Cassava Production and Extension in Central Africa

CASSAVA PRODUCTION AND EXTENSION IN CENTRAL AFRICA

H.C. Ezumah

Editor

Proceedings of a workshop held in Zaire
19-22 May, 1980

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CASSAVA PRODUCTION AND EXTENSION IN CENTRAL AFRICA

Proceedings of a workshop on cassava production
and extension in Central Africa

held at

Mbanza-Ngungu, Zaire, 19-22 May, 1980

H. C. Ezumah, Editor

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The National Manioc Program (PRONAM), Zaire.

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FOREWORD

Central Africa, which comprises the countries of: Angola, Burundi, Cameroon, Central African Republic, Congo (Brazzaville), Gabon, Rwanda and Zaire, produces more than 50% of the approximately 42 million tons of cassava produced annually in Africa and more than 200 million people, particularly in Central Africa depend on cassava for about half of their daily caloric intake. Researchers on cassava in the region had operated in semi-isolation; yet, the problem and technical solutions are common. It was felt necessary to bring together workers from the region, review their problems and formulate recommendations for future work and cooperation.

To achieve these objectives, this workshop was organized by the National Manioc Program (PRONAM), Zaire; the Department of Agriculture and Rural Development, Zaire; the U.S. Agency for International Development (USAID), Zaire, with contributions from the National Research Institute (INERA), Zaire; and the International Institute of Tropical Agriculture (IITA), Nigeria. Participants from 7 countries attended. (Participation by IITA explains the representation from Nigeria, as a West rather than Central African country).

Zaire as the choice of the venue for the 4-day workshop was unique because Zaire produces 25% (11 million tons) of the cassava roots produced in Africa and is highly dependent upon cassava for food. Zaire is boarded by 9 countries in the region, and, therefore, cannot escape the disease and insect problems of

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its neighbors. A regional approach toward solving the problem in cassava production is essential. The venue also enabled large participation by PRONAM staff, which reviewed its achievements and drew attention to its constraints in the present and in the future.

It is hoped that these proceedings, which are recommended as a guide for researchers, policy makers, technicians and others interested in assisting the region achieve self-sufficiency in cassava production, will be useful in attracting more attention to cassava in Central Africa. The efforts put into organizing the workshop and reproducing the proceedings are commended. Particular attention is directed to section VI that focuses on the areas of urgent research and extension needs of the crop and offers suggestions based on the concensus of participants on how to solve the problems.

E.H. Hartmans
Director General
IITA

WELCOMING ADDRESS

by

Citoyen Djogo Basome
Secretary of State,
Department of Agriculture, Zaire

It is an honor for me to open this cassava workshop organized by the Department of Agriculture and Rural Development with the assistance of the U.S. Agency for Internation Development(USAID) and the International Institute of Tropical Agriculture (IITA).

I would like first to thank all the brother counties whose delegates are at this meeting so we can exchange our knowledge and experience on the production of cassava, which is a very important food crop for our populations. These countries are Angola, Burundi, Cameroon, Central African Republic, Congo (Brazzaville), Gabon, Nigeria and Rwanda.

We also thank USAID and IITA for their very important support to the National Manioc Program (PRONAM) since its establishment and to the organization of this workshop.

We are also grateful to the Belgian Government which helped establish PRONAM.

The objective of this workshop is to study cassava production problems in participating countries, to examine the constraints and to propose solutions, which in both the short and long term will lead to concrete results.

Cassava is an extremely important staple food. In Zaire, cassava is the most important food crop. In 1979, 11 million tons of fresh tuberous roots were produced. In 1970, cassava bacterial blight (CBB) appeared in the savanna zones of the country, Bas-Zaire, Bandundu and Kasai. It is for this reason that the Zairean Government decided to establish a research program to face this disease and to develop some high yielding resistant varieties. PRONAM was then established in 1974. Terms of agreement between the Zairean Government and IITA specified that the government should provide PRONAM with all the necessary working facilities. It is in this aspect that the Zairean Government asked the Zairean National Institute for Agronomic Research (INERA) to provide PRONAM with a station and other facilities for its work.

So far, we appreciate the results of our collaboration with IITA. We encourage every organization to join in the endeavor to help in cassava production and research and enhancement of this collaborative effort.

PRONAM's objectives are as follows : 1) to develop high quality cassava clones that are resistant to diseases and insects

found in Zaire, 2) to develop cassava cultural practices for a maximum economic yield and 3) to identify and to train Zaireans to an adequate international level and to interest them in the development of Zairean's agriculture.

PRONAM has now developed some high yielding varieties that are resistant to diseases. For the training aspect, 5 staff members have been awarded M.S degrees, 2 of whom are now admitted to a Ph.D. program. At the end of this year, 6 other staff members will be finishing a M.S. degree program.

In Zaire, the Program of Minimum Agriculture (Programme Agricole Minimum'P.A.M.') has been set up by the government fo the production of some basic foodstuffs such as maize, rice and cassava, using as much as possible the country's financial resources. The achievement of this program requires PRONAM's extension to rural areas of its research results that will enable increased cassava production.

We are not expecting from this workshop only a simple exchange of scientific and technical experiences but emphasis on cassava production that interest our populations the most. From this workshop, PRONAM's short- and long-term objectives should be well defined, taking into account the limited financial possibilities of the country.

A possibility of establishing a regional organization

should be considered for an efficient use, in the future, of the technical support from IITA and other organizations interested in cassava production. I am, therefore, inviting you to avail yourselves during these few days so that together we can succeed in finding some solid and realistic steps on which our agriculture will be based for its development.

I am personally putting my hope in this workshop, and I believe from the quality of the participants that we will not be disappointed.

I declare the cassava workshop open.

SECTION I

Introductory and theme papers

Introductory and theme papers were presented by the Director of USAID, Zaire, and the Assistant Director, TRIP of IITA. Supporting papers on cassava, covering research strategies of PRONAM and its achievements were presented.

Expectations from the Cassava Outreach Project

by

N.L. Sweet
Director, USAID, Zaire

I would like to add my greetings to those of the previous speaker and to thank the sponsor, PRONAM, for inviting me to participate in this conference.

As many of you know, the U.S. program of economic assistance to Zaire concentrates on the agricultural section. It is our desire not only to help finance the technical assistance and equipment necessary to help Zaire emerge from its agricultural impasse but also to encourage the Zairean Government adopt appropriate agricultural policies having the same objective. We believe that PRONAM can be an effective instrument toward this end. Accordingly, this month, we have contracted IITA to continue the work in cassava that it began here in Zaire about 5 years ago and it has implemented so successfully to date.

We expect our project relationship with IITA and PRONAM to last 4 years, during which time, we hope that the institutional capability of PRONAM can be enhanced to conduct

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The extension phase of cassava work in Zaire, which includes provision for a center for training for Central African trainees, is sponsored by USAID and GOZ with IITA as the executing agent.

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adaptive and applied research on cassava using a farmer participatory approach and to make new cassava technology available to small farmers. We anticipate that PRONAM, in the next 4 years, will train intermediate level research workers and extension supervisors who will be capable of plant screening, plant multiplication and distribution and farm level trials. The trained personnel, in turn, should be capable of training extension agents in these areas.

At the end of 4 years, it is expected that PRONAM will be in a position 1) to identify high yielding, disease and insect resistant cassava varieties and improved cultural practices; 2) to multiply improved plant material and establish a system for distributing this material; 3) to improve cassava's consumer acceptance, nutritional value and processing characteristics and 4) to exercise a front-line role in the identification and control of economically significant cassava disease and insect problems.

In conclusion, let us admit that solutions are not easily found for the economic problems confronting Zaire today. However, it is certain that the country cannot continue to depend on the importation of foodstuffs to meet the needs of the people. First, even with foreign assistance. these importations have cost valuable foreign exchange, which, to say the least, is in short supply. Second, given worldwide food shortages, and the

cyclical nature of food production, no country should depend on external sources of basic foodstuffs if such a situation can be avoided. Zaire can and should meet its own basic food needs. PRONAM can make an important contribution to attain this objective.

Opportunities at IITA for National Programs in Africa

by

S.K. Hahn
Assistant Director, TRIP,
IITA

It is an honor for me to have this opportunity to speak to you on behalf of the IITA Director General and the IITA Root and Tuber Improvement Program.

In years past, outbreaks of plant diseases, insects and drought destroyed crops, resulting in famine. No one could help very much in preventing such occurences. Even today, there are often such disasters in many parts of the world. However, with modern agricultural science, it is possible to overcome such disasters to a great extent, to increase yield per unit area and time, to reduce production inputs and to grow crops more easily and with less toil.

The world food situation is serious because of higher population growth rate than food production. However, the ability to deal efficiently with this drawback does exist. One of the most powerful weapons against world hunger is improved production technology in terms of improved varieties and improved cultural practices.

IITA

In an effort to develop this powerful weapon suitable to

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Africa, the Ford and Rockefeller Foundations in cooperation with the Nigerian Government launched IITA in Africa in 1967. It is 1 of the 9 major links in an international network of agricultural research and training centers.

IITA is charged with improving the quantity and quality of food produced in the humid and subhumid tropics, improving selected important food crops and finding practical alternatives to shifting land cultivation and related bush fallow systems in order to increase landuse and maintain soil productivity.

Its responsibilities logically extend to disseminating information on alternatives to interested international, governmental and professional groups as well as individual scientists around the world. We have about 100 professional scientists of different disciplines and expertise from 20 different nationalities working toward achieving the Institute's goals. These scientists work in 4 research programs : Farming Systems Program (FSP), Cereal Improvement Program (CIP), Grain Legume Improvement Program (GLIP) and Root and Tuber Improvement Program (TRIP).

The primary objectives of TRIP are to develop viable production technologies, readily adaptable to all root and tuber crops, principally in terms of improved varieties aided by improved cultural methods most suited to the humid and sub-

humid tropics and also to assist in developing national root and tuber improvement programs by providing them with improved breeding materials plus advanced technologies that can be handed on, used and understood by local farmers. To achieve these objectives effectively and efficiently, the program has adopted an interdisciplinary team approach involving agronomy, breeding, entomology, pathology, nematology and tissue culture, all working toward common goals.

Our TRIP consists of a core program and 2 cooperative programs, the Zairean national cassava program (funded by Zairean Government and USAID) and the Cameroon national root and tuber improvement program (funded by the Canadian International Development Research Center and the Belgian Government). We are expecting more cooperative root and tuber improvement programs in Rwanda and Malawi in the near future, which will be funded by USAID, the home governments and the Belgian Government. We are planning to have a regional cassava program in Sierra Leone from 1981.

TRIP consists of 8 professional scientists in the core program, 2 in the Cameroon cooperative program and 2 in the Zaire cooperative program at the present time. All together, there are 12 professional scientists working

for the improvement of root and tuber crops. One of the most important aspects of our program is that of training. Each year a root and tuber production training course is held for graduate and technically trained members of the national root and tuber improvement programs. Degree related trainees are undergoing training at IITA for advanced degrees, registered at the University of Ibadan.

TRIP currently has the largest cassava breeding program in the world, producing from 100,000 to 200,000 improved cassava genotypes each year. IITA has been successful in producing improved cassava varieties that are highly resistant to cassava bacterial blight (CBB), cassava mosaic disease (CMD), Anthracnose disease (AD), high yielding and acceptable in quality and tuber shape.

Breeding material from these improved varieties have been distributed to many national cassava programs in Africa and Asia. In Nigeria, the improved cassava varieties have been multiplied rapidly on a large scale and are being distributed to farmers through state ministries of agriculture. There are tremendous demands by local farmers for the planting materials from these improved varieties. In Cameroon, Gabon, Liberia, Rwanda

Sierra Leone, Tanzania and Zaire, the most promising cassava clones from IITA improved seed have been tested in various locations along with standard local varieties. The improved clones outyield the standard varieties in all test locations by 2-3 times.

PRONAM

In March 1973 at the request of Zairean Government, a team was sent from IITA to Zaire to investigate a cassava disease problem. CBB and the cassava mealybug were observed. Subsequent to the visit, the Zaire Director General requested IITA to establish PRONAM.

A memorandum of understanding between the Zairean Government and IITA to establish the program was signed in May 1974 with the following main research objectives : 1) to identify and develop cassava varieties with superior yield, 2) to identify sources of resistance to the major diseases and insects and incorporate the resistance into high yielding potential varieties, 3) to develop a package of cultural practices that would allow the yield to reach the economic optimum and 4) to develop high quality cassava varieties in terms of consumer acceptance and nutrition.

IITA's participation in PRONAM began in November 1974 with the arrival in Zaire of an IITA plant breeder. In

July 1976, an agronomist joined the program as the project leader. In September 1976 and January 1977, a pathologist and an entomologist joined, respectively. The program was staffed at an early date. Thousands of improved seeds of cassava, which contain sources of resistance to CBB and CMD, were introduced by IITA and screened. Promising plants are now being identified.

Evaluation of Cassava Cultivars in Zaire for Cyanogenic Content

by

N.B. Lutaladio, H.C. Ezumah and T.P. Singh
IITA/PROMAN agronomist, agronomist/project leader and breeder

Roots from "sweet" cassava can be eaten raw while roots from "bitter" cassava usually undergo some form of processing to reduce their hydrocyanic acid (HCN). It has been observed that the traditional processing (fermentation, drying, boiling, etc.) does not eliminate all the HCN. (Cooke and Maduagwu, 1978).

The problem of cyanide toxicity as a factor limiting utilization of cassava in Zaire is not well known though the goitrogenic effect of cassava was demonstrated in Ubangi and Idjwi areas of the country. (Delange and Ermans, 1971; Delange et. al., 1973). There is sufficient evidence to suggest that chronic cyanide poisoning is of great importance where cassava constitutes a major portion of the diet.(Ekpechi et. al., 1966; Ekpechi, 1973, Ermans et. al., 1973; Osuntokun et. al., 1969). There is therefore, a need for finding cassava cultivars that are low in cyanide content. In view of this, the HCN content of the PRONAM cassava collection at its M'vauzi station is being screened.

At present, PRONAM does not have all the facilities to study this problem in detail. Hence, the sodium picrate test is employed

to screen for HCN estimation. This method is know to be suitable and practical for the screening of a large quantity of material. (Sadik et. al.,1974) In this method, the clones are usually classified as high, medium or low depending on the intensity of the color (from yellow to shades of red) scored on a strip of filter paper after the release of HCN through enzymatic reaction. However, we have been able to classify the clones as very high, high, medium, low and very low for HCN through color intensity.

The cassava collection at M'vuazi was screened 10 months after planting. A small number of varieties showed very high, low or very low levels of HCN content while the majority showed high to medium degrees of cyanogenesis (Table 1). Some high yielding varieties selected for multiplication and dissemination were also screened for HCN. Results of the test are presented in Table 2. Cassava plants showing low and very low degrees of cyanogenesis will be subjected to further quantitative analysis.

Scope of Activities.

In PRONAM's breeding program, selecting for low levels of HCN is the objective. However, the role of cyanogenesis, in determining the plants resistance to

diseases and pests, is not yet well understood. Hence, the breeding work in this aspect will take into consideration the possible role of cyanide in resistance to pests and diseases.

Table 1. Degree of cyanogenesis in cassava leaves of local and exotic cultivars.

Degree of HCN	Number of varieties (10 plants/variety)	% of Varieties
Very high	23	10.6
High	70	32.3
Medium	93	42.9
Low	22	10.1
Very low	9	4.1
Negative	0	0
Total	217	100%

Table 2. Degree of cyanogenesis in cassava leaves of some high yielding PRONAM clones.

Varieties	Average yield t/ha	Degree of HCN
A 56	23.3	High
70/4	20.7	Low
344/6	20.1	Medium
179/2	20.1	High
F 45	18.3	Medium
174/2	18.1	Medium
429/7	16.5	Medium
Mpelolongi	14.5	Very high
02864	13.8	Medium
280/7	13.0	Very high
122/2	12.6	Very high
93/1	12.4	High

Cyanide has been shown to vary with the geographical location, soil condition and climate. (De Bruijn, 1974; Polhuis, 1963). Little is known about these factors and the mechanism of their interaction to bring about an increase or decrease of cyanide in the tissues. It is important to study the effect of agronomically controllable factors such as time of planting, plant age and fertilizer use on the cyanide content of cassava.

Although we are concerned at this moment with the evaluation of cassava plants for low HCN, it would be useful to conduct surveys in order to know how cassava growers in Zaire who are themselves also processors view the problem of high and low cyanide content in relation to the processing and comsumption of cassava. Attention should be focused on the efficacy of traditional processing methods and their possible improvement to free cassava from cyanide.

In collaboration with appropriate laboratories in Zaire and outside, it will be necessary to know: 1) whether low lvevels of HCN as detected in the pricric acid test is due to low activity of limanarase or to actually lower levels of HCN and 2) whether unhydrolyzed (bound) cyanogenic glucoside is toxic as the hydrolyzed one and if so the level of toxicity to be expected from different cassava cultivars, irrespective of the level of HCN.

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Organization and Conducting of Multilocational Cassava Evaluation Including Cultural Practices

by

H.C. Ezumah and N.B. Lutaladio
IITA/PRONAM agronomist/project leader and agronomist

Certain questions should be borne in mind when conducting multilocational trails :

(a) What information is sought.

