 days.

Aerial dispersal

A reasonably consistent activity pattern by green cassava mites was recorded between 24 and 29°C in slight air currents. Strong winds do not influence aerial migration, although water, other insects, and various animals contribute greatly to their movement.

Nyiira (1975b) discussed the importance of meteorological factors in the development, migration, and dispersal of the green cassava mite. With sufficient knowledge of the aerobiological activity of the green cassava mite, a warning system for countries free of the pest might be developed. Such a system would greatly assist planning of control activities.

Seasonal abundance

Mite population density is highest during the driest periods, and high-humidity conditions tend to suppress major outbreaks and damage. In rainy conditions the population of mites decreases. The reduction in the population in wet weather may be due to a physiological phenomenon linked with the development habits of the mite, or a result of mechanical destruction of the mite stages.

Variation in the population density, followed over 12 months on three varieties of cassava, showed that mite populations remained low on all the varieties after 10 months irrespective of changes in weather conditions. Control measures may be unnecessary on infested cassava after 10 months. However, these results were not followed up to find out whether they had any bearing on planting time of the cassava.

Effect on yield

Different levels of infestation can result in over 40% loss in fresh tuber weight, as a result of green cassava mite attack (Table 1 and 2). The magnitude of the yield loss will depend on the age at which the crop is attacked and the number of mites involved. This aspect is under active study at this laboratory.

Control measures

Initial work (Nyiira 1972) on the control of cassava mites using chemicals indicated that the three acaricides tested (Kelthane (Dicofol), Chlorobenzilate (Akar), and Rogor (Dimethoate)) were effective against green cassava mites. Kelthane and Rogor were more persistent than chlorobenzilate. They provided sufficient protection for over 30 days.

Table 1. Yield and quality components of cassava (variety Bukalasa 11) from green cassava mite attack compared to the unprotected cassava of the same variety.

	Protected[a] (sprayed)	Unprotected (unsprayed)
Mean fresh yield per plant (*kg*)[b]	2.46	1.67
Estimated fresh tuber yield per hectare (*kg/ha*)	16,520	11,190
Mean diameter of tuber (at 12 months) (*cm*)	14.04	13.51
Mean length of tuber (at 12 months) (*cm*)	24.83	24.66
Mean no. of tubers per plant	8	6
Quality (taste score[c])	Good	Good
Texture	Good	Good

[a] Sprayed with Rogor (Dimethoate).
[b] Based on 3-score scale: Good, Fair, Bad.
[c] Mean of tuber weight from 40 plants/treatment.

Table 2. Tuber weight (*kg*) per plant recorded at different infestation levels in six replicates on cassava variety Bukalasa 11.

	Infestation levels (based on plots of 20 plants each)					
	0%	20%	40%	60%	80%	100%
1	2.22[a]	2.25	1.95	2.34	2.02	1.95
2	2.72	3.10	2.27	1.99	1.48	2.56
3	2.63	2.93	2.22	2.29	1.61	1.98
4	2.59	2.26	1.97	1.99	1.78	1.03
5	2.18	1.71	2.15	1.43	1.56	1.54
6	2.41	2.05	3.16	2.17	1.75	1.69
Total:	14.75	14.30	13.72	12.21	10.20	10.75
Mean:	2.50	2.40	2.30	2.10	1.70	1.80

[a] Weight of tuber (*kg*) per plant from 20 plants per treatment per replicate. Difference between yield of different infestation levels significant at 1% level of probability.

The mite population reduction after 2 weeks was over 70% in cassava treated with all three acaricides. The use of expensive acaricides against cassava mites is not feasible by peasant farmers in Uganda. Moreover, more severe mite infestation occurred after every application of chemicals. On further investigations, we found that the chemicals had an adverse effect on the common, abundant predators of the green cassava mites (*Oligota*, *Stethorus*, and *Thyphlodromus*).

Current results show that biological control agents can suppress the mite populations, particularly in the areas of bimodal rainfall (the southern zone of Uganda). Certain varieties of cassava can withstand infestation without much damage to leaves. If a variety is fast-maturing (therefore subject to fewer series of infestations), and fairly resistant or tolerant to the mite damage, coupled with biological control agents, the effect on that variety by the green cassava mite would be reduced.

Effective measures against the green cassava mite should, therefore, aim at an integrated control utilizing quick-maturing, resistant/tolerant varieties backed by a program of biological control.

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Summary of information on cassava production in Africa and Sri Lanka

Country	Germ plasm collected	Germ plasm evaluated	Yield (tons/ha)	Area (ha)	Type of culture	Diseases	Pests	Quarantine	Personnel	Finance	Projects
CAMEROON	Local Sénégal Madagascar	5 few	5	200,000	1 Monoculture 2 Mixed cropping	1 Mosaic 2 Bacterial blight	1 Mealy bugs 2 White fly 3 Grasshopper	No cuttings from surrounding countries	Several	Under expansion	1 Establishment National Root Crops Improvement Program 2 Expand production in north and east 3 Mixed cropping with cocoa 4 Provision of improved seed to farmers
GHANA	Local Foreign	90 3	12.5–37.5	270,000	1 Mixed with maize 2 Monoculture south-east	1 Mosaic 2 Anthracnose 3 Bacterial blight (new record)	1 Grasshopper 2 Mealy bugs	1 Cuttings through quarantine 2 No cuttings from Brazil, Nigeria Zaïre	Research: Several Extension: 1 per 100 farmers	Limited	1 Demonstration farms 2 Establishment processing plants 3 Effects of mosaic on yield 4 Affects of age on tuber yield
LIBERIA	Local Brazil Malaysia Nigeria	50 100 12 100	–	34,000	1 Mixed (72%) 2 Monoculture (28%)	1 Mosaic 2 Brown spot 3 White spot	1 Red mite 2 Deer 3 Rodents	1 No cuttings from Central & S. America, Gabon, Ivory Coast, Nigeria, Tanzania Zaïre	Research: 27 Extension: 220	Research: $270,000 Extension: $282,000	1 Cassava evaluation 2 Feasibility pellet plant
MALAGASY REPUBLIC	Local and introduced hybrid species		6	220,000	1 Monoculture 2 Mixed culture in the south	1 Mosaic 2 Root rot	–	Very strict	–	Govt. of Malagasy Republic	1 Productivity 2 Resistance to mosaic 3 Resistance to root rot
MALAWI	146	146	–	300,000	1 Monoculture 2 Mixed with beans	1 Mosaic 2 Witches broom	1 Mealy bug 2 White fly 3 Grasshopper	1 No cuttings 2 Treated seeds through quarantine	2		1 Germ plasm collection and evaluation 2 Agronomic trials 3 Screening for mosaic resistance 4 Screening for HCN 5 Fertilizer trials 6 Multiplication disease-free material