(b) What physical, biological and social environmental constraints are being evaluated.

(c) What locations are best suited to conduct the experiments.

(d) What level of cooperation can be expected from resident personnel.

If these and related questions can be answered to the satisfaction of the investigator, readily, then planning can be easier and information obtained can be meaningful.

Organizing the trials

Cassava clones, for example, selected by PRONAM need to be tested at different locations for their reactions to certain variables. Sites chosen may include areas having different soil types and elevations (altitudes) and, therefore, different temperatures, mean annual rainfalls, diseases and

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pest pressures, light intensities and vegetation.

As much as possible, these variables should be defined and noted; otherwise, one may not be able to interpret the data. Surveys carried out by the researchers or reports on the climate of the locations obtained from literature should be used to determine sites that satisfy the variables being tested. Tests should be limited to a few manageable variables in order to prevent confounding 1 effect with another.

Conducting the trials

Plot preparation, layout and plant spacing. Standard practices used in the areas should be employed. The method, whether flat, ridges or no-tillage, should be fully described. Early planting, soon after the first rains, is recommended. Standard plot layout used in international testing should be simple. It is suggested that an effective plot area should be 6 x 4m for varietal trials of cassava. If borders are included, the area becomes 8 x 6m. Randomized complete blocks with a minimum of 4 replications will be acceptable. The number of varieties for testing should not exceed 10. This makes management easy. Plant spacing usually employed by PRONAM is 1 x 1m. Whatever spacing is found optimal for a given location may be used for production, but for specific uniformity trials, standard uniform spacing must

be used. The project manager should provide the spacing to be employed to researchers or agents at each location. Stem cuttings selected for identical age and size should be used, and 30cm length is the usual size. Plant at an angle of 30-45°.

Weeding. At most, 3 weedings before the plants are 16 weeks old may be necessary. Weeding should be in response to necessity to weed.

Plant development. Information on plant development may be obtained by measuring several parameters at different ages. Simple parameters such as plant height, leaf number, branch number and vigor scores at 3, 6 and 9, or 2,4, 6, 8 and 10 months old could be very useful. Vigor scores usually include all growth parameters such as height, leafiness, growth and general ability of the plant to stand environmental and biological stresses. The scale is usually 1 (excellent vigor) to 5 (very poor vigor). A more complex and useful measurement is the leaf area on which complex photosynthetic reactions of the plant is based.

Diseases and pests. The major economic diseases are CMD, CBB and AD.

Other diseases of minor importance include white and brown leaf spots. Important pests are the cassava mealybug

and green spider mite. The seriousness of these diseases and pests are usually determined by severity or incidence scores. Severity is in a scale of 1 (no field symptom) to 5 (death). Incidence is determined by the number of plants attacked expressed as a percentage of total plant per plot (treatment).

Yield and other agronomic characters. To determine yield, the following procedures are recommended :

a) Count number of plants

b) Harvest the plants

c) Separate into marketable and nonmarketable roots and weight separately. The sum of these is the total root weight.

d) Gather the tops of plants harvested and weigh.

e) Record all information obtained.

Cassava Improvement in Zaire by PRONAM: Review of Breeding Activities

by

T.P. Singh
IITA/PRONAM plant breeder

PRONAM was initiated as a long-term project to improve cassava in Zaire. The objectives that concern cassava breeding are as follows : 1) to identify and develop improved varieties of cassava with high yield potential and suitable for different ecological areas of the country, 2) to identify and utilize sources of resistance to diseases for developing disease resistant varieties, 3) to identify and utilize sources of resistance to insects for developing pest resistant varieties and 4) to develop varieties of cassava with acceptable tuber quality and protein-rich, palatable cassava leaves.

To achieve these objectives, an interdisciplinary approach involving pathology, entomology, agronomy and breeding was envisaged.

At the beginning of the project, most of the local cultivars were susceptible to CBB; thus, there was a need to introduce more genetic variability for screening. More than 100,000 seeds introduced from IITA and from farmers' fields were planted at M'vuazi. A seedling nursery was

screened against diseases, particularly CBB and CMD, and suitable selections were made considering their agronomic characters and disease resistance. In addition to this, 200 indigenous and exotic clones assembled by INERA were established for evaluating their storage root potential and disease resistance. Contacts were established with some organizations, including INERA stations, for evaluating the selected materials under their supervision. The breeding material grown from 1974 to 1980 at M'vuazi and other locations is summarized in Tables 3a and 3b.

Clonal nurseries were established in 1975-76 at 17 different sites covering different ecological zones, forest, derived savannah and savannah, with the soils varying from deep forest, river valley, heavily eroded lateritic and Kalahari plateau sands in Bas Zaire and Bandundu. In all, 14,924 clones, 10,520 in Bas Zaire at 11 locations and 4,404 in Bandundu at 6 locations, were established for evaluation. Considerable efforts were made in transporting the planting material to these sites. Considerable enthusiasm was shown by the organizations in the growing of this material, which later-faded, and some fields were not well maintained resulting in the loss of material either through stealing or grazing or destruction by bush fire. Thus, at the end of the season,

Table 3a. Breeding activities of PRONAM in Bas Zaire, 1974-80.

GROWING SEASONS					
1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
S.N. ± 115,000	S.N.	S.N. Several thousand	S.N.	S.N. ± 10,000	S.N. 1,400
I. Coll. 200	I. Coll. 200	I. Coll. 200	I. Coll. 200	I. Coll. 200	I. Coll. 200
	C.N. 10520*	C.N.	C.N.	C.N. 1,735	C.N. 520
		P.Y.T. 401	P.Y.T. 1504+250	P.Y.T. 142	P.Y.T. 75+250
			A.Y.T. 38 + 15	A.Y.T. 39	A.Y.T. 31
			Ad. T. 15	F.Y.T. 13*	F.Y.T. 13*
				Ad. T. 12	
				Mult. 15 ha.	Mult. 45 ha.
				SP. Studies	SP. Studies Farm level testing
	*grown at 11 locations in Bas Zaire			*Planted at 4 locations in Bas Zaire	*Planted at 5 locations in Bas Zaire

S.N. : Seedling nursery C.N. : Clonal nursery A.Y.T. : Advanced Yield Trial Ad.T. Adaptive Trial

I. Coll. : INERA Collection P.Y.T. : Preliminary Yield Trial F.Y.T. : Final Yield Trial

Mult. : Multiplication SP. : Special Studies.

Table 3b. Breeding activities of PRONAM in other regions, 1974-80.

	GROWING SEASONS					
Region/Station	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
Bandundu *Materials grown at Kiyaka, Vanga and Iowa	-	S.N. - C.N. 4404*	S.N. C.N. P.Y.T. 89+100	S.N. - C.N. - P.Y.T. 22 A.Y.T. 24+32+10*	S.N. 2,100 C.N. - P.Y.T. 23+37* A.Y.T. 11 F.Y.T. 22+10*	-
Kasai Gandajika	-	S.N. 1,100 I. Coll. -	- -	S.N. 6,000	S.N. 5,000 C.N. 894	-
Kivu Zaire Mulungu Yangambi Luberizi	-	- -	-	S.N. 24,000	S.N. 5,000 C.N. 133+70	-
Haute Zaire Yangambi	-	S.N. 1,000	S.N. C.N. 37	S.N. - C.N. - P.Y.T. 19	-	-

S.N. : Seedling nursery C.N. : Clonal nursery A.Y.T. : Advanced Yield Trial Ad.T. : Adaptive Trial

I. Coll. : INERA Collection P.Y.T. : Preliminary Yield Trial F.Y.T. : Final Yield Trial

Mult. : Multiplication SP. : Special Studies.

very few clonal selections could be made at some of the sites. Apart from these 2 regions, where cuttings could not be transported, seedling nurseries were established at Yangambi (Haute Zaire) and Gandajika (Kasai).

Discouraged by the loss of valuable genetic material at most of the locations, the strategy to evaluate the material was modified. It was then decided to confine the materials to sites under direct supervision of the PRONAM staff or those who could be easily supervised from M'vuazi. Hence, another batch of seed, representing genetic variability, was introduced from IITA and Latin America. Added to this was the variability generated by local material and previous introduction from IITA. The material was grown in Bas Zaire at 2 locations, M'vuazi (river valley) and Kimpese (savannah). Part of the seed source was retained for distribution to out-stations for planting where PRONAM's staff were responsible.

At M'vuazi, in addition to the seedling nursery, preliminary yield trials with 140 clones selected from the 1975/76 clonal nurseries were established. The best INERA collections from the preliminary yield test stage were advanced for intensive yield evaluation. Outside the headquarters, clones selected for resistance to diseases

were re-established at Vanga and Lowa for preliminary yield evaluation. In Haute Zaire, a clonal nursery was established from the selections made out of the seedling nursery. From the seedling nursery at Gandajika, some selections were made.

During the 1977-78 season, activities of PRONAM were further expanded through the appointment of a staff member at Kiyaka (Bandundu), Gandajika (Kasai) and Mulungu (Kivu) stations. Seedling nurseries were established at M'vuazi and Kimpese (Bas Zaire), Kiyaka (Bandundu), Gandajika (Kasai) and Luberizi Valley (Kivu). Seeds for these nurseries came from IITA's cassava program, Latin America and open pollinated and artificially crossed seeds from selected clones at M'vuazi

At M'vuazi, apart from the seedling nursery, selected clones from the nursery were put in a preliminary yield trial, and those performing better than the local in the preliminary yield trial of last year were upgraded to an advanced stage and were established at 2 locations (M'vuazi and Kimpese) in Bas Zaire. Multiplication on a small scale was simultaneously taken up with some promising selections. An adaptive trial through farmers participating with the help of Groups Economie Rurale (GER) was initiated using the 15 best INERA lines.

At out-stations in Bandundu, a preliminary yield trial at Kiyaka (plateau) and an advanced trial each at Kiyaka (forest), Kiyaka (plateau sandy), Vanga (derived savannah) and Lowa (savannah) to evaluate 64 varieties were established. Single plants and clonal selections were made by personal visits at M'vuazi, Kimpese, Luberizi, Kiyaka and Vanga. At M'vuazi, a plant pathologist and an entomologist helped the breeder in the inoculation and screening of the material. As a result of this screening, 3 plants belonging to a Brazilian wild source were identified to show some resistance to the cassava mealybug. Unfortunately, these plants are difficult to clone. Therefore, to transfer their gene(s) for resistance, these plants were involved in hybridization with locally adapted and high yielding varieties. Some success has been achieved in obtaining the crossed seed. Hand pollination between selected clones was also done to recombine desirable characters. The resistance to diseases of the selected clones under advanced yield tests was confirmed by the PRONAM pathologist.

To continue the search for better sources of resistance to the cassava mealybug and green spider mite, genetic variability was further enriched in 1978-79 through introduction of seeds from IITA. The seeds introduced from

IITA and those produced at M'vuazi were distributed to Kiyaka, Gandajika, Mulungu and Mbandaka (Equateur). Approximately 125,000 seeds were planted at 7 different locations in 4 regions of Zaire. Seeds were also supplied to some Southern African countries on the request of some institutions involved in cassava development in these countries.

At M'vuazi, for thorough screening of the seedling nursery, a systematic procedure was developed based on the information generated by the studies of PRONAM's entomologist and pathologist. This procedure was put into operation in 1979, and the material was screened against CBB, CMD, AD and the cassava mealybug. Population screening after artificial infestation with the cassava mealybug resulted in the identification of 42 plants with some degree of resistance to the cassava mealybug. The resistance of these plants would be further confirmed under a controlled environment. In addition to the selection at M'vuazi, plant selections were made by the breeder at 3 locations in Bandundu.

To study the adaptiveness of the varieties selected from the advanced yield trial, a final yield trial comprising 13 varieties was established at 4 locations in Bas Zaire. Reliable results, however, were only obtained from 2 locations.

In addition to this, a clonal nursery, preliminary yield trials and advanced yield trials with promising selections were planted. The 6 best clones each from the INERA collections and from PRONAM material were planted by 12 farmers under their management practice.

At out-stations, yield trials to evaluate selected clones were conducted at Kiyaka (forest and plateau) and Vanga in Bandundu.

Performance of PRONAM material in Bas Zaire and Bandundu

Results of varietal evaluation based on early PRONAM selections and those selected at 2 locations in 1977-78 and 1978-79 revealed that PRONAM has some varieties that can yield up to 23 t/ha compared to about 14 t/ha from the best INERA selections (Table 4). These varieties have a higher degree of resistance to CBB, CMD and AD as compared to local variety 02864. These and some other high yielding varieties are presently under multiplication for farm testing and distribution. Variety 429/7, though not the best yielder, has shown some resistance to the cassava mealybug and, thus, can be used as a replacement to 02864 in areas with serious cassava mealybug problem. In addition to this material that is ready for farm testing and distribution, other good material is being developed.

Tabel 4. Root yield of some high yielding varieties at M'vuazi during 1977-78 and 1978-79.

CLONES	1977-78		1978-79		Average	Percent of 02864
	Mankewa	Mpalukidi	Mankewa	Mpalukidi		
A 56	37.1	-	16.4	16.3	23.3	168.8
70/4	36.1	12.6	19.5	14.7	20.7	150.0
344/6	42.5	14.8	12.3	11.0	20.1	145.6
179/2	37.7	15.5	15.9	11.3	20.1	145.6
F 45	23.1	-	20.0	11.8	18.3	132.6
174/2	33.3	18.1	11.2	9.8	18.1	131.2
429/7	24.6	12.2	18.2	11.0	16.5	119.6
02864	20.8	10.5	13.1	10.7	13.8	100.0

In the forest area of Bandundu, yields as high as 26.3 t/ha have been obtained from PRONAM selections. This yield is 2 times the yield of a local variety, Mundjoko. Some varieties selected from the INERA collection also show high yield levels (Table 5). In the plateau sand, varieties selected from the INERA collections as well as from PRONAM materials showed 4 times higher yield than the local variety, Mundjoko (Table 6). Research efforts are continuing for the development of high yielding and disease and insect resistant varieties for other regions of the country.

Future strategy and scope

PRONAM through its 5 years of existence has been able to arrest some disease problems while other problems such as the cassava mealybug and green spider mite still continue to threaten the production of cassava in different areas of Zaire. The scope of activities in coming years will be as follows :

1. The promising clones developed and identified to show high yield performance on research farms will be tested for their adaptability to varying conditions of soil and management on farmers' fields.

Table 5. Yield of some high yielding varieties at Kiyaka (forest).

Clone	Yield (t/ha)	Percentage of local
30577/5	26.3	208.7
F 150	24.1	191.3
F 112	21.8	173.0
F 100	19.9	157.9
F 162	18.0	142.9
F 156	17.4	138.1
Mundjoko	12.6	100.0

Table 6. Yield of some high yielding varieties at Kiyaka (plateau sand).

Clone	Yield (t/ha)	Percent of local
F 113	6.0	400.0
F 188	5.3	353.3
A 43	4.9	326.7
30741/5	4.1	273.3
D 149	3.3	220.0
30441/1	3.3	220.0
Mundjoko	1.5	100.0

2. Breeders stock of cassava varieties finally selected will be maintained and distributed to agencies involved in large-scale multiplication.
3. In the continuing search for resistance to the cassava mealybug and green spider mite, large populations of germplasm stock will be evaluated. This population will comprise the recombinations (open pollinated or hand crossed) made on site as well as the exotic introductions.
4. Resistance to the cassava mealybug observed in the Brazillian wild plants will be utilized in a hybridization program for the transfer of genes for resistance into locally adapted, high yielding varieties.
5. Evaluation of clones arising from steps 3 and 4 will be continued to develop varieties that can reach higher levels of production than presently available.
6. Breeding work in Kasai and Kivu will be strengthened further through large-scale evaluation of genetic variability.
7. Special studies will be initiated to find reasons for poor germination of seeds produced locally.

Agronomic and Related Work on Cassava Production in Zaire

by

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Zaire's mean cassava yield per hectare of about 7 tons is far below possible levels. Many factors contribute to low yields, including the use of low yielding unimproved cassava varieties; diseases, especially CBB, CMD and AD; pests, mainly the cassava mealybug and green spider mite; and poor management practices.

Recommendations for overcoming some of the problems are high yielding, disease and insect resistant varieties (Table 7) and good management practices.

Disease-free planting material. Use disease-free planting material to reduce the seriousness of CMD. Though secondary infection by white fly occurs, it is less serious and less injurious than primary infection originating and present in planting material used during establishment.

Soil. Use well-managed, mulched, fertile soil to reduce the seriousness of CBB and the cassava mealybug. Cassava growth is more vigorous in these soils than in highly drained sandy soils (PRONAM, 1977).

Table 7. High yielding cassava clones available at M'vuazi.