SIERRA LEONE	Numerous (most popular)	7	5	17,000	1 Monoculture (88%) 2 Mixed (12%)	1 Mosaic 2 White thread	1 Termites 2 Animals 3 Grass-hopper	None	4	Little	1 Effects delayed weed control on yield 2 Effects planting density on yield 3 Effects fertilizers on yield 4 Effects mulching on yield
SRI LANKA	Mauritius 76	Mu 22 most popular	10	90,000	1 Monoculture 2 Mixed with coconuts in some areas	None serious	None serious	No cuttings	Several	1 Min. of Central Agric. Res. Stn. 2 Univ. of Sri Lanka	1 Production manioc meal for animal feed 2 Chip storage 3 Methods removal HCN from tubers
TANZANIA	Local 73 Brazil 1	Mosaic-resistant 11 High-yielding 18 Mite-resistant 13	6–34	3,550,000	1 Mixed (coast) 2 Monoculture (West)	1 Mosaic 2 Brown streak	1 Green mite	1 Cuttings through quarantine	2	Limited	1 Germ plasm collection and evaluation 2 Location tests 3 Evaluation polycross progeny 4 Varietal improvement and multiplication 5 Intercropping
TOGO	Local 10 Foreign 60			800,000	Mixed with legumes, maize, rice, sorghum	1 Mosaic 2 *Cercospora* spp. 3 Anthracnose 4 Root rot 5 Bacterial blight (new record)		Import forbidden		Togolese Govt. IRAT (France) GTZ (Germany)	1 Creation of institute for root crops 2 Study of diseases 3 Improved culture practices
UGANDA	Local over 40 and introduced	A11	5–15	300,000	1 Monoculture 2 Mixed cropping	1 *Cercospora* 2 Cassava mosaic virus 3 *Sclerotia*	1 Mites 2 Scales 3 White fly 4 Grass-hopper 5 Thrips 6 Hedge hogs 7 Rodents 8 Monkeys	Phyto-sanitary certificate or quarantine clearing	2	Limited	1 Selection for resistance to *M. tanajoa* 2 Crop loss evaluation 3 Fertilizer trials
ZAIRE	Local 156 Foreign 40		9	1,000,000	1 Monoculture 2 Intercropped with beans, groundnuts, plantains, rice	1 Bacterial blight 2 Mosaic 3 Anthracnose 4 Mealy bugs 5 *Phytophthora cryptogea* 6 *Cercospora*	1 Mealy bugs 2 Mites	No seeds or cuttings admitted without quarantine certificate	2	Min. Agric. and IITA	1 Varietal selection 2 Staff training 3 Extension

Summary of General Discussion

Diet: Cassava is eaten in various ways in Africa. The roots are the primary source of food. However, in certain countries, notably Sierra Leone, Cameroon, and Zaïre, the leaves are extensively used as a vegetable. The possibilities of leaf removal contributing to the spread of diseases and yield reduction were noted. Diversification of food crops in Zaïre is presently favoured by the Zaïrean government, since the people are largely dependent on cassava for food.

Toxicity: Work in Sri Lanka suggests that the tolerance level for hydrocyanic acid (HCN) in cassava products fed to chickens is 9 ppm. For humans it is 180 ppm. The HCN content of tubers of commonly grown varieties is 35–50 ppm. Various ways to remove HCN from tubers have been tested, and it was found that almost all the acid could be destroyed by soaking dehydrated cassava chips.

Chips prepared in this manner were used in chicken feed. A cassava leaf meal preparation containing 22% protein also looks promising.

The terminology of "sweet" and "bitter" cassava caused some confusion, as it appears that in some countries the terms refer to consumer preference rather than HCN content.

Intercropping: Cassava is grown with many crops, the most common of which is maize. Problems have arisen when intercropping with oil-palm in Nigeria when the cassava becomes a weed in the plantation. This has not yet been a problem when it is intercropped with coconut in Sri Lanka.

Fertilizers: The value of conducting fertilizer trials was discussed, since many felt that it would be uneconomic to apply fertilizers to cassava, given their present high prices and low availability. Others felt that no general policy was possible and that there may be some instances where fertilizer application is an economic proposition in Africa. In Nigeria, fertilizers are recommended in East Central State, and Mid-West State as part of the national accelerated food production program and to aid crops infected with bacterial blight.

Processing: The possibilities of processing cassava to produce cassava flour for breadmaking, and pellets for export, were discussed. In Togo, a cassava flour factory has not been successful since it was trying to produce cassava products for export in an area where the local food supply was scarce.

Production: To expand cassava production, an integrated approach is needed. A successful expansion requires high-yielding varieties resistant to local pests and diseases and acceptable to the consumers; suitable marketing arrangements; and infrastructure for transport and storage of the crop. Such development requires the interest and cooperation of farmers and the relevant government agencies.

Diseases and pests: Cassava bacterial blight (*Xanthomonas manihotis*) was newly reported from Ghana and Togo. The incidence of bacterial blight was apparently reduced by intercropping.

Currently, the most important pests of cassava are mealy bugs in Zaïre and green mites in Tanzania. Some of the difficulties in identifying pest and disease problems in the field were discussed.

Cooperative testing: Scoring systems were discussed and the relative merits of a standard system for different countries were considered. A standard system would allow some comparison of reaction of the same material in different countries and give some indication of relative importance of diseases in different countries.

Conversely, disease assessment on a qualitative scale is subjective and it may be better for each pathologist to book out a scale with which he is comfortable since the primary purpose is to assess material for his own country.

Seed importation: The complexities of seed importation, and quarantine, were vigorously debated and it was obvious that there will be some difficulties in the movement of material throughout Africa.