Varietal	Name	Yield*	Quality			Remark	Disease scores			
		t/ha	Pondu+	Fufu	Chikwangue	General	CMD	CBB	ANTH.	Vigor
PRONAM 1	30555/3	31.4	Good	V.Good	Good	Good	2	1	3	3
PRONAM 2	A56	28.6	Good	Good	Good	Good	2	2	2	3
PRONAM 3	30933/1	24.9	Good	Good	Good	Good	3	2	2	3
PRONAM 4	30179/2	26.6	Good	V. Good	Good	Good	2	2	2	3
PRONAM 5	30697/272	21.2	Unaccept.	Good	Good	Good	1	1	2	3
++ Sr No. ID.										
PRONERA 1	02864	20.7	Good	V. Good	Good	Good	3	2	3	3
PRONERA 2	154	17.8	Good	Good	Good	Good	3	3	3	3
PRONERA 3	108	22.7	Good	V, Good	Good	Good	2	3	3	3
PRONERA 4	40	19.2	Good	Good	Good	Good	3	3	2	3
PRONERA 5	45	23.1	Good	V.Good	Good	Good	3	3	3	3
PRONERA 6	146	15.8	Good	V. Good	V. Good	Good	3	3	2	3

Based upon 3 year average at 2 locations. (++) Based on 5-year average at 2 locations where it served as control.

(+) Pondu quality based upon feel, experience and visual observation of leaves.

CMD= Mosaic; CBB=Cassava bacterial blight; Anthracnose.

Time of planting. Always plant early in order to use the entire rainy season. The economic crop also utilizes N and other mobile nutrients mineralized during the dry season before they are leached off by rains. Studies at M'vuazi and IITA show that yield losses may be quite high with each month's delay in time of planting (Table 8a, 8b and 8c). Thus, later planting may result in up to a 50% reduction in cassava root yield irrespective of locations or systems, mixed or pure.

Land preparation. Land preparation for cassava is basically the same as for most other arable crops. In the forest, the bush fallow must be cleared and the land tilled. The amount of work required varies with dominant vegetation. In the savannah, the field is usually set on fire before plot preparation. All practices involving burning, though easier, should not be employed if alternative methods can be readily used.

Whether the field is prepared as mounds, ridges, flat-tilled or no-tilled depends upon soil type and drainage. Size of ridges or mounds and placement of crops on them are influenced by drainage. Thus, water-loving crops, such as rice, may be placed in the interspace between mounds or ridges in areas prone to water-logging while cassava, maize and legumes may be planted on the sides and/or tops

Table 8. Effect of time of planting on cassava establishment and root yield in S.W. Zaire.

8a) Sole Cassava :

Month planted	Average plants/ha (000)	t/ha fresh root			
		02864	Boma	Mean	%
November 1975	8.4	11.2	12.9	12.1	82
December 1975	10.0	16.5	13.1	14.8	100
January 1976	10.0	17.0	12.6	14.8	100
February 1976	10.0	22.2	9.6	10.9	74
March 1976	9.8	10.5	8.9	9.7	66
April 1976	10.0	8.9	8.3	8.6	58
May 1976	9.1	6.7	7.2	7.0	47
Average		11.5	10.5	11.1	
LSD (0.05)		2.8	1.8	2.2	

8b. Mixed : (02864).

	Sole Cassava	%	Cassava maize t/ha	%	Mean
Oct. Maize + Oct. Cassava	11.50	-	12.02	100	-
Oct. Maize + Nov. Cassava	20.44	100	10.80	90	100
Oct. Maize ± Dec. Cassava	17.68	86	12.17	101	96
Oct. Maize + Jan. Cassava	13.85	68	8.42	70	71
Oct. Maize + Feb. Cassava	9.90	48	10.60	88	66
Average	14.67		10.80		

8c. Effect of delayed planting on root yield (t/ha) of late cassava in S. Nigeria.

Month planted	Cassava alone	% June yield	Maize / cassava	% June yield	Mellon / cassava	% June yield	Average	%
June	10.8	100	9.5	100	11.2	100	10.5	100
July	9.7	90	8.9	94	9.4	84	9.4	89
August	6.9	64	6.5	69	7.0	63	6.8	65
September	6.7	62	8.1	85	7.9	71	7.6	78
October	4.9	41	4.7	49	4.4	39	4.5	44
Average	7.7		7.5		8.0			

of ridges. Where there is no danger of standing water, ridging, mounds or flat planting of cassava gave no advantage in root yield. This has been observed in Zaire (M'vuazi and Kimpese) and in Nigeria (Okigbo, 1978). No tillage may give poor yield owing to high weed growth and competition with cassava.

The extent of bush clearing may not be related to land preparation needs of cassava; thus, complete destumping may be required in forest areas if there is an established history of root rot caused by Formes lignosus for which several forest trees are alternate hosts. This is suspected to be the case in the Yahuma area of Haute-Zaire, an equatorial area where this epidemic caused big losses in cassava yields in 1976 and 1977. Recommended practices include harvesting early (8-10 or 11 months), removing all old plant debris from the field during land preparation, avoiding areas prone to water-logging and removing trees stumps before planting.

Population and spacing. Spacing and population varies with the cassava cultivar, its branching habit and its rate of leaf cover development. Spacing is also related to soil type and moisture regime. Thus, some authors report higher yields at 1.5 x 1m.

(6,600 plants/ha) spacing (Okigbo, 1979) while others report higher yields at 1 x 1m (10,000 plants/ha) and 1 x 0.67m (15,000 plants/ha) (Hahn et al, 1979; IITA, 1974; Unamah, 1976). In the M'vuazi river valley with alluvial soils and a higher water table, the yield from 26,000 plants/ha (18 t/ha) was slightly higher than that from 10,000 plants/ha (21 t/ha) leading to a belief that 10,000 plants/ha was more economical. In the sandy Mpalukidi with a higher water infiltration rate, there was a 50% reduction in yield at the higher population indicating that where moisture could be limiting, it is better to use a low population. In general, a population of 10,000-15,000 plants/ha gives a good crop of cassava.

The planting arrangement may vary between 0.9-1.5m between rows with the row spacing adjusted to bring the population to 10,000-15,000 plants/ha. The double row cassava planting system common in Bas Zaire gives root yields comparable to 1 x 1m spacing. In the double row pattern, (stem) cuttings are spaced 50cm apart on ridges 1-1.5m apart.

When spacing is too wide and the plant is unable to produce leaf cover fast enough to cover intervening spacings, weed competition becomes a big problem.

Weed control. One of the most important factors limiting the area a farmer can plant are weeds. Weed control absorbs more than 40% of the labor required in cassava production. The experience of the GER at M'vuazi showed that when 1 of the factors that limits the area a farmer can handle was solved, another was readily imposed. Thus, GER used tractor power to prepare larger areas of cassava for each participating farmer in the 1976-77 season. Out of 33 participating part-time and full-time farmers who were given prepared land areas of 200 x 50m, only 6 farmers or 20% could cope with weeding the 1 ha. Eight farmers abandoned half of their plots to weeds while 2 abondoned all their plots only to harvest what they could from a complete fallow 1 year later. All participating farmers planted all the area provided indicating that planting was not a limiting operation in the study.

For good cassava development and yield, weeding must be frequent and timely, especially during the first 12 weeks. Late weeding may result in 40-60% yield loss (Akobundu, 1980, Moddy et. al., 1974; PRONAM, 1978). Hoe weeding is laborious, but it is still the main method of weed control in cassava culture. Excellent herbicides have been identified, but their utility is limited by knowledge, lack of water for

application and by the mixed cropping system of cassava (Akobundu, 1980).

Fast growing cassava cultivars planted at the recommended population may produce enough leaf cover to shade off weeds within the first 12 weeks. Such clones as 30555/3 and 02864 are available at M'vuazi. Other methods to be considered and for adoption include the use of Pueraria and Stylosanthes as mulches, which may be killed with paraquat, and cassava planted with the no-tillage system. Mulching is also excellent in suppressing weed growth, but this is limited by the availability of mulching materials. PRONAM's results from sandy soil areas and rich alluvial soil types, each locations dominated by different weed types, show that from 2 to 3 hand weedings at 30, 60 and 105 days after planting are enough for good weed control (Table 9).

In a study in which different levels of management were compared using an improved variety (02864) and a local cultivar (Mpelolongi), the following was found :

a) 1 weeding at 45 days resulted in an average yield loss of 54% for the 2 varieties, b) 2 weedings at 30 and 60 days resulted in an average loss of 49% c) 3 weedings at 30, 60 and 105 days was as good as the same treatment with mulch, d) a costly advanced

treatment in which mulching, 80 kg/ha NPK : 15-15-15 and insecticides, malathion and rogor to control the cassava mealybug and green spider mite, respectively, resulted in only a 17% average yield increase (Table 10). The increase in yield due to the advance treatment was more for the local, highly susceptible Mpelolongi (27%) than for the improved 02864 (7%) (Table 10). This experiment has been repeated in sandy soil and alluvial soil deposit areas of M'vuazi.

Fresh weight of weed at harvest varied from 34 t/ha (100%) for very low input through 30 t/ha (87%) for low input to 20-21 t/ha for adequate, high and advanced treatments (Table 11). By the time of harvest, the field was regenerating into fallow. A lack of difference in weed weight for the adequate, high and advanced input levels confirm that with 3 weedings, mulching is not necessary to control weeds in cassava culture under the ecoclimatic conditions at M'vuazi.

Table 9. Effect of weeding frequency on cassava root yield.

Weed treatment	Mankewa 1976/77 Alluvial t/ha	weed free %	Mpalukidi 1977/78 Sandy-Clay t/ha	weed free %
0. No weeding	0	0	1.2	10.1
1. 30 days	9.1	23.4	2.1	18.1
2. 30, 60 days	31.5	81.4	4.3	37.3
3. 30, 60, 105	44.8	115.5	9.4	80.0
4. Weed Free	38.8	100.0	11.6	100.0

Table 10. Effect of management levels on cassava root yield.

Level of Management		Mpelolongi (Local) t/ha	%	02864 (Improved) t/ha	%	Average t/ha	%
V. Low:	1 weeding at 45 days	7.0	43	8.3	51	7.7	46
Low:	2 weedings at 30, 60 days	5.4	33	11.4	70	8.4	51
Adeq.:	3 weedings at 30, 60, 105	12.1	74	14.9	91	13.5	82
High:	" " " + mulch	12.0	73	15.2	93	13.6	83
	(+ mulch)	16.4	100	16.4	100	16.4	100
	(+fertilizer)						
	(+ insecticides)						
	Mean	13.10		13.2		11.9	
	LSD (0.05)	4.7		2.9		3.3	

Table 11. Fresh weight of weed at harvest.

Level of management	Mpelolongi t/ha	02864 weed	Average t/ha	%
Very low	24.6	43.1	33.9	100
Low	26.1	33.1	29.6	87
Adequate	20.6	21.3	21.0	62
High	21.4	18.1	19.8	58
Advanced	24.4	15.6	20.0	59
Average	23.4	26.2	24.9	
LSD (0.05)	2.0	10.1	5.7	

Planting material and planting. The planting material used in commercial cassava production are cuttings 25-30cm long preferably from disease-and insect-free fields 12-18 months old. The following observations have been documented: a) older cuttings give higher root yield (Enyi, 1970; PRONAM, 1979); b) cuttings are usually planted with 2/3 of the older end buried obliquely in the soil; c) root yield and plant establishment are significantly reduced when cuttings are planted upside down (Onwueme, 1978); d) given optimum growth conditions, young cuttings are more readily established than stumps and primary stem cuttings. They also dehydrate and die more readily under an adverse environment, e.g.

moisture stress or water logged conditions. Maximum sprouting may occur between 5 and 10 days depending upon the age of the cutting (the young cuttings establish faster).

Planting methods vary from upright, horizontal and slanted positions in which 2/3 of the length of the older end of the cutting is buried at an angle of 30-45° to the ground surface. Results of effects of planting positions on root yield vary from no difference (PRONAM, 1978b) to higher yields from slanted positions (Unamah, 1976). Significant increments in leaf yield, number of stems per plant and reduced lodging have been noted from horizontally planted cuttings compared with slanted and upright.

Of great importance is the preservation of cassava planting materials. Production of cuttings is a slow process. In general, one requires 1 year and 1 ha of field to produce enough cassava cuttings to plant from 6 to 10 ha. Therefore, cassava should be harvested when there are chances of reutilization of a large part of the cuttings.

A method of conserving planting materials is to stack them upright under shade in a shallow ditch with the base covered with soil. This method is useful only

when the soil is moist enough for the plants to root. An organization such as PRONAM cannot produce enough planting materials for commercial use by everyone. Therefore, each interested organization must start with a small quantity of improved cassava and do its multiplication and conservation of the materials by itself.

Mixed Culture. It is beneficial to plant cassava in mixtures with other crops such as maize, peanuts, bean, etc. By planting cassava alone, farmers lose a considerable amount of revenue. However, cassava and the accompanying crops must be planted early in the growing season in order to take advantage of the rainy periods.

Studies by PRONAM show that by not mixing cassava with peanut, for example, farmers lose up to 46% of their possible revenue (Table 12). Also, there is no yield reduction between cassava and maize planted at the same time or when cassava is planted through October maize in November, December or January.

Leaf harvest. Very frequent leaf harvests result in reduced root yield. If limited to once a month, no loss in root yield occurs, and root yield may actually increase when leaf harvest is once in 2 months for cultivar 02864 but not for Mpelolongi. Revenue from leaves are high and may be up to 5 times that from roots. However, this is

Table 12. Effect of planting pattern and intercrop with peanut on cassava and peanut yields.

Treatments	1977/78 Peanut (kg/ha)	Rev.	Cassava (t/ha)	Rev.	Total Revenue Z/ha	Revenue as % Sole manioc
1. Double Row Cassava (DRC)	-	-	13.9	2085	2085)	76
2. 75 cm x 100 cm Cassava	-	-	17.8	2670	2670)	97
3. 100 cm x 100 cm Cassava	-	-	18.4	2760	2760)	100
4. DRC + Peanut 50 x 10^3	500	1750	15.2	2280	4030	146
5. DRC + Peanut 100 x 10^3	613	2146	12.1	1815	3961	144
6. 75 cm x 100 cm + Peanut 50 x 10^3	384	1218	10.4	1560	2778	101
7. 75 cm x 100 cm + Peanut 100 x 10^3	690	2415	6.8	1020	3435	124
8. 100 x 100 + Peanut 50 x 10^3	334	1169	10.9	1635	2804	102
9. 100 x 100 + Peanut 100 x 10^3	639	2237	9.0	1350	3587	130
Means :	527	1823	12.7	1908	3123	
LSD (0.05):	116	427	2.6	385	430	

hardly the case because leaves are easily perishable. Frequent leaf harvests increase the incidence of CBB and CMD (Table13).

Slopes. Preliminary data from PRONAM studies suggest that farmers may be losing 50% or more of their potential yield by planting cassava on slopes greater than 10% irrespective of the method of land preparation (Tables 14a and b). Where such a terrain must be used, it seems preferable to plough and and plant cassava on flat rows instead of on ridges. Loss of top soil and nutrients by erosion are high at high slopes in high rainfall areas. More detailed study along the lines suggested in this preliminary evaluation is recommended.

Table 13. Effect of leaf harvest on root and leaf yield and on incidence of CMD and CBB.

Harvest frequency	Kangu	02864	Kangu	02864	Kangu		02864	
	t/ha	root	t/ha	leaf	CMD	CBB	CMD	CBB
V. Regular	4.9a*	15.4a	5.7	6.9	5.0	4.8	4.8	2.5
Once a month	11.0b	25.2b	22.7	24.5	4.5	2.8	4.8	2.3
Once 2 months	14.0c	35.8c	16.3	17.6	3.0	1.8	2.8	2.0
Control	14.5c	30.2c	-	-	3.0	2.2	2.2	2.2

* Values within a column followed by the same letter are not significantly different at 0.05 level.

Table 14. Effect of slope and cultivation on cassava root yield.

Table 4a. Low slopes :

Percent slope	Flat, ploughed and mulched		Large ridges along slope (4 meters)		Flat ploughed		Small ridges		Flat unploughed	
			kg/6 m^2							
	kg	%	kg	%	kg	%	kg	%	kg	%
10	1.5	19	2.7	42	4.0	78	3.0	50	3.5	100
0	5.2	65	7.2	113	4.6	90	5.4	90	2.3	66
7	7.0	88	4.9	77	3.6	71	3.8	63	0.3	9
5	7.0	88	4.8	75	3.7	73	3.8	63	0.1	3
0	8.0	100	6.4	100	5.1	100	6.0	100	0.3	9

Table 14 b High Slopes:

Percentage Slope	Flat, ploughed mulched		Large ridges along slope (4 meters)		Average	
	kg	%	kg	%	kg	%
23	0.5	6	-	-	-	-
22	0.7	9	0.1	2	0.4	6
20	0.6	8	0.2	3	0.4	6
18	0.7	9	0.3	5	0.5	7
15	1.5	19	0.3	5	0.9	13
12	1.0	13	0.5	8	0.8	11
11	1.2	15	1.9	30	1.5	21
10	1.5	19	2.7	42	2.1	29
9	5.2	65	7.2	113	6.2	86
7	7.0	88	4.9	77	5.9	82
5	7.0	88	4.8	75	5.9	82
0	8.0	100	6.4	100	7.2	100

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Some Important Economic Factors in Cassava Production and Reasons of Predominance of Cassava as Food Crop in Zaire

by

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Cassava is now the most important food crop in Zaire. Cassava has developed considerably in Africa since its introduction in the seventeenth century from Latin America. It is grown in all the hot regions of the world.

The importance of cassava in Zaire is shown by its large cultivated area, its role as a staple food, comprising about 57% of the caloric intake by an average Zairean. It is grown throughout Zaire.