Training: A panel considered the various types of training available at IITA with respect to root and tuber crops. People who had experienced different types of training at IITA described their programs. These vary from short-term (3 months) production or extension training to longer appointments (6–9 months) during which the people conduct a small research project under the supervision of a staff member. Postdoctoral fellows who come for scientific positions, usually for 2 years, also come under the auspices of the Training Program.

Some of the problems discussed were: the importance of having research programs designed to commence immediately the trainee arrives; communication between IITA and African countries as to the type of training available and the type desirable; desirability of field trips within Nigeria to see local agricultural practices and problems; follow-up contact and assistance after the people have returned to their homes.

Appendix 1

Agronomic Aspects of the International Exchange and Testing of Cassava Germ Plasm

Part A
Cooperative Testing and Selection*

The cooperative testing of improved cassava in Africa will be coordinated by the International Institute of Tropical Agriculture (IITA) in cooperation with CIAT.

The main objectives of the cooperative testing are: 1) distribution of elite seed material to national cassava programs; 2) identification of the most promising material with respect to quantity, quality, and stability under respective environmental conditions; 3) development of national cassava improvement programs; 4) determination of productivity levels attainable under a wide range of growing conditions; and 5) obtaining information on genotype × environment interactions.

To achieve these goals with maximum efficiency, it is desirable to have a uniform system of trials, and for this reason, guidelines are proposed as follows:

1) Materials for testing: Material containing great genetic variation for international testing will be true seed. This material will be produced by IITA or other agencies but distributed by IITA according to the regulations of IAPSC.

2) Choosing testing site: It is important to choose an area of land as uniform as possible. The area should be representative of the major cassava-growing areas of each country in terms of climate, soil, biological, and cultural factors.

3) Land preparation: The land should be prepared to provide uniform testing conditions. Planting should be either on ridges or flat depending on the traditional cultural practices.

4) Planting: Obtaining a uniform stand is essential to the meaningful assessment of performance material.

Three seeds of each family can be planted directly in each hill with a distance of 1 m between and within rows. Thin off the seedlings after germination leaving one in each hill. Missing hills can be filled with the thinned-off seedlings. Seeds can also be planted in green houses in the areas where the soil temperature is not high enough and the seedlings can be transplanted to the field at the same spacing.

5) Field design and size of experiment:

- i) Field design: field design shall be a randomized complete block
- ii) Replications: there shall be four replications or blocks
- iii) Size of plot: plot size shall be 4 × 8 m, i.e. four rows 10 m long; harvest only central 2 × 8 m, i.e. two rows 8 m long
- iv) Number of families: these shall be 10 plus one local standard cultivar

6) Management:

- i) The plot should be kept free of weeds
- ii) Seedlings should be protected during the first 3 months against pests to allow for good establishment
- iii) There shall be no chemical control of diseases
- iv) There shall be no irrigation except during early growth stage of seedlings under drought conditions

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* Drafted by S. K. Hahn (IITA) and approved by the workshop.

v) Soil sample in each location should be taken
vi) No fertilizers shall be used
vii) The plants should be protected from attack by animals

7) Collection of Field Data

i) Number of stands — number of plants germinated in each plot
ii) Diseases — see guidelines for diseases
iii) Insects — see guidelines for insects
iv) Days to 50% first flowers: number of days from planting to the time when half the number of plants have produced their first flowers in each plot
v) Plant height: plant height at harvest in centimetres. Measure three plants in each of the two centre rows and find the average height per plot
vi) Lodging: number of plants inclined 45° and beyond from the vertical
vii) Time of harvesting: 12 months after planting

8) Harvest Data

i) Number of plants harvested to be recorded for each plot
ii) Total number of tubers per harvest area
iii) Total weight of tubers per harvest area in kilograms
iv) Tuber characteristics:
a) Shape — round, oval, cigar, long fat, long thin
b) Neck length — nil, short, medium, long, very long
v) Dry matter percent: dry weight of peeled and finely shredded 500 g sample from fresh tubers of average size dried at 50°C for 48 hours

9) Selected seedlings will be cloned and subjected to further evaluation in cooperation with IITA.

10) Reporting Data: Field notes and harvest data will be provided in duplicate. One set of each should be returned to the address below:

Assistant Director
Root and Tuber Improvement Programme
International Institute of Tropical Agriculture (IITA)
P.M.B. 5320
Ibadan, Nigeria

Part B
Germination and Pollination

Seed germination

Cassava seed germinates quickly and easily given the right conditions of temperature and moisture. No scarification is necessary. Seeds can be sown direct to the field (a) if constant soil moisture can be assured and (b) if the daytime soil temperature is about 30–35°C and the night temperature does not fall too low.

At IITA, seed is planted in the dry season during January and February and the seed beds are irrigated regularly for about 3 weeks and at intervals thereafter until the rainy season commences.

Especially valuable seed (i.e. new accessions from abroad) are pregerminated in the screenhouses. Each seed is planted in either a peat pellet or a jiffy pot and the seedlings are planted in the field when they are about 20 cm high. Such seed may be planted in wooden flats and kept well watered. To transplant the seedlings the flats should be taken to the field and the seedlings removed thereafter to avoid drying out of the roots.

Pollination

Pollination is most successful if done in the mornings on sunny days. Pollen should be collected early in the morning and pollinations made later on the same day. Both male and female flowers are ready for use when the flower is on the point of opening. This point becomes obvious with practice, but in general if the flower bud is pale green, with a paler almost cream-coloured tip, it will be found that the stamens have ruptured and the stigma is sticky.

To obtain higher heterozygosity IITA uses the following pollination method: as many male flowers as possible are collected from the desired parent, into a small plastic box. They are then cut in half laterally with small scissors; the bottom half which contains nectar is discarded and the ruptured stamens in the top half are kept and should be well mixed before use. The inflorescence bearing the female flowers to be pollinated should have all the male flowers cut away. The female flowers are then opened from the tip with fine forceps and pollen is dusted onto the stigma. The flowers are then covered with a light paper bag (not glacine as this is too hot) which is folded at the bottom and secured with a paper clip.

A suitable pollen applicator can be made by using a small plastic label with the tip covered to a depth of about 2 cm, with a piece of velvet-like material to which the pollen readily adheres. Several flowers can be pollinated without recharging the applicator. If the applicator is to be used for other pollen parents then it should be dipped in alcohol to kill the pollen grains remaining on it before using it for the new pollen parent.