Planting is done at the beginning of the rainy season in the tropical regions while in the equatorial regions planting is done at any time. Cassava may be grown as a sole or more commonly in association with maize, groundnut, beans, etc. The yield is higher in the equator (15 t/ha). Following the epidemic of the CBB in some parts of Zaire in 1970, there have been a slow increase of cultivated areas since 1974.

Although cassava is deficient in proteins and vitamins, cassava roots are a very important source of energy. Cassava

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Table 15. Production, cultivated areas and yield of cassava in Zaire (1974-78).

Year	Production (1000 t)	Area (1000)	Yield (t/ha)
1974	11,447.3	1,647.7	6.95
1975	11,844.1	1,688.2	7.02
1976	11,909.7	1,724.3	6.91
1977	12,138.7	1,759.1	6.90
1978	11,778.9	1,778.2	6.62

Source : Department de l'Agriculture, Ann. Stat.

leaves or "pondu" on the other hand, contain high levels of proteins, vitamins and mineral elements. The value of food intake based on cassava is somehow improved by the culinary practice where fish, meat and other foods are added to pondu. Table 16 gives the comparison in nutritive value between cassava products and other staple foods.

The marketing of cassava chips, fufu and "chikwangues" takes place at various levels: in the village, between villages and with merchants from afar. Although the marketed volume seems small at the village level, it becomes important and organized at the merchant level.

Motivated by the profit in the urban centers, bigger merchants who have means of transportation arrange for

evacuation of processed cassava on a regular basis. They order in advance and fix the collecting dates. The merchants sometimes, when going to the villages, bring along manufactured products such as soap, salt, clothers, etc., for sale. In return, they buy cassava and other agricultural products for sale in towns. More often, there exist many intermediate merchants between the producers and the consumers.

Table 16. Comparison in nutritive value between cassava products and other stample foods (per 100g dry weight) (After Ezumah, 1980).

	Cassava tuberous root	Cassava leaves	Cassava flour	Maize flour	Yam	Plantain	Spin-ach leaves
Calorie	109-168	53	338-352	363	30-105	75-127	44
Proteins (g)	0.7-1.0	7.0	1.5	8.4	2.1-2.4	0.8	4.0
Vitamin A (IU)	0	10,000	Traces	300	Traces	0-600	13.0
Vitamin B_1 (mg)	0.2	0.14	(0)*	0.18	0.08	0.04	0.15
Vitamin B_2 (mg)	0.1	0.26	(0)	0.08	0.03	0.03	0.25
Nialin (mg)	0.6	1.5	1.0	(0.06)	0.4	0.4	0.85
Vitamin C (mg)	30	3,000	0	(0)	9	11	100

*Figures in brackets are estimates.

Each intermediate merchant wants to make a big profit on the product and, thus, contributes to the high price of the product faced by the consumer. In fact, the purchasing price and the selling

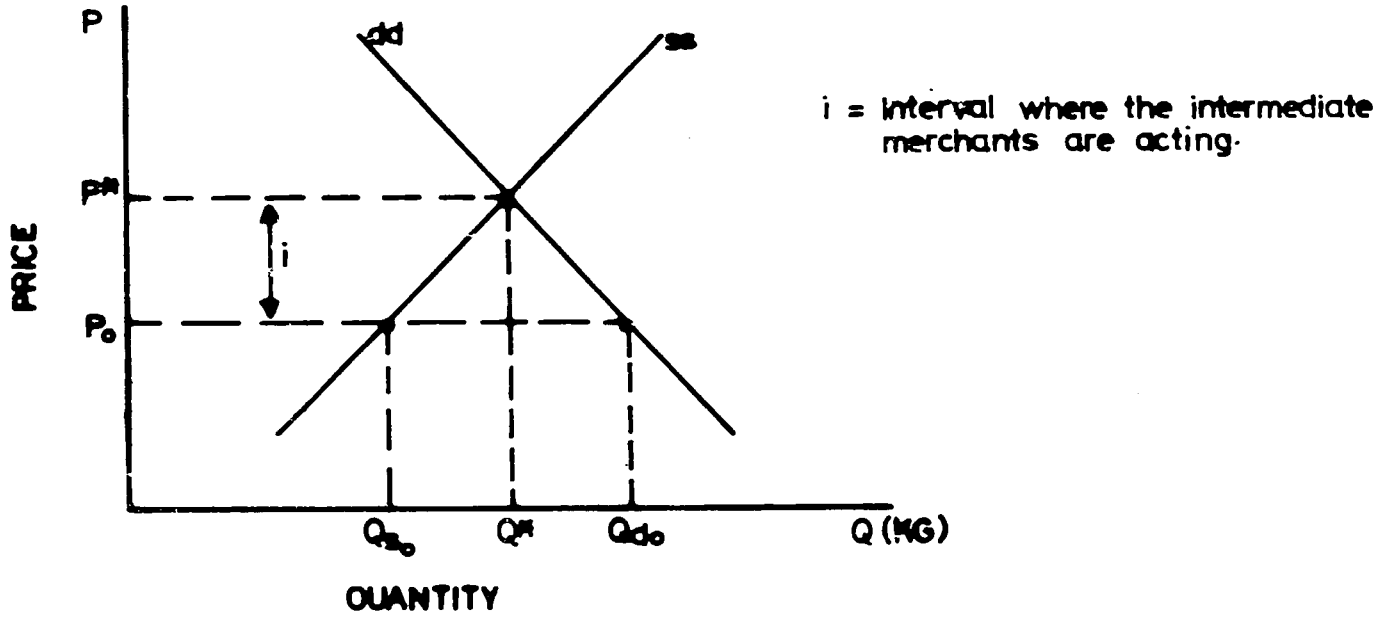
price fixed by the government are not in line with the equilibrium price between the offer and the demand of cassava (Fig. 1). The fixed price is usually low, and there are always some persons buying cassava to resell at a high price.

This situation will continue as long as the equilibrium price is not reached. The bigger the difference between the fixed price and the equilibrium price, the more there are intermediate merchants. On the other hand, if the fixed price was equal to the equilibrium price, nobody would like to buy at this price for reselling at a higher price. The market should have been balanced, and all the intermediate merchants automatically reduced (Fig. 1).

At price Po, the demand (Qdo) is higher than the offer (Qso) leading then to an unbalanced market and the interference of intermediate merchants (Fig. 1).

Some cassava production constraints.

Although cassava is adapted to various soils, the cultural practice used can improve yield. Crop and land rotations are recommended for good soil conservation. Cassava is always at the end of the rotation. Apart from soil types, climatic factors influence cassava production.



P^* = Equilibrium price

Q^* = Demanded and offered quantity at a balanced market

P_o = Government fixed price

Q_{so} = Offered quantity at price P_o

Q_{do} = Demanded quantity at price P_o

Fig 1. Marketing factors affecting production of a commodity

Cassava is adapted to equatorial rains well distributed throughout the year. It can stand a more or less long dry season, but then the tuber yield may be reduced. Lack of sufficient labor is an important limiting factor in cassava production. More than 50% of the total labor is consumed by processing works after the harvest. To process cassava roots into dried chips, flour and chikwangue consumes a lot of labor and time. It is, therefore, important to find some other new processing techniques capable of improving the productivity per individual and per unit of time. Ignoring this difficulty could lead to the substitution of cassava by an alternative, more economic crop.

Finally, various cassava diseases and pests are serious constraints. The quality of the material used in planting, appropriate cultural practices and use of resistant plants are some of the ways of overcoming these constraints.

Predominance of cassava production in Zaire.

As mentioned earlier, the largest cultivated areas are occupied by cassava. This is not a hazardous situation; it is the result of some special advantages gained by a family cultivating cassava. Contrary to the general belief, the predominance of cassava in terms of cultivated areas is not due to its importance in the food intake of the population.

Because of its easy production with less complicated cultural practices and its adaptations to various soils and climates, cassava is the "savings-bank" and a certain source of income for the farmer's family.

Cassava can be left in the soil and harvested as required. Thus, it protects the farmer from unfavorable market fluctuations. Harvest can be delayed while waiting an improvement in market price. Convenience in storage by leaving the plants unharvested is also a means of providing for some unexpected family expenditures such as sickness, school fees and burial expenses. Cassava is also a safety-valve for the farmer's family income. Risks of loss and the cost of the storage in the soil are almost nonexistent in comparison to other food crops.

These above reasons explain the predominance of cassava on cultivared areas and its important place in the food intake of Zaireans.

Some orientations to follow for a better cassava production.

PRONAM and IITA have realized very successful work with regard to cassava agronomy. They have generated some cassava varieties resistant to CBB and are still selecting cassava clones for quality and for resistance to diseases. The big tasks remaining include making these technologies available

to farmers.

The improvement of technology for processing cassava tuberous roots into various marketed products is still a very important aspect for economic cassava production. The main economic objective is to reduce the time and the labor required for various operations done after harvesting.

Finally, the improvement of marketing circuits for an equitable remuneration to the producer and a better price for the consumer is an urgent policy to be taken into consideration. This policy will contribute to the regular supply of town and to price stability.

In conclusion, it may be important to reemphasize that if cassava is cultivated on large scales in Zaire, it is not only because it is a staple food of many Zairians but because of its ease of production and many advantages it provides. That it is a staple food plays a secondary role.

The consumers in the town complain about the presence of intermediate merchants. This is the result of a deficient policy of unrealistic fixed prices by policy makers. Once the fixed price is equal to the equilibrium price of the cassava marketing, the intermediate merchants will no longer exist.

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SECTION II

Pests of Cassava

Cassava was once regarded as a crop immune to pest attacks. Only the grasshopper (Zenocerus) was known to be a serious dry season insect. Serious pests of cassava, most of which cause up to 60% root yield loss and 100% leaf yield loss now include the cassava mealybug (Phanacoccus manihoti) and the green spider mite (Mononychellus tarajoa). Nematodes and weeds can also be regarded as important pests of cassava.

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Plant-parasitic Nematodes on Cassava

by

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IITA nematologist

Introduction

Cassava (*Manihot esculenta*) is one of the major sources of food energy for many of the millions of people who live in the tropical regions of the world. The globa importance of cassava has increased in recent times from the need of food for more people, utilization as specialized starches, a source of animal feedstuffs and a raw material for industrial uses. Annual production exceeds 100 million tons of raw roots making cassava of considerable importance in total world output of foodstuffs. It is also of considerable social, economic and political importance in that almost the total production of cassava is in developing countries.

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Perspective.

In this world of living things, nematodes are probably the most numerous amongst multicellular animals. In a rich soil as many as 14,000 million nematodes could be living in a single hectare.

Nematodes are sometimes known as eelworms or roundworms and live wherever there is food to support life - from tree tops to ocean depths, hot deserts to polar ice, hot springs to chilled mountain streams, and, of course agricultural soil and plant roots. Except for what they do as plant parasites, nematodes are seldom noticed because of their small size and hyaline appearance. Some of the nematodes inhabiting soil and water feed on bacteria, fungi and algae as well as other small animals including other nematodes. Many soil-dwelling nematodes feed only on higher plant forms causing disease or functioning as an active agent in a disease complex with bacteria or fungi. Some nematode species harbor and transmit virus diseases of plants. Virtually every plant and crop has its nematodes parasites and some nematodes are parasitic on many crops. Crops are affected by nematode kinds and numbers with the interplay of environmental factors such as plant cultivar, soil type, fertility, moisture and temperature.

Table 1. Plant-parasitic nematodes associated with cassava with their geographical distribution.

Nematodes	Location and Literature citation
Aphelenchoides spp.	Brazil (46)
Aphelenchus avenae	Brazil (46)
Criconemoides Citri	Malagasy Republic (28), Togo (23,30)
Criconemoides spp.	Nigeria (5), Trinidad (4)
Ditylenchus dipsaci	(48)
Helicotylenchus cavenessi	Nigeria (6, 47)
Helicotylenchus dihystera	Brazil (46), Nigeria (5)
Helicotylenchus arythrinae	Nigeria (47), Togo (23)
Helicotylenchus longicaudatus	Nigeria (47)
Helicotylenchus microcephalus	Nigeria (6, 47)
Helicotylenchus multicintus	Nigeria (5, 47)
Helicotylenchus pseudorobustus	Nigeria (6, 47)
Helicotylenchus spp.	Togo (33), Trinidad (4)
Hemicriconemoides cocophilus	Nigeria (5)
Hemicriconemoides mangiferae	Brazil (46)
Hemicrycliophora oostenbrinki	Nigeria (5)
Hemicycliophora spp.	Brazil (46), Nigeria (5)
Heterodera spp. juveniles	Nigeria (5)

Nematodes	Location and Literature citation
Hoplolaimus pararobustus	Nigeria (5)
Macroposthonia spp.	Brazil (46)
Meloidogyne arenaria	Nigeria (5)
Meloidogyne incognita	Brazil (46), Ghana (25), Ivory Coast (27), Nigeria (5), Tanzania (21), Zimbabwe (31). (32).
Meloidogyne incognita, race 2	Nigeria (8, 9).
Meloidogyne javanica	Nigeria (5)
Meloidogyne spp.	Brazil (3, 5), Cape Verdian Republic (49), Colombia (10, 35), Ecuador (18), Ghana (16, 17, 26), India (38), Ivory Coast (34), Peru (19, 20), Togo (33), Trinidad (4), USA, Florida (36) and Hawaii (39).
Peltamigratus holdemani	Brazil (46)
Peltamigratus nigeriensis	Nigeria (6)
Pratylenchus branchyurus	Ivory Coast (34), Nigeria (5), Togo (23, 30).
Pratylenchus coffeae	East Java, Indonesia (22)
Pratylenchus spp.	Nigeria (5), Togo (33), Trinidad (4)
Rotylenchus reniformis	Brazil (46), Ghana (41), Jamaica (15), Marie galante, West Indies (45), Nigeria (5), Pueto Rico (2)
Scutellonema aberrans	Nigeria (5)
Scutellonema bradys	Nigeria (5), Togo (29)

Nematodes	Location and Literature citation
Scutellonema cavenessi	Nigeria (5)
Scutellonema clathricaudatum	Nigeria (5, 6), Zaire (1)
Scutellonema spp.	Nigeria (5)
Tyleochus spp.	Brazil (46)
Kiphinema attorodorum	Nigeria (5)
Xiphinema ebriense	Nigeria (5)
Xiphinema ifacolum	Nigeria (5)
Xiphinema longicautum	Nigeria (5)
Xiphinema nigeriense	Nigeria (5)
Xiphinema rotundatum	Nigeria (5, 7)
Xiphinema setariae	Nigeria (5)
Xiphinema spp.	Brazil (46)

Plant-parasitic nematodes associated with cassava plants

Considering that cassava is one of mankind's major sources of carbohydrate and is a major factor in the economics of some countries, they study of nematodes pests of the crop has received scanty attention. However, early reports of nematodes on cassava (13, 36, 42, 48) and the fact that nematodes on cassava are widespread, is well documented (5, 14, 24, 29, 31, 37, 38, 39, 40, 51). Only minor segments of the world's cassava growing areas have been explored for plant-parasitic nematodes. The nematodes species and their locations reported in the literature are listed in Table 1.

Meloidogyne species, The root-knot nematodes

The root-knot nematodes are of great economic importance throughout the tropics and warmer regions of the world. Some root-knot nematodes species are well adapted to the cold climates and are agricultural pests there as well. The distribution of this group of nematodes is worldwide and they have the ability to parasitize an extensive range of crops and plants. Root knot nematodes can also be involved in disease complexes with fungi and bacteria. The several species of root-knot nematodes attack nearly every crop that is grown reducing yields and product quality as well.

Disease

Root-knot nematodes attack the root systems of cassava causing a reduction and disruption in the functions of fine feeder roots. Root galling occurs on small roots and in the more susceptible cultivars, the storage roots can be galled and distored as well. Thus cassava quantity and quality can be affected.

Crop losses

Sasser (44) estimates cassava yield reduction throughout the tropics as about 6 percent of total production. This equals a loss of about six million tons annually from the world's food supply. Caveness (8, 9) demonstrated storage root reductions up to 87 percent in pot tests of cassava grown from seed (Fig. 1). Maximum reduction in feeder root weight and plant height were 44 and 52 percent, respectively.

Biology

The biology and life history of the several species of root-knot nematodes are similar. The female nematode matures in root tissue to produce upward of 300 to 500 eggs into a gelatinous egg sac. The egg sac is usually outside the root in the soil but egg sacs can be within roots as well. The gelatinous egg sac completely envelops the eggs and offers protection particularly against desiccation. Generally, males are not necessary for reproduction.

The first molt of the juvenile nematode occurs within the egg. The infective second-stage juvenile hatches from the egg and enters the root. Points of penetration are usually root tips, minor wounds or sites or previous entry. Once established at a feeding site in the root, the juvenile body thickens and undergoes an additional three molts to enter the adult and reproductive stage the cycle is repeated. Egg laying generally begins about 21 days after root penetration.

Symptoms

The group of root-knot nematodes take their common name from the galls or knots the infections produce on roots, tubers and other underground plant parts. The galls occurs singly and often coalesce to form a string of knots on roots. Sometimes root tips are devitalized and their growth stopped. The roots of some of the more susceptible plants form massive galls several centimeters in diameter. In these severe instances of a massive attack, the feeder root systems is totally destroyed. Multiple and repeated infection is commonplace.