Details (parentage, date, and number of flowers pollinated in the one inflorescence) are written on a small merchandise tag which is attached to the base of the flower stalks.

Out-crossing

Since self-pollination is rare in cassava the required hybrids can be produced by open pollination. The plot for this purpose should be in an isolated area and should contain one plant each from the selected clones.

North of the equator planting should be done before May in order to obtain maximum flowering. South of the equator planting should be done before November.

Part C
A Rapid Multiplication Technique

A. K. Howland
International Institute of Tropical Agriculture, Ibadan, Nigeria

This technique has been developed for use in rapid multiplication of desirable clones and for the production of planting material free from bacterial blight.

Basically the method involves planting mature stem cuttings, repeatedly cutting off the young green shoots, as they occur, and rooting these in a controlled environment of high humidity and shade. Thus from any one mature stem cutting it is possible to produce a number of green rooted cuttings.

In the mature stems cassava bacterial blight (CBB) is confined to the vascular system and it does not immediately translocate to the young new growth. Therefore if the young shoots are removed and rooted separately disease-free material should result.

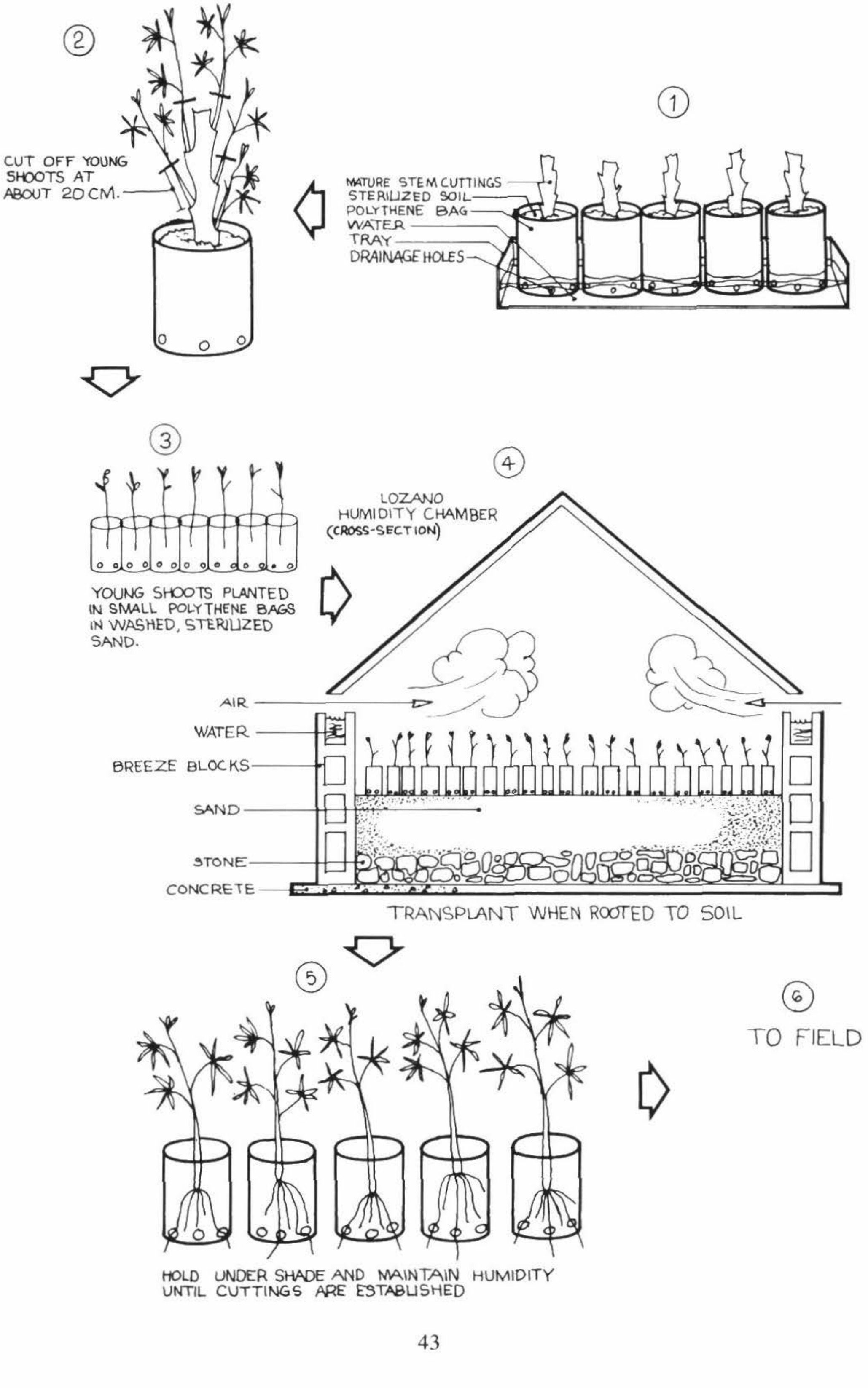
The success of this method depends upon good horticultural practices (clean equipment and controlled moisture, humidity, and shade).

Method

Mature stem cuttings about 25 cm long (i.e. the same type which would be used in field planting) are planted upright in polyethylene bags having drainage holes at the bottom. These are held in trays and sub-irrigated. No overhead watering is done to avoid the possibility of cross-infection if, by any chance, any of the young shoots are diseased. These mature stem cuttings will produce shoots 20 cm long in about 3 weeks. Shoots are cut at about 15 cm and all but the youngest leaves are removed. These green cuttings are planted in small polyethylene bags with drainage holes in washed, sterilized sand, watered, and then placed in a humidity chamber until rooting occurs and new growth is observed. Rooting takes 2–3 weeks. Alternatively the cuttings may be planted directly into the bed of the humidity chamber thereby accommodating a greater number of cuttings.