Above ground disease expression can be seen as reduced plant vigor and growth, early wilting on warm days, and other symptoms of plants with a reduced root system.

Other host plants

The genus Meloidogyne contains 38 described specis. Of these, four species cause most of the losses to food crops. Three species are common and widely distributed in the tropical zone. M. incognita is comprised of at least four races and is encountered most often (43). M. arenaria appears to have two races. There is considerable uniformity in host response amongst the species. Collections from widely separated geographic regions have shown that M. incognita population do not reproduce on groundnut, M. hapla populations do not reproduce on watermelon and populations of M. arenaria, M. javanica and M. hapla do not reproduce on cotton. Since the root-knot nematodes collectively attack almost all crops, the accurate identification of species and rate is essential for proper recommendations on rotation schemes and cultivar selection to minimize losses to these nematodes.

Distribution

In worldwide cooperative survey Sasser (43) found that M. incognita and M. javanica together made up 80 percent of all the root-knot nematodes encountered. The other root-knot nematode common to the tropics M. arenaria, occured 4.5 percent of the time. Population mixtures of root-knot species occur frequently.

Control

Cultural control including the use of selected crop rotations and nematodes resistant cultivars, where available, are effective (11, 12). Weed control increase the efficiency of the cultural control methods. Root-knot nematodes are effectively killed by nematicides but the economics of their use need be carefully considered.

Pratylenchus spp., The root-lesion nematodes

The root-lesion nematodes occur abundantly worldwide in tropic, subtropic and cool climate soils where crops favorable to their development are grown. The root-lesion nematode group has a wide host range and can attack and damage crops which include cassava, pineapple, potato, groundnut, cowpea and maize. The root-lesion nematodes have been found associated with fungi and bacteria in plant disease complexes.

Disease

All life stages, adults and juveniles, can penetrate and exit root tissue. Invasion is generally at the root tip, in the root hair zone and at the junction of lateral roots. The nematodes feed on the cortical parenchyma resulting in cavities due to death of the cells. In many host plants these appear as brownish elongate lesions which sometimes rupture the epidermis. In a favorable host plant the entire

root system can be affected showing a lack of feeder roots and exhibiting a general necrosis.

Crop losses

Data on yield and quality reduction in cassava attacked by root-lesion nematodes are not available.

Biology

Eggs are laid in root tissue or in the soil singly and without protection of an egg sac. The first molt occurs in the egg and after the fourth molt the nematode is a mature adult. In warm tropic soils one generation can be completed in four to six weeks. Cooler temperatures can extend the generation time to several months.

Symptoms

The lesions formed by the root-lesion nematodes are generally small initially. Further enlarging and coalesing often causes root pruning. Severely affected plants are easy to pull from the ground due to the destruction of the root system. Lesser affected plants exhibit varying stages of root survival with many more roots near the soil surface. Individual roots can be discolored and coarse in general appearance due to a lack of fine feeder roots. Above ground symptoms are reduced plant growth and vigor and the general expressions of plants lacking a good root system.

Other host plants

The root-lesion nematodes form a large group of about 37 species. Each species has a wide host range covering widely separated kinds of plants in the plant kingdom. The available information indicates that all plants infected by a particular species are not equally suitable host plants as shown by variations in nematodes population increase and degree of root damage. A single plant species can be simultaneously invaded by more than one species of root-lesion nematode.

Distribution

Root-lesion nematodes occur worldwide in tropic, subtropic and temperate climates with some species apparently being better adapted to particular zone. The extensive host ranges of the several species allows for their survival on weeds, trees and shrubs in the absence of a preferred food crop host.

Control

The several species of root-lesion nematodes build up populations on different host plants at different rates. This indicates that control by crop rotation may be feasible when the necessary research is available on crop-nematode relationships. Root-lesion nematodes in soil can be controlled by nematicide application and chemical dips can be effective against nematodes in bare root stock.

Helicotylenchus spp., The spiral nematodes

The spiral nematodes are the most commonly encountered plant-parasitic nematodes in the soil. Some species of spiral nematode is usually found in almost every soil sample examined. Spiral nematodes can be found in the tropic, subtropic and temperate regions. In addition to their cosmopolitan distribution, many species are highly polyphagous.

Disease

Spiral nematodes are generally termed ectoparasites but the various species have been observed on root surface cells, in semi-endoparasitic feeding positions or totally within root tissue. Apparently spiral nematodes feed on any part of the root with the exception of the root tip and region of elongation. Feeding results in the development of necrotic pits and small lesions. Specific observations on cassava roots are lacking.

Crop losses

Information is lacking on crop loss in cassava caused by spiral nematodes parasitism. Various reports on other crops place yield and plant growth reductions for heavy infections in the range of 50 to 78 percent. In one trial the mean spiral nematode population increased from 249 to 2,718 nematodes per liter of soil during 10 months growth of cassava (unpublished data). The effect on yield was not

known as all plots contained spiral nematodes.

Biology

The spiral nematodes are basically ecto- or semi-endoparasitic nematodes. Some species may totally enter the root. Usually feeding is accomplished by penetration of the root only of the stylet. Large soil populations are frequently encountered. All life stages of the nematodes are capable of feeding on roots except when molting and the first stage juvenile in the egg.

Symptoms

No information is available for cassava but observations on other plants report small brown necrotic lesions and areas of discolored cells as the result of nematode feeding.

Other host plants

The *Helicotylenchus* species of the spiral nematodes group are about 75 in number. Relatively few host range studies have been made on the numerous species and the known range and limitations of each species is not known or is incomplete. In general terms the spiral nematodes are polyphagous and host plant names cut across many plant families.

Distribution

The spiral nematodes are numberous and ubiquitous in both warm and cool climate soils. Mixtures of two or more species in a single field are common. Due to their pomyphagous nature, the spiral nematodes maintain their presence on numerous wild and domestic plants.

Control

The selective population increases and declines on various crops suggests that control through crop rotation may be possible once the necessary research data has been accumulated. Spiral nematodes are readily killed by nematicides but the cost-benefit studies have not been done.

Miscellaneous plant-parasitic nematodes associated with cassava

Table 1 shows the numbers of other plant-parasitic nematodes, reported parastitic or associated with cassava. Some species are only of importance in local situations while little is known of most other species. Investigations in Ibadan, Nigeria examined the host range of five species of nematodes over a 14 month period (16).

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Biological Control Strategies for the Cassava Mealybug and Green Spider Mite

by

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The cassava mealybug and green spider mite were first reported in the early 70s in Zaire and Uganda. To date, they have spread rapidly from Central to West Africa, threatening cassava production. It is believed these insects were accidentally introduced from the Americas to Africa about 10 years ago. The rapid spread and seriousness of the damage caused by these 2 insects warrant serious search for a guide and permanent solution to the problem. One viable solution is biological control.

The concept of biological control is a phase of natural control. It is the action of parasitoids, predators and pathogens in maintaining another organism's population at a lower average density than would occur in their absence. The target of biological control is the regulation of an organism's abundance below the level of economic injury. Occasionally, insects formerly under natural control are introduced into a new area containing all the requisites for growth and are lacking their natural complex of parasitoid, predators and pathogens. Therefore, such insects obtain a

higher average density than what they formerly held. If this new equilibrium position is more than that of an established economic injury level, they are noted as a new pest. The general strategy of biological control is to seek the area of origin of the insect's host plant; it is in this area where the insect evolved its complex of parasitoids, predators and pathogens, which prevented the insect from becoming a pest. Such introduction of the pest's natural enemies when released establish the control of the insect below an economic injury level in its new habitat.

The procedures (Fig. 2) for classical biological control program for the cassava mealybug and green spider mite are as follows :

Planing aspects of the projects

Establish whether the target species is introduced or native. It is assumed that these 2 pests were accidentally carried over on cassava planting material from Brazil. Both became pests in Africa immediately. The cassava mealybug and green spider mite were never found as pests in cassava-producing countries of northeastern parts of South America.

Evaluation of available information of the cassava mealybug

So far as is known to date, the genus Phenacocous is

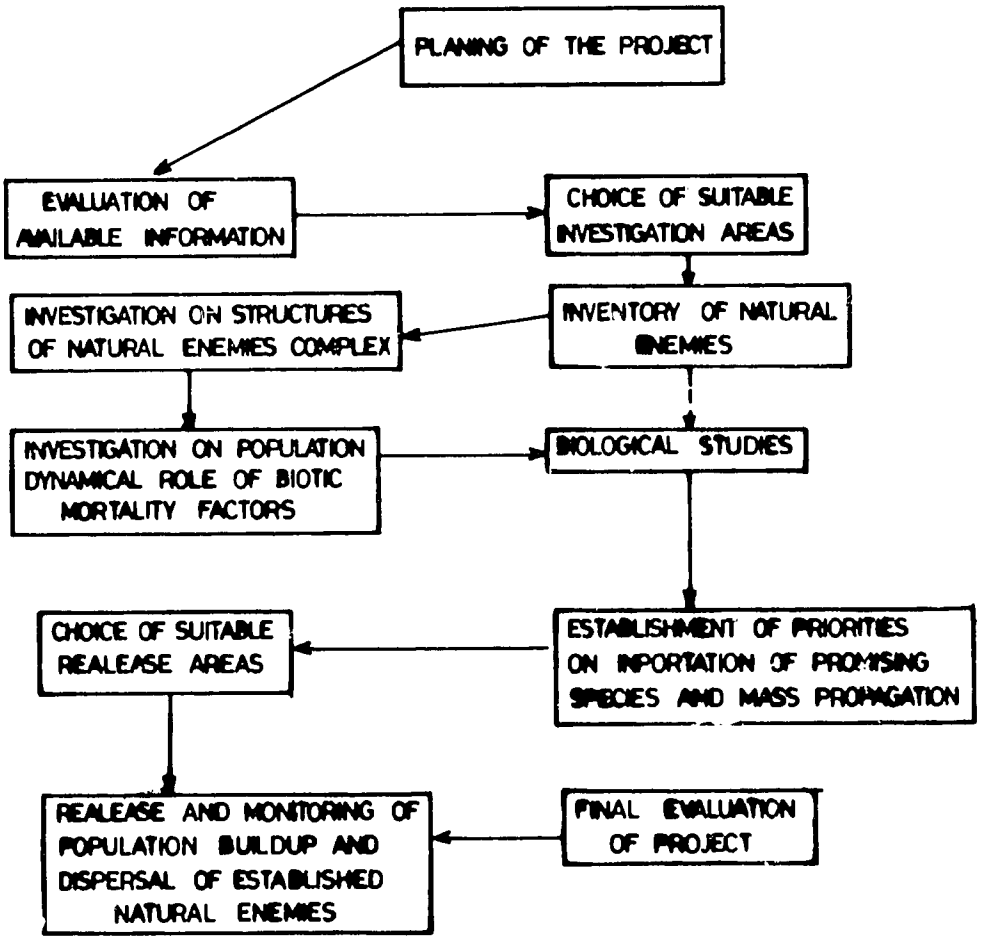

Fig 2. Flow diagram of the cassava mealybug biological control project

Paleotric and Neortic. Reports of Phenacoccus found in the Neotropics are scarce, and those few that are found are probably introductions as they are found on exotic ornamentals or economic plants. The North American continent (including Central America) is home to more than 50 Phenacoccus species. In contrast, the South American continent has no native Phenacoccus.

There is a great deal of literature available about the distribution and origin of the host plant Manihot esculenta and other wild species of Manihot. Rogers and Appan (1973) proposed Meso-America (Central America) as the center of origin for M. Esculenta. The South American continent can, therefore, be considered as a secondary distribution area for M. esculenta and as the primary area for wild Manihot species.

The green spider mite apparently occurs in the same areas as the cassava mealybug, indicating a similar host plant association and natural enemy complex. These views suggest that it has a similar area of origin as the cassava mealybug.

Choice of a suitable investigation area

After information has been gathered from the literature as to the origin of infested plant material, origin of the host plant and origin of the pest insect, suitable areas

for investigation for natural enemies can be chosen. Potential biological candidates are obtained from a region within the native home of the pest that is similar climatically to the areas of introduction.

Investigation will start in the southern part of the United States and extend all the way south to Panama. After an exploration of Mexico and Central America, investigations will be undertaken in Colombia, Venezuela and western and southern Brazil. Since the occurrence of these 2 pests are dependent upon the season, all the areas will have to be searched in depth; once during the dry season and once during the rainy season. The objective is to collect natural enemies adapted to both climatic conditions as well as different host densities. It is of great importance to get the whole spectrum of natural enemies for an efficient biological control program.

Inventory of natural enemies

Once suitable exploration areas are established, the next step is to make an inventory of the parasitoids, predators and pathogens associated with the pest insect. The first problem arising here is that the target species may occur in very low densities because of their control

by natural enemies. Therefore, they may be difficult to locate.

Investigation into structure of the enemy complex

A complex of natural enemies is usually composed of a set of species acting in sequence (attacking different stages of the host). This implies that any search for natural enemies must cover the entire life cycle of the host. In some cases, there are some key species that will control the pest, but generally a complex of many different parasitoids and predators is required for effective control.

Investigation into the population dynamic role of biotic mortality factors

Once an area with natural enemies is found, their collection and rearing will begin. A simple census should be undertaken with regard to the host density and other variable parameters with the view to assess population dynamic impact of the biotic mortality factors involved. The rapidity with which effective natural enemies will be imported depends to a large part of those preliminary investigations.

Bioecological studies

These studies include an array of investigation into

such questions as host searching and specificity, synchronization with the host, physiological tolerance to different climatic factors and genetic aspects of natural enemy populations. A simple model built with the gathered information about the host and the natural enemies populations dynamics and behavior will give us the opportunity to know in advance what our manipulation may produce. Investment in reasonable preintroduction studies in the area of collection will pay off and save costs of shipping inadequate material.

Establishment of priorities in importation of promising species and mass propagation

The preintroduction studies undertaken in the country where the potential natural enemies are found will provide information about the potential of these species. The applicable criteria include the following: (1) high searching ability, (2) high degree of host specificity, (3) good synchronization with their host, (4) high reproductive rate and (5) high degree of adaptability to a wide range of ecoclimate conditions.

Selected species of natural enemies, which are good colonizers and able to penetrate into and adapt to a new environment, should be given high priority in any introduction program.

Choice of suitable release areas

For the first releases, semi-isolated areas are usually preferred. A prerelease monitoring of the populations is necessary to provide life-table information about the dynamics and mortality factors that take place. This will help in interpreting the effectiveness of the release.

Release and monitoring of population build-up and dispersal of natural enemies

After the release in 1 or more areas, life-table studies should be undertaken in order to assess the establishment and the effectiveness of the introduced natural enemies. The study about the dispersal will give necessary information on how to plan the release over the entire pest area.

Final evaluation of the project

Follow up studies on population build-up must be done in the release areas, over a period of at least 2 years. This will demonstrate that the natural enemies have been the causative agents of the control. In the case of failure, the follow-up studies will indicate what did not work and what can be done to correct it. The lack of monitoring in release and nonrelease areas of the past has been widely criticized; whereas, it was impossible to find

out the reason for a partial or total lack of success. A proper economical analysis of the project may provide interesting figures about the economic benefits obtained from biological control.

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The Control of the Cassava Mealybug and the Green Spider Mite by the Effective Use of Their Natural Enemies

by

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Biological control has been successfully employed in many countries of the world to control insect pests and weeds (DeBach, 1965). They have been especially effective against introduced or alien pests. The most popular example is the control of the cottony cushion scale, Icerya purchasi Mask, by the ladybird beetle, Rodalia cardinalis Muls., in California. The scale was introduced to the U.S.A. where it quickly established itself as the most dangerous pest of citrus in California. When it was discovered that this scale was not a problem in the home country in Australia due to the predatory action of the ladybird beetles, the beetles were imported to California and released into the citrus orchards. After sometime, they succeeded in regulating the population of the pest to a level where they were unable to cause any economic injury (Clausen, 1956; 1958). Since then, it has been the practice to look for the natural enemies of an alien pest in its country of origin.

Consequently, following the discovery of the outbreak of the cassava mealybug and green spider mite in Nigeria

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(Akinlosotu and Leuschner, 1979), an exploration for their natural enemies in South America was embarked upon under a joint program by IITA and the Institute of Agricultural Research and Trianing (IAR & T), Nigeria.

Meanwhile, some of the local predator species already established in the country are known to be predating on both the cassava mealybug and green spider mite. These species are shown in Table 18. Local predators were only observed when the populations of the pests were at the peak and when considerable damage has been done to the host plant. Therefore, the local predator species should not be relied upon for successful biological control of the new pests. While they may not be able to keep the pest population below injury level, attention should be drawn to the facts that both pests are new to the local predators and that at the time of the outbreak, the predators were still able to find their traditional preys in the field and would, therefore, not be able to divert attention to the new species. Consequently, there is a need to evaluate the roles that the local predators can play in the control of the cassava mealybug and green spider mite. This will involve a comprehensive study of their biology and ecology with emphasis on their development period, their searching ability and the interrelationships

Table 18. Predators associated with the new pests of cassava in Nigeria.