Humidity chambers

Lozano Chamber: A trough is constructed of breeze blocks on a concrete plinth. Two traces of blocks are sufficient. If the blocks are made of very coarse concrete the inside and outside walls of the trough will need plastering. The trough is filled with a layer of coarse stone and then a layer of washed, sterilized sand and then watered. The green cuttings are placed on the sand layer. An alternative composition of the humidity chamber bed is a base layer of sterilized soil and a top layer of sterilized sawdust which had previously been rotted for 3 weeks. Direct planting into such a sawdust layer induces more rapid rooting. The trough is covered with a hood which should reach to half way across the breeze block holes, which are kept filled with water. The hood has a triangular elevation and consists of a wooden frame,


2
CUT OFF YOUNG SHOOTS AT ABOUT 20 CM.
1
MATURE STEM CUTTINGS
STERILIZED SOIL
POLYTHENE BAG
WATER
TRAY
DRAINAGE HOLES
3
YOUNG SHOOTS PLANTED IN SMALL POLYTHENE BAGS IN WASHED, STERILIZED SAND.
4
LOZANO HUMIDITY CHAMBER (CROSS-SECTION)
AIR
WATER
BREEZE BLOCKS
SAND
STONE
CONCRETE
TRANSPLANT WHEN ROOTED TO SOIL
5
6
TO FIELD
HOLD UNDER SHADE AND MAINTAIN HUMIDITY UNTIL CUTTINGS ARE ESTABLISHED

covered with clear polyethylene sheeting. The frame is supported at each corner with a wood block about 2 cm thick to ensure air flow.

The hood should be shaded at first, but the shade can be reduced after a few days. Sacking, black polyethylene sheet, or palm leaf can be used for shade.

This humidity chamber design is useful in dry areas since the air takes up moisture as it passes over the water-filled breeze blocks.

Simple humidity hoods may be constructed using rectangular wooden frames covered with clear polyethylene with a 2 cm leg at each corner. This type of hood can stand on a bed of moist sand or soil.

Transplanting of rooted cuttings

The small polyethylene bags are slit open and the rooted cutting is carefully removed and planted in a larger container in soil. They should be held under shade and humidity should be maintained until the plants are strong enough to be transplanted to the field.

Part D
Guidelines for the Establishment of a Cassava Improvement Project: the Zaïre Model

H. C. Ezumah, *IITA/PNM plant breeder*
S. Kabonyi, *ingénieur agronome*
K. Beya, *section director, Inera-M'Vuazi, Zaïre*

The main objectives of the Programme National Manioc (PNM), a cooperative cassava program between the International Institute of Tropical Agriculture and the Government of Zaïre, is the improvement of cassava productivity and quality in Zaïre through breeding, improved culture management practices, and identification, study, and control of major cassava pests and diseases. PNM intends to utilize the results of research efforts from appropriate agencies, particularly IITA, in an effort to help find solutions to problems of cassava production in Zaïre.

The following steps are planned: (1) to establish a broad-based germ plasm comprising improved populations from IITA and other organizations and agencies; (2) to screen the materials for desirable qualities (disease resistance (cassava mosaic disease, cassava bacterial blight, and anthracnose); pest resistance (mainly mealy bug); high leaf retention especially during dry seasons; high yield and high starch content and, later, low HCN content); (3) to locate areas of maximum impact and conduct multilocational trials (preliminary and advanced yield trials) with each location constituting a centre of distribution of locally acceptable materials; and (4) to get local officials involved in uniformity and demonstration trials and most important, to identify local personnel for training to ensure the long-term improvement of the crop in Zaïre.

Local materials

About 200 clones collected from Zaïrean cassava cultivars and exotic introductions have been established by the PNM at M'Vuazi, Bas-Zaïre (Table 1). Some of these give a higher yield than those presently grown by farmers, and some of them (e.g. 02864) are improved clones. This particular line has many good characteristics including high yields, early maturity (12 months), moderate resistance to anthracnose, good architecture similar to Isunikekiyan in Ibadan, and very high foliage production especially during rainy seasons. Yet it has not been multiplied and distributed to farmers although it has been grown in Zaïre since 1950. Therefore, in addition to disease and pest problems (cassava bacterial blight, cassava mosaic disease, stem anthracnose, mealy bug), other factors limiting cassava productivity (multiplication and distribution of available materials, logistics, and personnel development) should be considered in establishing a cassava improvement program. The 200 clonal materials are being evaluated for resistance to important diseases and pests, yield, leaf retention, root characteristics, and general architecture. Bulked polycross seeds from this collection will be sent to the Root and Tuber Improvement Program of IITA at Ibadan for incorporation into its program.

Introductions and other seed stock

Since quarantine regulations prohibit transfer of clonal cassava materials, PNM introductions into Zaïre are in seed form. About 100,000 improved seeds from 165 families supplied by IITA were established in M'Vuazi in December 1974. Also, in March 1975 a further 2500 seeds from 138 families were established in the same location.

Over 50,000 seeds from inbred lines of about six cassava varieties collected by farmers in areas adjoining M'Vuazi have been established. Open pollinated bulked seeds collected from the 1973 planting of the 200 local collections have also been established as well as bulked seeds from IITA (Table 1).

Table 1. Manioc established at M'Vuazi, Bas-Zaïre, by the PNM.

Clones	Source		Date planted
200	Local and exotic		11 Nov. 74
Seeds	*Families*	*Source*	
100,000	165	IITA	12-13 Dec. 74
50,000	Bulked hybrids	IITA	17-18 Dec. 74
2,000	Bulked (OP)	INERA	22 Dec. 74
50,000	Local inbred (Bas-Zaïre)	Farmers	16 Jan. 75
2,500	138	IITA	14 Mar. 75

Utilization of the materials

All the plants established are being evaluated for resistance to CBB, CMD and anthracnose. PNM plans to screen for mealy bug, a very important pest in Bas-Zaïre. Anthracnose is more serious in Zaïre than in many other parts of Africa. Unlike CBB and mealy bug, and like CMD, its symptoms are fully expressed during both dry and rainy seasons. Many of the heterozygous stands from the improved populations from IITA exhibit resistance to CBB, CMD, and moderate resistance to anthracnose.

Multilocational trials

Selected plants from the nurseries will be established at several ecological locations in Zaïre (Table 2). The soil type in these locations ranges from very poor sandy soil to rich,

Table 2. PNM locations for 1975 trials.

Location	Elevation (*m*)	Annual rainfall (*mm*)
Bas-Zaïre		
M'Vuazi	490	1565
Mbanza-Ngungu	750	1412
Kimpese	450	1165
Kwilu-Ngongo	400	1360
Bandundu		
Kiyaka	700	1593
Feshi Tonu Vanga	893	1762
Equateur		
Eala	320	1720

forested areas. Rainfall distribution also varies from continuous rains throughout the year at Eala, Equateur, to various distribution patterns of dry and rainy seasons for the other locations (Table 3).