Scientific names	State of development	Prey
*Coleoptera: Coccinellidae		
Hyperaspis pumila Muls	Adult & Larva	*Phenacoccus manihoti*
H. senegalensis Muls.	" "	" "
Exochomus Flavipes Thum	" "	" "
Cheilomenes lunata F.	" "	" "
Cheilomenes vicina Thum	" "	" "
Symnus sp.	" "	" "
*Hemiptera: Lygaeida		
Geocoris amabilis	" "	" "
Unidentified Syrphid	Larva	*Mononychellus tanajoa*
" predatory mite	Adult	" "

with each other. For example, a natural enemy with potential ability to control a pest species may itself be subject to the attack of other natural enemies. This type of relationship has been established in the case of the primary parasite of the cabbage and the hyperparasites and predators of the same aphid (Akinlosotu, 1978).

In addition to the evaluation of the roles of the local predators in the control of these new pests, their predatory activities should be taken into consideration in the development of a suitable pest management program for the pests. Where chemical control is involved, the effect of such chemicals on the predators ought to be considered.

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Biology, Ecology and Control of the Green Spider Mite and Cassava Mealybug

by

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Cassava, in general, did not suffer from too many insect pests in Africa. The only pests of some importance observed until 1971 were the cassava red mite (Oligenychus gossypii) and the grasshopper (Zonocerus variegatus). The situation changed when in 1971, the green spider mite was observed in Uganda. In 1972, the cassava mealybug was observed in Zaire.

Since then, the green spider mite has spread over the following countries in Africa: Uganda, Kenya, Tanzania, Zanzibar, Zaire, Congo (Brazzaville), Republic of Benin and Nigeria. The cassava mealybug has spread to Angola, Congo (Brazzaville), Gabon, Senegal, Republic of Benin and Nigeria.

Symptoms, yield loss, biology and ecology of the cassava mealybug and green spider mite

The cassava mealybug and green spider mite attack the young cassava shoots. The symptoms in the case of the mealybug are stunting and bunchtoping and in a severe case, cnadle-stick appearance results. In the case of the

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green spider mite, the young leaves remain spiny, do not enlarge and turn yellow.

The economic damage to cassava caused by the mealybug is in both the loss of roots and leaves. The leaves are eaten by many persons in Central Africa. In Nigeria, only tuber yield loss is important. Yield loss depends on 4 factors; the severity of mealybug attack, the age of the plant, the fertility of the soil and the length of the dry season. Yield loss dates from Zaire show clearly that yield losses up to 80% can be expected when cassava is planted late and is severely attacked.

The same applies to the green spider mite. Data obtained from Uganda indicate that yield losses up to 40% are possible. Both pests are dry season pests. As soon as the rains stop and drought stresses increase on the cassava plants, mealybug and green spider mite colonies appear in the field. The mealybug population has usually 1 population peak at the end of the dry season while, in the case of the green spider mite, 2 peaks may occur, 1 at the beginning and 1 at the end of the rainy season. During the wet season, the mealybug disappears more or less completely. The green spider mite reduces only to sub-economic level and remains in the field in countable numbers.

The mealybug, at least here in Africa, is parthenogenetic. No males have been observed. The female lays about 400 eggs. One generation is completed in about 20 days. The young larvae, which hatch from the eggs, are called crawlers and are important for the spread of the pest. In the case of the green spider mite, males and females are present. One female lays about 70 eggs, and 1 generation is completed in from 10 to 13 days.

Both pests spread by wind and by being carried on vegetative planting material. The first larvae stage of the mealybug climbs to the top leaves of the plant during the morning hours and then even low wind currents are able to pick them up. In this way, they can spread more than 1km. In the case of the green spider mite, the females and males lower themselves on silken threads from the shoot leaves where they are then easily picked up by wind currents. Mites can be translocated by wind more than 100km because they are lighter than mealybug crawlers.

Young mealybug larvae and green spider mites can hide in buds of cuttings and survive there for a longer period of time. In this way, they can be carried by a person over long distances. More work is needed to prove the observations.

One of the reasons why the mealybug and the green spider

mite are so successful in Africa is the absence of effective natural enemies, like predators and parasites. These beneficial insects feed on their hosts and help in this way to reduce the population. In Zaire and Nigeria, a number of predators have been found feeding on mealybugs. These are ladybird beetles. Also, on the green spider mite, some predators have been found.

Unfortunately, they seem to be density dependant, which means that they only appear in higher numbers when the pest population is also high and the damage has been done.

Control

IITA and PRONAM are focusing on 5 different control approaches : (1) breeding for resistance, (2) biological control, (3) cultural control, (4) chemical control and (5) integrated control.

Breeding for resistance and biological control can be stated as long-term solutions while cultural practices and chemical control might be the short-term answer.

Breeding for resistance. In Nigeria and Zaire, cassava germplasm has been evaluated for resistant sources. About 40 seedlings could be identified as resistant to mealybug (Singh, per com.). These will be included in a resistance breeding program. In IITA, about 25 cassava clones have

been identified to be less susceptible to green spider mite attack. Pubiscence may be associated with resistance.

Biological control. IITA and PRONAM will start a biological control program. This includes identification of natural enemies in South America, which will be, after careful screening for efficiency and hyperparasites, released here in Nigeria.

Cultural control. As already mentioned, the time of planting has a significant effect in reducing yield loss.

Experiments carried out in Zaire show that yield losses are significantly lower when planting is done at the beginning of the rainy season. In Nigeria, the peak infestation of the mealybug is around February-March. Up to this time, cassava will be already 10 months old when planted early. The experiments in Zaire also indicated that not all cassava varieties react equally to planting times. Therefore, varieties have to be screened specifically for their suitability for this control recommendation (Ezumah and Knight 1977, Nwanze et al. 1979.

Chemical control. Since each above mentioned control measure may not be able to control mealybugs and green spider mites sufficiently, an integrated control approach may solve the problem; for example, a clone with a low

level of mealybug resistance will be planted early to get good establishment until the mealybug comes in. Because of the level of resistance, the mealybug population may build up slowly. This may give a chance for the natural enemies to build up in time and to reduce the developing mealybug colonies to subeconomic level.

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Incidence of the Green Spider Mite and Cassava Mealybug in Nigeria

by

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Following the initial sighting of the cassava mealybug and the green spider mite in Lagos State, Nigeria, in 1979 (Akinlosotu and Leuscher, 1979), a survey was conducted to determine the extent of distribution of both pests in the southwestern part of the country, the susceptibility of local cultivars of cassava to their attack and the natural enemies of the pests.

This survey revealed a widespread distribution of the green spider mite in Lagos and Ogun States and in Ibadan and Ibarapa Local Government areas (LGA) of Oyo State while the cassava mealybug occurred along the Nigerian border with the Republic of Benin, extending from Badagry LGA in Lagos State to Egbado (LGA) in Ogun State (Fig. 3). Later in May, 1979, reports came from Anambra State in the southeastern part of the country that there was an extensive outbreak of the same mealybug and that about 65,000 ha of cassava field in Enugu, Nsukka, Oka, Ugwu-Oba and other areas of the state

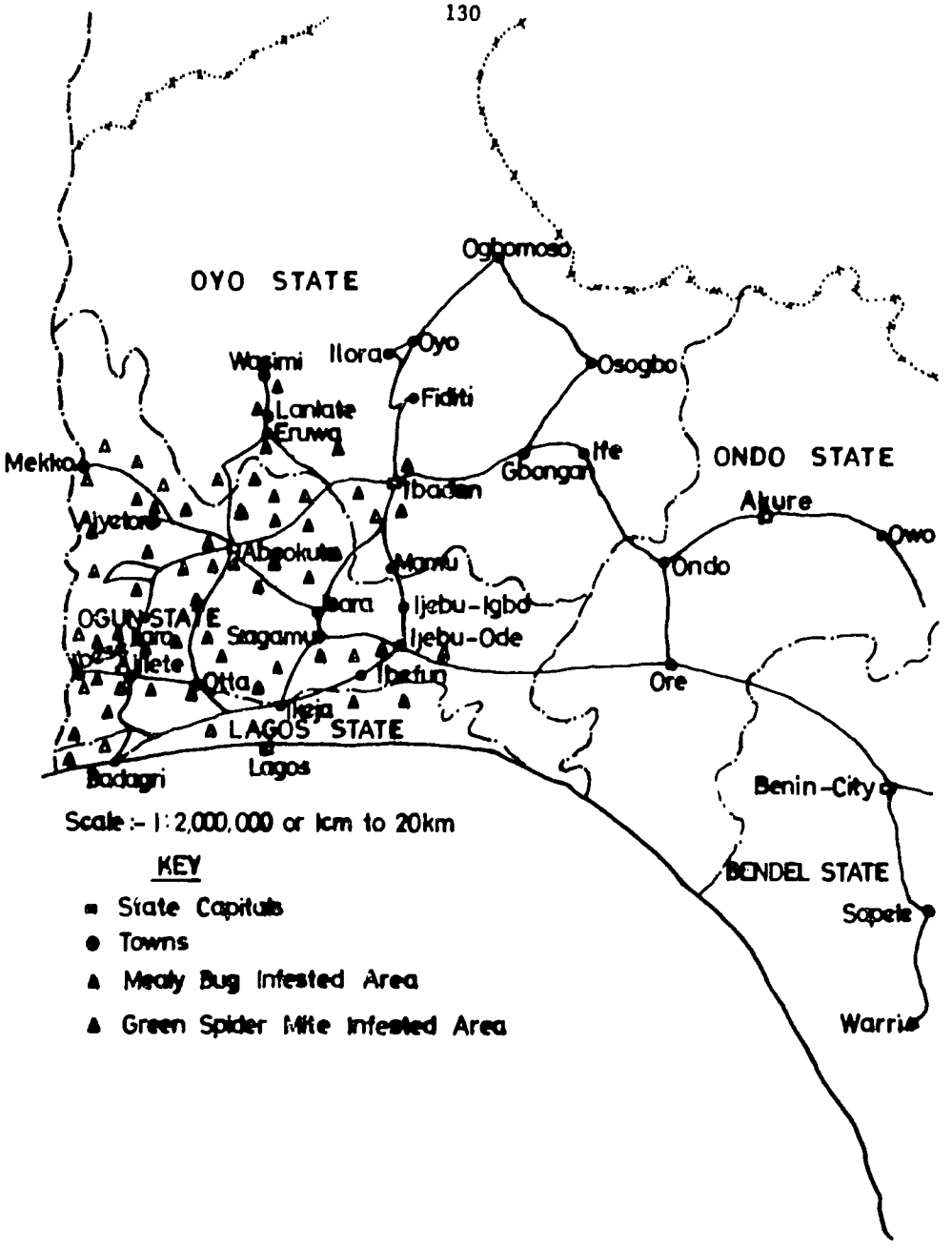

FIG. 3. SHOWING THE EXTENT OF THE OUTBREAK OF *M. tanajoa* (▲) AND *P. manihoti* (▲) IN SOUTH WESTERN NIGERIA

was badly damaged by the mealybug. The damage caused in the area was estimated to run into millions of Naira (Ogbogu, pers. com.). Today, both pests have been reported from virtually all the states in the southern part of the country, Lagos, Ogun, Oyo, Ondo, Bendel, Anambra, Imo, Rivers and Cross Rivers. Unconfirmed report also indicate the presence of both pests in Kwara and Benue States.

Epidemiology

Both pests are suspected to have been accidentally introduced into the country most probably through the Lagos port and by passive transport of infested cassava materials. It is also suspected that the outbreak in Anambra State is a separate introduction, possibly from the neighboring Republic of Cameroon. However, there is no evidence of the presence of the cassava mealybug in that country yet. It is, therefore, possible that the pest was spread from the southwest through the exchange of infested planting materials. The short distance distribution of both pests is mainly effected by the wind since both the adults and nymphs of the green spider mite as well as the crawlers of cassava mealybug are airborne.

Host plant resistance

None of the locally available cassava cultivars in Nigeria are resistant to either of the 2 pests. Nevertheless, from preliminary observations, it appears that cassava cultivars with hairy shoots are less favored by the green spider mite; whereas, such cultivars tend to be more susceptible to the cassava mealybug than nonhairy cultivars. However, more work has to be done to confirm this. Also, a local cultivar called 'Odongo', which is widely cultivated in Ogun State and parts of Oyo State appeared to be fairly tolerant to the attack of both pests and it is already being screened together with other cultivars at IAR & T and IITA.

Natural enemies

At the time the 1979 survey was conducted, only 2 coccinellid predators of cassava mealybug were observed, Exochomus flavipes Thum. and Hyperaspis pumila Muls. The former being more frequently observed. Since then, however, 3 other Coccinellid predators of cassava mealybug have been identified, Hyperaspis senagalensis Muls., Symnus sp. and Cheilomenes lunata F., while only a syrphid larval predator of the green spider mite is frequently observed.

Control

Because of the vital importance of cassava as a major

staple food crop in Nigeria, whic is second only to Zaire as the largest producer on the continent, the Federal Department of Agriculture (FDA) set up a task force to advise the government on the control of the new pests. Members of the task force were made up of scientists from IAR & T, IITA and the National Poot Crops Reasearch Institute (NRCRI) and representatives from the National Root Crop Production Company (NRCPC), the Federal Department of Agriculture (FDA), the Plant Quarantine Division of FDA as well as the ministries of agriculture of the various states affected by the pests.

Among other things, the task force recommended the following interim control measures for the 2 new pest:

a) Cultural control

Early planting of cassava as soon as the rains become steady, other agronomic practices such as fertilizer application, selection of good soil and regular weeding to ensure the vigorous establishment of crop before the dry season sets in. These measures should enable the crop to withstand the attack of the pests in the dry season.

b) Chemical control

i. Preplanting treatment of cassava cutting by dipping them in either Rogor 40 or Dimecron at 0.1% concentration for a few minutes.

ii. Foliar application of Rogor 40 at 45ml in 36L of water per hectare for green spider mite and Dimecron or Rogor 40 at 1-2L in 10 L of water per hectare for cassava mealybug. This foliar treatment was only recommended for isolated occurences of the pests to prevent further spread.

c) Internal quarantine measures

There should be no exchange of cassava planting materials between farmers in the infested and noninfested areas unless such planting materials have been treated by experts with appropriate chemicals.

For the long-term control measures, the task force felt that a more permanent solution to the pest problems can only result from properly planned research into the various aspects of the biology and ecology of the pests and, therefore, recommended that NRCRI and IAR & T in collaboration with IITA conduct research in the following suggested areas : 1) biology and ecology of the 2 pests, 2) breeding for resistance to the pests, 3) biological control of the pests, 4) evaluation of pesticides for their control and 5) cultural control.

These recommendations have since been accepted by the Federal Government through the Federal Department of Pest Control Services (FDPCS). The research institutions have since been collaborating with each other in their bid to

evolve suitable control measures for the 2 new pests. For example, IAR & T and IITA are already collaborating with each other in different areas of research and have already opened a biological control laboratory at the Texagric Cassava Plantation at Obene near Abeokuta, Nigeria. They have jointly hosted a national workshop on the new pests and released a manual for the identification and control of the new pests as well as the other major pests and diseases of cassava (Leuschner et al, 1980).

Farmers in the areas affected are also being advised from time to time on the interim control measures for the new pests through the various news media, television, radio and newspapers.

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Selections for Resistance to the Cassava Mealybug and Effects of Some Cultural Practices on Incidence and Severity in Bas Zaire

by

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The cassava mealybug was first observed in Zaire in 1972 (Hahn and Williams, 1972) and has spread all over Bas Zaire and most of adjoining Bandundu. It is a dry season pest, which incidence is more serious in impoverished sandy or highly eroded soils resulting in significant yield reductions (Ezumah and Knight, 1977; PRONAM, 1977). Variations in degree of susceptibility of cassava clones assembled at M'vuazi had been observed, but the degree of resistance was low. Recently, 3 Manihot species with wild characteristics introduced from Brazil have shown a high degree of resistance to this pest during 2 successive dry seasons. These are crossable with cultivated cassava, readily produce flowers and seeds and are available for use in genetic improvement.

Screening for resistance to mealybug in Zaire.

Screening for genetic resistance to the cassava mealbug was started in 1975-76. On a 1-5 scoring scale of

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increasing severity, the best that could be achieved was a score of 3,which frequently dropped to 4 as the dry season became prolonged. Most of the seedlings and clones scored 5. The germplasm at M'vuazi was increased through seed introductions IITA obtained from Nigeria, Colombia and Brazil. Thousands of seeds from some 1,000 families were planted at M'vuazi in March 1977. Seedlings were also tagged for hairiness and vigor. Only 1.1% of these seedlings scored 3. About 93.5% of the families in classes 3 and 4 were earlier selected for vigor and leaf pubescence.

Source of resistance to the cassava mealybug. In June 1977, 2 plants, TMI 6134 and TMI 6151, showing characteristics of wild cassava introduced from Brazil, were observed to be resistant to mealybug colonization. These were inoculated with the pest at 2 weekly intervals during the dry season of 1977 and 1978. Colonization was not achieved. Another plant, TMI 6096, showing a similar character, introduced from Brazil, also showed a high degree of resistance to mealybug attack. The seedlings produce flowers, can be crossed with commercial cassava varieties, but efforts to clone them have been unsuccessful. The buds remain dormant for a few weeks then abscise, and the cutting soon dries up. PRONAM plant breeder has made several

crosses between these seedlings and cultivated cassava and is producing several pure seeds by self-pollinations. It is hoped that the resistance is highly heritable and easily transferable to the cultivated cassava because like M. glaziovii, these wild cassava are not for commerical use.

Cassava clones as affected by mealybug severity.

Vigor is closely related to the cassava mealybug severity rating under natural infestation. Following an artificial mealybug infestation and subsequent high pest pressure, most of the clones scored 4 and 5. It has been observed that the mealbug's damage symptoms completely disappear after several months of rain, and almost all clones scored 1 and 2 (Ezumah and Knight, 1977). A few cassava mealybugs may survive the rain constituting a ready source of infestation during the proceeding dry season (nwanze,1977).

Attempts to relate some cultural practices with mealbug incidence and severity.

Observations that the mealybug incidence was more severe in highly eroded, poor or sandy soils and during periods of moisture stress led to studies to evaluate the effects of nutrient application and mulching on incidence and/or severity of cassava mealybug.

Nutrient treatment. Table 19 shows that mealybug incidence

Mulching has been demostrated to reduce water loss and soil temperature (Rao Rama Mohan *et al*, 1977). These conditions favor cassava growth and development during the dry season.

Table 19. Effect of nutrient treatment on cassava root yield and mealybug incidence (1976-78).

	Treatment	Root yield (t/ha)	CMB[1] scores 1-5	Treatment NPK(10-15-20)	Root yield (t/ha)	CMB[1] scores 1-5
1.	20 $(NH_4)_2SO_4$	11.5	5	100	17.7	4
2.	40	12.6	5	200	19.6	4
3.	60	12.1	4	300	18.8	5
4.	80	13.9	4	400	22.3	3
5.	10,000 Cow Dung(CD)	16.0	4	100 + 10,000 CD	18.9	3
6.	20 $(NH_4)_2SO_4$ + 10,000	17.8	4	20,000	16.4	4
7.	Control	12.4	5	Control	13.6	4
	Means	13.8			17.8	
	Std. Dev.	2.3			2.8	

1. Scoring scale : 1 = no apparent symptom; 5 = death of stem tip

Table 20. Effect of mulching and cultivation treatment on cassava root yield and mealybug incidence[1] (1977-78).

Cultivation		02864			Mpelolongi		
Main Treat.	Sub Treatment	Root Yield (t/ha)	Severity mean	% attacked	Root yield (t/ha)	Severity mean	% attacked
Ridge	1.Mulch	8.0	1.5	35.9	6.7	1.0	12.1
	2.Bare	4.6	2.3	49.2	4.2	2.5	54.7
Flat	1.Mulch	6.9	1.3	32.1	9.6	1.3	16.6
	2.Bare	5.6	2.3	61.0	7.2	1.9	23.6
No-till	1.Mulch	3.7	1.3	32.1	5.5	1.3	16.6
	2.Bare	2.7	2.3	61.0	4.1	1.9	23.6

1. Date represent means of 4 replications.

2. Scoring scale: 1= no apparent symptom; 5=death of stem tip

Table 20b. Effects of mulching and cultivation treatment on root yield (t/ha) of cassava (1977-78).

	Ridge	Flat	No-till	Mean
Mulch	8.0	6.9	3.7	6.2
Bare	4.6	5.6	2.7	4.4
% Bare	(174)	(123)	(134)	
Mean	6.3	6.3	3.2	

Mulching rate. No direct relationship was observed between the rate of mulching and mealybug incidence (Table 21). Reduction in incidence was, however, obtained about 55% in mulched plots compared to 100% in nonmulched plots.

Table 21. Effect of mulching rate on mealybug incidence (1978-79).

Mulching rate	No. of plants sampled/ plot	Number of plants attacked	% Incidence	% Control
Control (0 t/ha)	40	14	35	100
5 t/ha	40	4	10	29
10 t/ha	40	11	28	79
15 t/ha	40	10	24	71
20 t/ha	40	6	15	43
Total	200	45	22.5	

$\frac{\text{Mulch}}{\text{No mulch}}$ = 55.4% incidence

Effect of mulching rate on cassava regrowth. Rapid regrowth of cassava leaves and stems following a serious dry season mealybug attack has been observed in Zaire. A few plants (15 per plot) that escaped a serious attack were compared to those that had a severe infestation. Leaf number per plant and mean area per leaf were observed after 3 months of rain. Only very small

differences in these agronomic characters were observed (Table 22). Though development may be surpressed by mealybug attack, regrowth of leaves during the rainy season is very rapid and may equal or surpass that of escapes (Table 22).

Table 22. Effect of mulching rate on cassava

Mulching rate	No. of leaves per plant		Mean area per leaf cm^2	
	Attacked	Escapes	Attacked	Escapes
0	96	94	338	346
5	105	92	431	347
10	140	120	540	415
15	106	124	472	441
20	129	120	400	489
Mean	115	110	436	408

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Aspects of the Biology and Control of the Green Spider Mite

by

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In 1979, an outbreak of the green spider mite was reported in 3 southern states in Nigeria (Akinlosotu and Leuschner, 1979). The pest was known to cause serious damage to cassava, and yield losses of 46% in Uganda, 29-53% in Colombia and 50-80% in Tanzania had been reported by various authors.

As a newly introduced pest in Nigeria, there was an urgent need to investigate the biology of the pest as a basis for planning control measures. There was also an urgent need to identify cassava varieties that may be resistant to this pest, an alternative to chemicals that are too expensive and hazardous for the small farmer.

Biology of the green spider mite

The developmental biology was studied at 22, 28 and 35°C to cover the range of temperatures that normally occur in southern Nigeria. The effect of temperatures on the biology was evaluated by the following parameters: (1) fecundity and hatchability in mated and untamed females, (2) the length of

developmental period from egg to adult and (3) preoviposition and oviposition period in females. The effect of light and shade on fecundity was also studied under laboratory conditions of fluctuating temperatures of 25-30°C and 60-80% R.H.

The studies were conducted in plastic petri dishes modified as a rearing cage. Fresh healthy cassava leaves were offered to the captive mites, and water was supplied in the perti dishes through a small font using a modified glass vial.

Three experiments involving 20 virgin couples in 20 petri dishes per experiment (1 virgin couple per petri dish) were conducted at 22, 28 and 35°C. Observations were made on the preoviposition and oviposition periods of the females, the number of eggs laid and the hatchability of the eggs.

Three other experiments involving 20 individual virgin females in 20 petri dishes per experiment (1 virgin female per petri dish) were conducted also at 22, 28 and 35°C. Observations were made as above. For the studies on developmental period, 30 freshly laid eggs were placed individually on separate petri dishes and incubated at the experimental temperatures. The development of the resultant nymphs was also followed and recorded.

Table 23. Number and hatchability of eggs laid by mated and unmated females of *M. tanajoa* under 3 temperature regimes.

TEMP. °C	Number of females observed	Range of pre-oviposition period in days	Mean no. of eggs laid per female	Range of total eggs deposited	Range of oviposition period	% hatch. of total number of eggs laid	Status mated or unamted
22	20	1-5	12.70	2-48	1-13	50.0	unmated
28	20	1-3	15.75	2-70	1-10	39.3	unmated
35	20	1-3	6.3	1-10	1-6	16.6	unmated
22	20	1-4	8.8	2-22	1-11	51.1	mated
28	20	1-3	16.8	1-58	1-9	39.7	mated
35	20	1-3	5.5	1-11	1.4	4.76	mated

Table 24. Number and hatchability of eggs laid per female of *M. tanajoa* under shaded and unshaded conditions at 25-30°C and 60-80% R.H.

Number of females observed	Mean number of eggs laid per female	% hatchability	Under
15	17.3	39.1	Shade
20	11.6	25.5	Light

Table 25. Duration of different stages of development of *M. tanajoa* under 3 temperature regimes.

Temperature °C	Stages of development	Mean length of development in days	Number of individuals at each stage*
22	egg	4.73	30
	larvae	2.79	24
	protonymph	2.14	21
	deutonymph	2.21	19
28	egg	3.06	30
	larvae	1.62	24
	protonymph	1.79	17
	deutonymph	1.36	11
35	egg	2.26	30
	larvae	1.42	21
	protonumph	1.42	21
	deutonymph	1.00	10

The effect of light and shade on fecundity and hatchability was studied with similar rearing cages, except that the shade condition was provided by covering the petri dishes with black polythene on which holes had been made with an office pin to allow ventilation.

Table 23 shows that the highest number of eggs was laid at 28°C by both mated an unmated females, but the hatchability was higher at 22°C. The preoviposition and adult oviposition

periods were also longer at 22°C than at either 28°C or 35°C for both mated and unmated females.

Fecundity and hatchability were increased by shade as shown in Table 24. The developmental period was reduced by an increase in experimental temperature and was shortest at 35°C (Table 25).

Control of the green spider mite

Cassava clones in the seedling nursery, intermediate yield trial and hand-crossing nursery were evaluated for the occurence of resistance to M. tanajoa damage. The clones of cassava were evaluated and graded according to the degree of damage observed. A scale ranging from 1-5 was used :

1. no obvious damage,
2. few whitish dots on young unfolded and first expanded leaves.
3. shoot leaves do not expand fully. Older expanded leaves covered with distinct chlorotic spots. Leaf size reduced by 25%.
4. shoot leaves do not expand and remain spindly. Reduction of leaf size more than 50%. Severe chlorosis on older leaves. Beginning of lower leaf infestation may or may not occur.
5. shoot dead or does not produce new leaves. Older infested leaves dropped. Mild or no infestation of lower expanded leaves. Plant shows stick appearance.

Clones that showed evidence of resistance, i.e., those with scores from 1-3 were then selected and labeled for more intensive evaluation in the greenhouse and were completely randomized. A month after planting, the youg cassava shoots were mass infested with various stages of M. tanajoa. Mass infestation was repeated 2 weeks afterward to ensure success. Two weeks after the second infestation each plant was sampled and examined in the laboratory for evidence of mites on the leaves. The plants were also graded using the same scale as for field evaluation. The clones selected from the greenhouse screening were subjected to further evaluation in the laboratory.

First of all, 4 leaf discs per clone were placed on wet filter paper in a rearing cage, and 1 female was released on each leaf disc. Five days later, the number of eggs laid on the selected clones was compared with the number of eggs laid by females on 4 leaf discs of a known susceptible clone. In a second set of experiments, 1-day-old larvae was individually released on 4 leaf discs per clone in separate petri dishes and their development period was compared with that on a susceptible clone.

Out of 84 clones selected from the field, 16 clones were retained from a greenhouse screening (Table 26). The 16 clones can be divided into 2 groups: 8 clones sustained very low mite population (less than 100 mites per leaf) and the other clones sustained moderate mite population (between 100-200 mites per leaf).

The susceptible clone had more than 200 mites per leaf. The laboratory observations on the number of eggs laid on 4 leaf discs from the retained clones after 5 days and the length of development of the mite on these clones revealed that fewer eggs were laid on the retained clones than on the susceptible clone, and there was no difference on the length of developmental period between the retained and susceptible clones (Table 27).

General discussion

The results on the biology of the green spider mite under 3 temperature regimes are consistent with those by Nyiira (1975) in Uganda and Yaseen and Bennett (1977) in Trinidad. In laboratory conditions of 26.8 ± 2.2°C in Trinidad, Yauen and Bennett reported that a female was able to lay up to 65 eggs in the 9-14 days of their egg-laying life span, and the total egg to adult period was 11-13 days; the preoviposition lasted 1-2 days. In Uganda, similar results were obtained at a room temperature of 29.9 ± 3.6°C. The preoviposition period lasted 1-3 days; the total egg to adult period was 8-13 days; 25 individual mites were able to lay from 35-117 eggs. Mean hatchability of the eggs from mated females was 54.4%. Nyiira as well as Yaseen and Bennett reported egg and 3 preadult stages of development.

Table 26. Score and mites count on the 16 selected clones throughout the greenhouse screening period.

	Score and mite count at the first rating		Score and mite count at the second rating		Score and mite count at the third rating		Score and mite count at the fourth rating		Remarks
91229	3	211.6	2	120.6	3	203	3	146.6	
91233	3	194	2	150	3	250	2	140	
91280b	3	24.3	3	86.3	3	144.6	2	83.3	*
91280c	2	28.3	3	160	3	82	2	98	*
91281	2	26	3	63	3	91	3	68	*
91288	3	61.3	3	44	3	-	2	38.3	*
91290b	3	52.3	3	61.3	3	-	2	96	*
91349	3	71.6	3	42.8	3	58.3	3	134.3	*
91352	3	34.6	2	29.3	3	67.6	2	52.3	*
91403	3	110.3	3	70.3	3	148	3	106.6	
91473	3	91	3	56.3	3	142	3	60.6	
91479b	3	89.3	3	6b	3	60.3	3	83.3	
91595b	3	37.6	3	67.6	3	45.3	2	309.6	
TEXCO	3	112.6	3	82.6	3	94.6	3	171.3	
HC 15	3	98.6	3	-	-	-	3	107.6	
IYT 91459	2	65	3	180.25	-	-	2	58.2	
4(2)0763 Control	4	211	4	307.5	4	227	4	416.3	

* Clones with less than 100 mites per leaf.

Table 27. Mean number of eggs laid per day and length of development of 1-day-old lavae on the selected clones compared to the susceptible clone.

Clone no.	Mean number of eggs laid per day	length of development
91229	11.8	
91233	5.8	6.75
91280b	5.4	5.75
91280c	9.2	6.00
91281	4.2	7.50
91288	9.4	5.75
91290b	5.6	7.50
91349	11.4	7.25
91352	11.4	7.25
91403	8.4	5.00
91479b	4.4	6.00
91596b	5	5.75
Texaco	7	5.75
HC 15	10.00	7.25
IYT 91459	19.8	6.00
4(2) 0763 (Control)+	17.8	6.50

+ the susceptible clone.

The highest number of eggs laid under shade may be due to the ecological habitat of the mites. By its ecology, the mite lays its eggs on the under-surface of the cassava leaves, which is less exposed to the light.

On the resistance, only $^{1}/_{5}$ of the selected clones that showed evidence of resistance in the field sustained increasing mite population in the greenhouse. The reason for this may be due to the age of the plants during the screening period. The plants were 10-11 months old at the time the screening was done. At that stage, the plants were old enought to resist the attack by the mites. Studies by Nyiira showed that plants less than 3 months or more than 9 months were less attached. The greenhouse screening showed that as the plants get older, they were more exposed to the attack. The laboratory observations corresponded to the greenhouse screening for the number of eggs laid on the selected clones. The results on the developmental period need more investigation. The results have also shown that there is a certain level of resistance of cassava cultivars to the green spider mite at IITA.

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Strategies for Weed Control for Large-Scale Cassava Production

by

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Excessive weed growth during the crop production seasons coupled with increasing shortage of labor imposes severe limitations on the cassava production capabilities of the average farmer in the tropics. Traditional methods of weed control are limited to hand pulling or hoeing of weeds. These methods were effective when the population was low and farm sizes were small. Widespread shortage of farm labor at peak periods together with increasing cost of labor make a change to improve weed control methods imperative on tropical farmers, especially where increase in farm size is envisaged.

Weed problems in cassava

Weed problems in cassava are mainly from annual and perennial weeds. The intensity of infestation will vary with the local weed flora, fallow length period and land preparation. The growth and branching habit of cassava together with plant population play important roles in influencing weed pressure in a cassava crop. It is generally recognized that annual weeds are the most serious

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in terms of the severity of infestation. The environmental conditions of high rainfall and temperature favor germination and rapid seedling growth of these weeds. These considerations coupled with the slow rate of initial vegetative growth in cassava make 2 properly timed weedings necessary in cassava during the first 3 months of crop establishment. A third weeding is usually advocated later in the season to minimize weed interference during crop harvest.

Weeds cause serious reductions in cassava yield and yield components. Weeds were shown to cause up to a 70% reduction in cassava tuber yield at IITA (Table 28). Cassava is most susceptible to weed infestation during the first 10-12 weeks of growth. Delaying the first weeding by more than 2 months has been reported to cause more than a 20% reduction in tuber yield even when improved varieties and recommended fertilizer rates are used.

Weed management problems in cassava increase with an increase in farm size. The most common weeds associated with cassava production in the tropics are *Imperata cylindrica* *Rottboellia exaltata* L., *Andropogon* spp., *Penisetum* spp., *Panicum maximum* L., *Sida* spp. and *Eupatorium odoratum* L. In areas of high rainfall, *Aspilia africana* and *Paspalum* spp. are also serious weed problems. While some weeds such as *Rottboellia exaltata* become serious problems where traditional hand weeding is replaced by interrow cultivation and chemical

weed control, Imperata cylindrica is a problem in all farm sizes and where most weed control methods are used. Although Eupatorium odoratum is common in cassava, its problem in newly cleared land is intensified where cassava is the last crop before a short fallow period (2-3 years).