Table 3. Monthly distribution of rainfall (in millimetres) at offsite locations (6-year average, 1950–55).

	M'Vuazi	Mbanza-Ngungu	Kimpese	Kwilu-Ngongo	Kiyaka	Feshi	Eala
Jan.	99	69	171	100	148	201	96
Feb.	90	119	123	96	93	149	146
Mar.	267	234	180	210	227	249	158
Apr.	247	197	303	259	199	243	157
May	178	134	81	121	102	45	169
June	3	00	TR	TR	9	9	88
July	TR	00	00	TR	9	12	87
Aug.	0	TR	00	7	–	34	85
Sept.	17	26	TR	14	137	141	183
Oct.	109	126	73	79	213	239	231
Nov.	284	300	201	297	243	226	203
Dec.	250	206	231	176	179	213	115

September planting is possible in Bandundu, with mid to late October planting in Bas-Zaïre. Rains start and stop earlier in Bandundu than in Bas-Zaïre.

For each location, a total of 1000 heterozygous clones will be evaluated for yield, starch content, vigour, and earliness of maturity.

Nursery centres

Establishment of several nursery centres may be an easy means of transporting cassava materials. For a country as large as Zaïre, and in which transportation of cuttings (clones) is expensive, establishment of seedling nurseries at strategic locations instead of at one central location will minimize these costs. Five suitable locations suggested are M'Vuazi, Eala, Kiyaka, Lumumbashi, and Kisangani.

From 1976, improved seeds from IITA will be established and screened for important characteristics at these locations. Selected clones will be evaluated, and preliminary and advance yield trials conducted. Materials will be distributed to farmers in areas adjoining the nursery centres.

Exchange of seed materials

While improved seeds will continue to be received from IITA, local seeds from the germ plasm (open pollinated) will be bulked and sent to IITA for incorporation into its breeding program. Also stocks of selected locals will be planted in isolation at M'Vuazi with stocks of selected seedlings. Resulting seeds will be bulked, part of which will be established and screened at the main station in M'Vuazi, and the balance given to IITA and other interested organizations.

The 200 local cultivars as well as other exotics and new collections will be maintained at M'Vuazi. The genetic stock will, therefore, continue to be available for future breeding programs.

Effectiveness of the program

An important way to ensure an effective program is to get local personnel fully involved. Their familiarity with the language and understanding of local problems can ensure that the villagers and host officials cooperate with foreign personnel. Training should also be started as soon as a program gets established. The trained personnel should be scheduled to take up positions of responsibility at the various locations at an early stage.

New graduates from universities or those who have served in different capacities for some time would make excellent trainees. The plan is to eventually have 30 professionals working in the program including breeders, agronomists, pathologists, entomologists, and specialists in processing, storage, and production.

Locating areas for maximum impact

For a country as large as Zaïre (total land area is 234.5 million ha or 905,000 square miles), throughout which cassava is important, it is essential for the program to isolate and concentrate its efforts in areas of maximum impact. This choice has been made easy for the following reasons: (1) the problems of CBB, CMD, and anthracnose, and mealy bug are widespread in Bas-Zaïre and Bandundu regions; (2) cassava consumed as foofoo, chikwangue, and pondu or sakasaka is the major food item in these areas; (3) transportation infrastructure is much better developed in the Bas-Zaïre region than in any other region. A new road to Bandundu is being constructed, so communication with Kinshasa will be much better; (4) providing cassava to feed the large urban population of Kinshasa, which is still growing very rapidly, is largely the responsibility of these two regions, especially Bas-Zaïre, which at present supplies over 80% of the cassava needs to the city.

Conclusion

With the broad-based improved seed population available at IITA and perhaps at other agencies and organizations, a cassava improvement program, which relies on the results of these populations, should be able to provide a sustaining solution to the enormous problems in many cassava-growing areas. There are many problems of cassava production in Zaïre. These range from disease and insects to logistical difficulties.

We must therefore (1) establish a broad-based germ plasm; (2) identify areas of maximum impact and concentrate in these areas; (3) establish nursery centres at various locations to screen for desirable characters, conduct yield trials, and distribute to areas close to these centres. This will minimize transportation difficulties of heavy cuttings unique with cassava since seeds are less bulky and less costly to handle; (4) get local personnel involved in the program as early as possible; (5) clarify responsibilities of host and foreign staff.

Appendix 2

Phytosanitary Aspects of the International Exchange and Testing of Cassava Germ Plasm

Some cultivars have varying degrees of resistance to pests and diseases. Special effort is underway to breed for resistance to cassava mosaic disease which is widespread throughout Africa. The plants shown here at IITA have varying levels of resistance to CMD.

Part A
Suggested Guidelines Relating to the International Movement of Cassava Planting Materials*

A. General

1. These guidelines are presented as a suggested supplement to existing quarantine regulations of recipient countries. Their implementation is the joint responsibility of the donor and the recipient country

2. It is recommended that at all times the smallest amount of planting material be imported; the smaller the amount the less chance of its carrying infection, and the greater the ease of inspection and post-entry quarantine

B. The Movement of Vegetative Propagating Material

1. Cassava material should not be imported from countries where cassava African mosaic disease and brown streak virus of cassava exist into countries free from these diseases**

2. For importations from all other countries the following procedures are recommended:

a) *in the donor country:*
   - (i) material for export should be selected from sources which are free from symptoms of: all virus and virus-like diseases, stem borers, mycoplasma, cassava bacterial blight, superelongation
   - (ii) material for export should be treated with a combination of an effective fungicide and insecticide. For this purpose the fungicides*** Thiram (25 g a.i/litre) and Chloroneb (20 g a.i/litre) and the insecticides Methamidophos (0.8 g a.i/litre) and Carbofuran (1.2 g a.i/litre) have been found satisfactory although these chemicals are not exclusive
   - (iii) material for export should be handled with extreme care and all tools and packing material should be either heat or chemically sterilized before contact with the material to be exported

b) *in the recipient country:*
   - (i) any material which on arrival shows evidence of pests or diseases should be destroyed immediately by burning
   - (ii) on arrival the material should be retreated with insecticide and fungicide as described in paragraph 2 (a) (ii)
   - (iii) the imported material should be planted in an isolation area and be subjected to regular and careful inspection for a period of one year
   - (iv) if at any time the imported material shows evidence of pests or diseases hitherto unknown in the country it should be destroyed by burning

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* Drafted by Drs A. Bellotti, C. Lozano, and A. van Schoonhoven (CIAT), E. Terry (IITA), and R. Booth (TPI), and approved by the workshop.

** The distribution of these two diseases has not yet been mapped, however, cassava mosaic disease has only been reported from India and the African continent, and brown streak is only known in small areas of East Africa.

*** For chemical nomenclature see 1972 Ed. Pesticide Manual, Published by the British Crop Protection Council.

3. In addition to the above general recommendations:
   a) material being exported from a country where superelongation is known to be present should receive a hot water dip (50°C for 30 min) before dispatch
   b) countries without cassava bacterial blight (CBB) importing material from countries where CBB is present should undertake shoot tip indexing within 20 days of germination

C. The Movement of True Seeds

a) *in the donor country:*

(i) seed for export should be selected only from plants free from symptoms of: all virus and virus-like diseases, superelongation, mycoplasma, cassava bacterial blight

(ii) the best quality seed should be selected visually

(iii) seed should be dusted with a fungicide (e.g. Thiram) and an insecticide (e.g. Malathion) powder at the manufacturer's recommended level prior to shipment

(iv) seed should be handled carefully and all handling and packing materials should be disinfected and sterilized before use

b) *in the recipient country:*

(i) seed which is pest-infested or obviously diseased should be destroyed on arrival

(ii) imported seed should be planted in an isolation area and be subjected to regular and careful inspection for a period of one year

(iii) if at any time the plants originating from imported seed show evidence of pests or diseases hitherto unknown to the country they should be destroyed by burning

Part B
Description and evaluation of cassava mosaic disease in Africa

E. R. Terry
International Institute of Tropical Agriculture
Ibadan, Nigeria

At present, there is limited information on cassava diseases and even more limited data from reliable studies on yield losses due to these diseases. This lack of information has led to the assumption that cassava diseases are of minor importance.

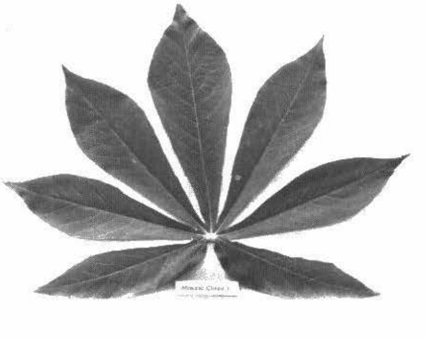
There are several cassava diseases caused by bacteria, fungi, virus, and other unknown agents. In Africa, although cassava mosaic disease is one of the most widespread, cassava bacterial blight which has been recognized to date in Zaïre, Nigeria, and Cameroon, is considered to be more serious in terms of its severity, ease of spread, and the loss of yield and planting material that it causes.

The following is a brief description, with photographs, and suggested procedures for evaluating the severity of cassava mosaic disease. These descriptions should be considered only as tentative aids to field recognition of the disease, and the scoring procedures merely as suggested guidelines to evaluating the severity of the disease and the reaction of cassava plants to it.

Symptoms The disease is characterized primarily by chlorosis of discrete areas of the leaf lamina and these areas fail to expand fully so that stresses set up by unequal enlargement of adjacent areas cause distortion of the leaflets. The typical picture is a leaf reduced in size, misshapen and twisted with bright yellow areas separated by normally green areas. All leaflets may show a nearly uniform mosaic pattern or the mosaic pattern may be localized in a few areas only.

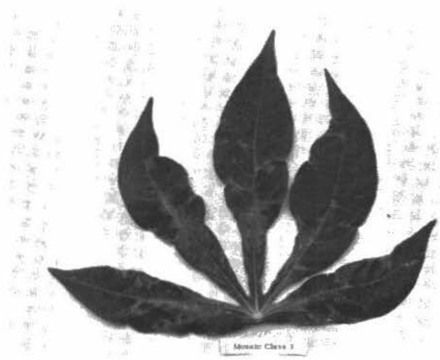
Classification of disease severity The scoring system for evaluation of test plant reaction to CMD is based on the following five classes of severity:

Class 1 — Apparent field resistance, no symptoms seen.



Class 2 — A mild chlorotic pattern over entire leaflets, or mild distortion only at the base of leaflets, with the remainder of the leaflets appearing green and healthy.

Class 3 — Strong mosaic patterns all over leaf, narrowing and distortion of lower one-third of leaflets.



Class 4 — Severe mosaic pattern, severe distortion of two-thirds of leaflets, and general reduction of leaf size.

Class 5 — Severe mosaic, severe distortion of four-fifths or more of leaflets, twisted and misshapen leaves, and severe reduction of leaf size.

Part C
Major Pests of Cassava in Africa and Preliminary Guidelines for Screening of Resistance

K. Leuschner

International Institute of Tropical Agriculture
Ibadan, Nigeria

Cassava has, compared with other crops, relatively few insect problems. Traditional methods of cultivation in smaller plots and mixed cropping are less favourable to severe insect attack. However, there are some insect and mite species which are, or may become, major pests in Africa.

The main pests of cassava in Nigeria are the white fly (*Bemisia tabaci*), the grasshopper *Zonocerus variegatus*, and the red spider mite *Tetranychus telarius*. Outside Nigeria, the green spider mite (*Mononychellus tanajoa*) which occurred recently in Uganda and Tanzania and a not-identified mealy bug in Zaïre have become serious pests of cassava. *Scirtothrips manihotis* reported from East Africa and termites can occasionally be dangerous.

Major pests of cassava

Bemisia tabaci

Distribution:	All over Africa
Damage:	Vector of cassava mosaic virus; no damage by the insect itself
Yield losses:	Yield losses between 20 and 90% for CMB between 1930 and 1940; today cassava seems to live with the virus and is still able to produce
Biology:	*Bemisia* lays its eggs on new developing leaves; larvae and pupae can be easily detected on older, fully grown leaves. One generation lasts about 4–5 weeks depending on climatic conditions (about 10 generations per year). The population level depends more on the physiological conditions of the plant than on climatic conditions
Host range:	Tomato, eggplant, tobacco, cassava, sweet potato, cowpea, and many others
Control:	Because of the wide host range and the fact that a single insect can transmit the mosaic disease, only total immunity of cassava would be of value. Because this rarely can be obtained, either with insecticides or in resistant varieties, we should look only for varieties which do not favour white fly development

Zonocerus variegatus

Distribution:	Widespread in Africa between 10° north and south of the equator
Damage:	Defoliation of plants between November and March; heavy outbreak can result in stripping of the bark
Yield losses:	Yield can be affected when plants are younger than 1 month; 60% loss has been reported

Biology: *Zonocerus* is a dry-season pest. Eggs are laid in April and hatching occurs at the end of October and November. Two generations are possible of which only the dry season one is of importance. Young hatchings do not touch cassava until they reach the 3rd instar. By this time cassava is often the only suitable food-plant because it can withstand drought. With increased cultivation of cassava *Zonocerus* seems to gain in importance

Host range: Cotton, citrus, sweet potato, cassava, tobacco, etc.

Chemical control: *Zonocerus* can be controlled by insecticides like Gamalin 20 and Tenitrothion

Screening for resistance: Screening for resistance against *Zonocerus* might be possible. Preliminary tests showed a preference for certain varieties: 60444, Isunikakiyan, 58101. Screening is not very easy because of high mobility and large numbers, but possible during early morning. Possible rating system: 0 — none; 1 — few resting only; 2 — slight feeding; 3 — obvious feeding; 4 — numerous skeletonized leaves, no extensive bark damage; 5 — near defoliation with extensive bark feeding

Tetranychus telarius (red spider mite)

Distribution: Worldwide

Damage: With increased mite population, yellowish-white dots occur and later the leaves turn yellowish-brown and eventually drop; heavy outbreaks can cause complete defoliation; tips show light-coloured mottling, leaves remain stunted, drop, and the growing point dies

Yield losses: Unknown, but might be heavy if cassava is attacked by young as in the case of *Zonocerus*

Biology: Life cycle varies from 7 to 12 days; 2–6 eggs are laid per day with a total of 70 eggs per female. They hatch in a few days into six-legged larvae which molt into two recessive nymphal instars and an eight-legged adult. The mite is a dry-season pest. It prefers high temperature and low relative humidity. Mostly older and well-maintained plants are attacked. The mite is spread by wind, animals, and man

Host range: Groundnuts, cassava, cotton, cucurbits, etc.

Control: Heavy outbreaks might require the use of acericides like Azadrin Dicrotophos, Dimethate fundal, etc.

Resistance: There may be differences in the susceptibility of cassava varieties to spider mites, but this has not yet been established. Possible rating system: 0 — no evidence of mites or damage; 1 — nil damage, only occasional speckling; 2 — speckling localized, less than 25% of the leaf surface speckled; 3 — speckling extends length of the mid-side and covers 30–50% of leaf surface; 4 — most leaves including young ones showing over 50% speckling; 5 — whole plant looks whitish with large amount of webbing and defoliation. Actual counting of mites is also possible but rather time-consuming.

Minor pests

Minor pests should be carefully watched especially in connection with newly released, high-yielding and resistant varieties.

Appendix 3

A Note on the IITA Training Program

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To facilitate communication and understanding, and for planning purposes, the Training Office of IITA has defined its areas of responsibility and activity in the following terms.

Seminars

Weekly seminars are held at which trainee and IITA staff present results of their research, thus providing a means for trainees and others to become familiar with the work of the Institute as a whole and to learn of the activities of scientists working in other areas of the humid tropics. Conferences and workshops are also held at the institute and trainees are encouraged to attend those of direct interest and concern to them.

Postdoctoral fellowship

Fellowships are offered each year to selected young scientists who have recently qualified for advanced degrees (doctorate level). These fellowships are offered for three reasons: (1) to affirm the research skills and orientation of young scientists by affording them the opportunity to work with experienced research scientists on relevant problems of crop production in the lowland humid tropics; (2) to assist the institute to achieve its research goals in priority areas where insufficient regular staff is available; and (3) to assist in the identification and training of staff for the institute or for one of its cooperative program contracts.

Research training

Under the supervision of members of IITA's scientific staff, trainees work on research problems that permit the acquisition or perfection of needed research skills. All programs or projects are tailored to meet individual needs and all are planned in such a way as to contribute to IITA's research effort.

Training in research is arranged both for postgraduate degree candidates and for those seeking degrees. Cooperative arrangements have so far been made with 18 universities of Africa, Australia, Europe, and North America for postgraduate degree candidates to conduct the research portion of their degree requirements at IITA. The insititute has also provided non-degree research training for employees of 19 research institutes, universities, and departments of agriculture in 12 countries of Africa and Asia.

Research scholars from many countries, including those shown from Zaïre and Korea, are studying cassava diseases and pests at IITA.

Crop production technology and extension training

This training leads to a thorough familiarity with one crop as well as with the methods of conducting an accelerated production campaign for that crop. The activities are designed to create production specialists who have a high level of competency in five areas: (1) *Technical competency* Knowledge and understanding of the production practices involved and the physical environment. This must include the ability to diagnose correctly and treat, if possible, typical problems and abnormalities of plants growing in the field. (2) *Economic competency* Ability to weigh alternatives of production input and marketing strategies, and to make recommendations in the light of economic relationships within the reality of the physical and socioeconomic systems in which the farmer operates. (3) *Scientific competency* Basic understanding of the philosophy of science and the ability to conduct simple replicated field experiments which objectively test whether an innovation is worthy of adoption under farm conditions. (4) *Farming competency* Willingness and skills to perform the range of physical tasks involved in producing crops. Once the production specialist has acquired these four skills, a fifth becomes vital in his role of change agent. (5) *Communication competency* Ability to plan, prepare, and present adequate messages for the farmer, the credit agency, the input retailer, the market, or even the consumer.

The broad objective of crop production technology and extension courses is to prepare extension leaders to promote, organize, and conduct crop production training courses for extension agents and others, thus multiplying the effects of their training at IITA.

Training is done on a group basis, with emphasis on in-the-field experience. Adequate time is allowed in the classroom for lecture and discussion.