Weeds not only reduce the crop yield but increase the cost of production. Studies in Nigeria and Colombia show that weeding alone accounts for more than 50% of the average 300 man-days/ha/year used in cassava production (Anon, 1972; 1976; Pinstrup-Anderson and Diaz, 1973). Rhizomes of Imperata cylindrica are known to pierce cassava tubers and predispose them to fungal infection (Terry, per com.). Insect pests of cassava such as Zonocerus variegatus L. are known to use such weeds as Eupatorium odoratum for egg laying and for spending their early instars (Leuschner et al, 1980). Other insect pests may use weeds as alternate hosts during the fallow periods.

Weed control methods for large-scale cassava production

The effectiveness of any weed control program must include timely operation. Consequently, the suitability of any weed control method in any crop production system will depend, in part, on the ability of that weed control method to permit timely weeding within the context of the farm size. Weed control methods appropriate for cassava

cultivation are discussed in relation to their suitability for large-scale cassava production.

Hand weeding. Although this is the traditional method of weed control in cassava and other field crops, the method is labor intensive, and it is a slow process. It depends on proper timing to be effective and on cheap and readily available labor to be economical. There is hardly any place now in tropical Africa where these conditions can be jointly met.

Consequently, hand weeding cannot be recommended for large-scale cassava production but should be used as a supplement to other weed control methods.

Chemical weed control. Several herbicides such as ametryn, linuron, paraquat and karbutilate control weeds in cassava (Pacheco et. al., 1974a; 1974b. Santos and Das, 1973). Better weed control and higher crop yield have, however, been demonstrated for diuron, fluometuron, alachlor, metolachlor and trifluralin when each is used alone or as a component of a mixed formulation (Akobundu, 1977; 1980; Doll and Piedrahita, 1976; Leone and Arismendi, 1974). Results of a 3 year study at IITA to evaluate several herbicides for weed control in cassava and compare relative costs and returns to the farmer for using alternative weed control methods show that several herbicides were effective in controlling weeds in cassava (Akobundu, 1980). In 1 such study in which a local cassava

cultivar was used, excellent weed control and good crop yield were observed in plots treated with fluometuron (2.0-3.0 kg/ha), diuron (2.0 kg/ha) and formulated mixtures involving low rates of atrazine (0.8 kg/ha) plus metolachlor (1.7 kg/ha) and diuron plus paraquat (2.8 kg/ha) (Table 29).

Postemergence application of diuron controlled weeds but depressed cassava tuber yield significantly.

In subsequent studies carried out with IITA's improved cassava cultivars, highest crop yield was obtained where fluometuron was used alone or in combination with alachlor or metolachlor as preemergence herbicides. Other mixed forumulations that were equally effective were atrazine plus metolachlor (2.5-3.0 kg/ha) applied preemergence and diuron plus paraquat applied as a directed spray (Table 30). Cassava yield in plots treated with a tank mixture of alachlor plus cyanazine (3.0 + 1.5 kg/ha) was significantly higher than yield from plots treated with a mixture in which the cyanazine was replaced with atrazine. Cassava was sensitive to atrazine even though the rate of atrazine was reduced to 1.0 kg/ha. Pendimethalin (2.0 kg/ha) used as a tank mix with either diuron or cyanazine reduced cassava yield. In locations where Rottboellia exaltata is a serious weed, the pendimethalin tank mixture is recommended with a suitable preemergence herbicide effective on broadleaf weeds.

Cost of weeding has been shown to be higher in hand weeded than in chemically weeded plots (Akobundu, 1980). Provided that the correct amount of herbicide is used at the right stage of development, chemical weed control will not only enable the farmer to obtain yield comparable to weed-free plot, but the net return will be higher in the plots in which herbicides are used for weed control.

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Table 28. Effect of weeding treatment on weed control and crop yield in cassava (1976).

Treatment	Rate (kg a.i./ha)	Time[1]	Weed rating[2] Broadleaved 39[3]	67[3]	90[3]	Grasses 39	67	90	Fresh wt. roots (t/ha)
Atrazine + metolachlor[4]	2.5	Pre-em	100	80	56	97	70	56	10.4
Atrazine + metolachlor[4]	3.0	Pre-em	99	83	76	94	85	66	9.6
Fluometuron	2.0	Pre-em	99	84	68	98	81	73	12.4
Fluometuron	3.0	Pre-em	100	79	67	99	83	77	10.3
Diuron	1.5	Pre-em	80	40	35	88	26	21	9.0
Diuron	2.0	Pre-em	96	70	64	95	59	34	11.3
Diuron	2.0	Post-em	100	85	84	99	85	74	8.1
Diuron + paraquat[5]	2.8	21 d.a.p.	100	87	82	100	78	59	10.3
Prometryn	1.5	Pre-em	91	56	39	97	70	48	7.7
Prometryn	2.0	Pre-em	93	67	64	90	62	40	9.5

Table 28 (contd.)

Terbutryn	3.0	Pre-em	99	80	63	98	68	45	8.7
Terbutryn	3.5	Pre-em	100	75	53	97	74	53	8.8
Hoe-weeding	-	21 + 56 d.a.p.	75	83	89	75	73	83	12.0
Hoe-weeding	-	14 + 42 + 70 d.a.p.	87	92	88	83	94	93	14.6
Weed-free	-	Weekly	100	100	100	100	100	100	12.8
Weedy	-	Weekly	0	0	0	0	0	0	4.6
S.E. ($\bar{d}$)									1.68
L.S.D. 0.05									3.36

[1]d.a.p. - days after planting

[2]Weed rating 0 - No control, 100 - complete control

[3]Weeds rated at 39, 67 and 90 d.a.p.

[4]Primextra

[5]Gramuron

Table 29. Effect of weeding treatment on weed control and crop yield in cassava (1977)

Treatment	Rate (kg a.i./ha)	Time[1]	Weed rating[2] Broadleaved 21[3]	Broadleaved 90[3]	Grasses 21[3]	Grasses 90[3]	Stand establ. %	Fresh wt. roots (t/ha)
Atrazine + metolachlor[4]	2.5	Pre-em	92	89	93	94	94	22.7
Atrazine + metolachlor[4]	3.0	Pre-em	83	82	96	92	94	22.1
Fluometuron	2.0	Pre-em	88	86	84	83	100	21.8
Fluometuron	3.0	Pre-em	92	82	90	84	100	26.4
Fluometuron + alachlor	2.0 + 2.0	Pre-em	84	83	95	90	100	25.2
Fluometuron + metolachlor	1.5 + 2.0	Pre-em	87	79	93	96	94	25.6
Atrazine + alachlor	1.0 + 2.0	Pre-em	86	88	86	80	94	17.6
Diuron	2.0	Pre-em	78	79	82	70	88	24.4
Diuron	3.0	Pre-em	92	90	86	81	94	24.2

Table 29. (contd.)

Diuron + paraquat[5]	2.8	Pre-em	92	90	86	81	94	24.2
Diuron + Alachlor	1.5+2.0	Pre-em	87	77	85	78	100	21.3
Diuron + alachlor	2.0+3.0	Pre-em	88	89	84	79	100	22.1
Fluorodifen	3.5	Pre-em	72	87	84	82	100	22.3
Hoe-weeding	-	21 + 56 d.a.p.	100	89	95	93	100	20.6
Hoe-weeding	-	21+49+84 d.a.p.	98	100	88	100	94	23.4
Weed-free	-	Weekly	100	100	100	100	94	21.9
Weedy	-	-	0	0	0	0	94	13.9
S.E. (d)								4.84
LSD 9.95								9.87

[1]d.a.p. - days after planting

[2]Weed rating - 0 = No control, 100 - Complete control

[3] Weeds rated at 21 and 90 d.a.p.

[4] Primextra

5 Gramuron

Table 30. Effect of weeding treatment on weed control and crop yield in cassava (1978).

Treatment	Rate (kg a.i./ ha)	Time[1]	Dry wt[2] weeds (kg/ha)	Fresh wt roots (t/ha)	Plant height (cm)	Yield stand (kg)
Atrazine metolachlor[3]	2.5	Pre-em	640	29.0	107.0	3.19
Atrazine metolachlor[3]	3.0	Pre-em	1200	28.6	131.8	3.17
Fluometuron	2.0	Pre-em	745	30.8	132.5	3.74
Fluometuron	3.0	Pre-em	615	30.1	138.8	3.35
Fluometuron +	4.0	Pre-em	575	28.2	137.8	3.12
Fluometuron + metolachlor	6.0	Pre-em	610	29.4	142.8	3.08
Diuron	2.0	Pre-em	1638	26.8	124.3	3.04
Alachlor + diuron	3.-+2.0	Pre-em	1695	25.2	109.5	3.18
Diuron + pendimethalin	2.0 + 2.0	Pre-em	1010	25.6	125.8	3.05
Alachlor + cyanazine	3.0 + 1.5	Pre-em	1333	29.7	132.3	3.09
Cyanazine + pendimethalin	2.0 + 2.0	Pre-em	1855	25.8	102.0	2.73

Table 30 (contd.)

Alachlor + atrazine	2.5	Pre-em	613	24.0	127.0	2.68
Alachlor + atrazine	3.0+1.0	Pre-em	1278	22.8	101.0	2.62
Alachlor + atrazine	3.0+2.5	Pre-em	1695	21.4	117.3	2.74
Diuron + paraquat[4]	2.8	21 d.a.p.	553	29.7	139.0	3.19
Hoe-Weeding	-	21 + 56 d.a.p.	330	30.1	155.3	3.12
Hoe-weeding	-	21 + 49 +84dap	63	32.1	138.5	3.39
Selective weeding (Talinum spp.)			520	27.3	123.8	2.78
Weed-free			0	27.8	150.5	3.01
Weedy			2198	19.9	94.3	2.23
S.E. (d)			383	3.32	14.4	0.36
LSD 0.05			765	6.64	28.8	0.72

[1] d.a.p. = days after planting

[2] Weed weight taken 182 d.a.p. (outset of dry season)

[3] Primextra

[4] Gramuron

SECTION III

Production of Cassava Planting Materials

Improvement in yield is highly dependent upon the availability of healthy planting materials with high yield potentials. Without proper establishment, the production potential of cassava and other crops cannot be realized. Emphasis is, therefore, placed on provision of disease and pest-free planting materials through rapid multiplication of improved materials. Among the relatively high yielding disease tolerant cassava varieties recommended by PRONAM* in 1980 are the following :

PRONAM 1 (30553/3) 31.3 t/ha; PRONAM 2 (A 46) 28.6 t/ha; PRONAM 3 (30933/1) 24.9 t/ha; PRONAM 4 (30179/2) 26.6 t/ha; PRONAM 5 (30692/272) 29.2 t/ha. Others originating from INERA collections but recommended for dissemination by PRONAM* include : PRONERA 1 (02864) 20.4t/ha; PRONERA 2 (02715/SY 39/40) 17.8 t/ha; PRONERA 3 (Mbuaki 2) 22.7 t/ha; PRONERA 4 (0443/45/7) 19.5 t/ha; PRONERA 5 (5746 7b) 23.1 t/ha; PRONERA 6 (5733) 15.8 t/ha.

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* Credit for yield evaluation of these materials goes to Citoyen Kwanze Bolamba, Research Tech. PRONAM

The Production of Pathogen-free Cassava Planting Material for Distribution

by

E.R. Terry
IITA pathologist

The virus, bacteria and fungus pathogens that cause the most serious diseases of cassava persist in their viable states in the woody stem cuttings by which the crop is propagated. Thus, a highly efficient mechanism for the survival and dissemination of these pathogens is ensured.

The interaction between these vegetatively-borne pathogens and their cassava hosts at sprouting and early growth adversely affect the establishment and health of a cassava crop. Although accurate estimates of crop loss due to the cumulative effects of cassava diseases are unavailable, recent results from studies on crop losses indicate yield reductions of 32 and 69% for CMD resistant and susceptible cultivars, respectively, due to use of cuttings from CMD infected plants (Terry and Hahn, 1980). Lozano and Sequire (1974) reported that 86% of the plants in a plot established with cuttings from a CBB infected planting became infected. The continued economic production of cassava will, therefore, be seriously handicapped unless a system for the production of pathogen

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free planting material is developed and efficiently utilized.

The success of the system proposed will depend to a very large extent on the following factors : (1) the ability to recognize and characterize the major diseases of cassava and their causal agents; (2) the development of reliable techniques for eliminating these agents from planting material; (3) the development of reliable techniques for indexing to ensure that propagating materials are pathogen-free and (4) the development of procedures to maintain on a routine basis pathogen-free planting material.

With regard to the recognition and characterization of major cassava diseases, the review papers by Lozano and Booth (1974) and Lozano and Terry (1976) provide adequate coverage on the symptomatology of the diseases and the biology of the pathogens.

Vegetative-borne cassava viral and viral-like pathogens

A summary of the global distribution of the virus and virus-like diseases of cassava is presented in Table 31.

In general, all viruses and mycoplasma of cassava invade the vascular system and are disseminated mainly by propagation of infected woody stem cuttings (Lozano 1977). They, therefore, have a high risk potential for

Table 31. Virus and virus-like diseases of cassava.

Disease	distribution	Causal agent	Transmission
African mosaic	Africa India	paired polyhedral isometric?	cuttings, *Bemisia tabaci*
Common mosaic	Latin America	flexous rods	cuttings, mechanical
Brown streak	East Africa	long flexous rods? paired polyedral? isometric	cuttings, mechanical
Veinal mosaic	Latin America	polyheral isometric	cuttings, mechanical
Latent virus	Latin America	rhabdovirus, paired polyhedral	cuttings

Source : J.C. Lozano, 1977.

introduction into areas that are presumably free of the diseases they cause.

Techniques for elimination of CMD

The Africa cassava mosaic agent has been successfully eliminated from 6 IITA developed improved cultivars; TMS 30040, TMS 30211, TMS 30337, TMS 30395, TMS 30555 and TMS 130572) (Frison, pers. com.), and from 2 cultivars of Indian and Nigerian origin (Kartha and Gamborg, 1975) by culturing shoot apical meristems. Growing of disease cuttings at 35°C for 30 days resulted in the production of plants

without symptoms, and from such plants, meristem tips of up to 0.8mm have been cultured and mosaic-free plants regenerated.

Attempts to inactivate the cassava mosaic agent by hot water treatment by immersion of cuttings for varying periods at temperatures ranging from 50-52°C were unsuccessful (Chant, 1959).

Indexing. The African cassava mosaic agent can be transmitted by means of sap inoculation to *Nicotiana benthamiana* causing severe leaf curling and chlorotic spots (IITA, 1978). There is also a very good correlation between symptom expression in cassava and the ability to transmit the agent mechanically to *N. benthamiana*. It has also been observed (Frison, pers. com.) that low temperatures enhance CMD expression. Consequently, a reliable indexing for the confirmation of freedom from CMD involves sap transmission tests from meristem tip culture plantlets to *N. benthamiana* accompanied by a 6 month observation period of the plantlets maintained at a temperature range of between 20 and 25°C. The plantlets that index positively by this procedure are recultured as single node cuttings in tubes.

Genetic resistance to CMD. One component of resistance to CMD is expressed in certain cultivars as resistance to

vector transmission (Terry, 1979). The rate of increase of CMD incidence on improved cultivar TMS 30395 established from CMD-free cuttings in field tests conducted over 2 seasons was particularly low, reaching a peak of 17%. The data indicates, therefore, that an average of 83% of TMS 30395 plants if established from CMD-free cuttings can maintain their disease-free status throughout their growth cycle, thus, providing a more than adequate number of CMD-free cuttings for the succeeding crop.

The value of this type of resistance as exemplified by TMS 30395 is not only the low field CMD-incidence that it provides, but also the possibility of maintaing a CMD-free crop by roguing out the small number of plants with disease.

Vegetatively-borne cassava bacterial pathogens

A summary of the global distribution of the bacterial diseases of cassava is presented in Table 32.

Xanthomonas manihotis is a vascular pathogen and can be disseminated through vegetative planting material (Lozano and Sequeira, 1974). Although *X. cassavae* was originally reported as inducing only leaf spots (Wiehe and Dowson, 1953), it has recently been isolated from blighted cassava stems in Kenya (Onyango and Ramos, 1978) and can, therefore, possibly be disseminated by vegetative propagation of infected woody stems.

Two other bacterial pathogens of cassava have been reported from the Americas:(1) Erwinia carotovora var. carotovora (bacterial stem rot) and (2) Agrobacterium sp. (bacterial stem gall). The latter is a vascular pathogen and can be disseminated through vegetative planting material. There is no evidence presently that the former is vegetatively-borne.

Techniques for propagation of bacteria-free planting material. A method for the production of CBB-free cassava planting stock has been developed (Lozano and Wholey, 1974), and it involves (1) the careful selection of apparently CBB-free plants; (2) the excision of 10cm - long green shoots from newly sprouted CBB-free cuttings and (3) the planting of the shoot-tips in sterile gravel in peat-pots or waxed paper cups in a mist chamber at a temperature of 25-30°C (Fig. 4).

Xanthomonas manihotis, the causal agent of CBB, and X. cassavae isolated from blighted cassava and confirmed pathogenic in Kenya (Onyago and Ramos, 1978) and in Rwanda (Maraite and Perreaux, 1978) are the 2 most important bacterial pathogens of cassava in Africa presently.

Roots are formed at the basal end of the shoot tip between 7 and 14 days after which they may be transferred to plastic pots containing sterile sandy soil and maintained in a screen house for 30 days for observation to confirm

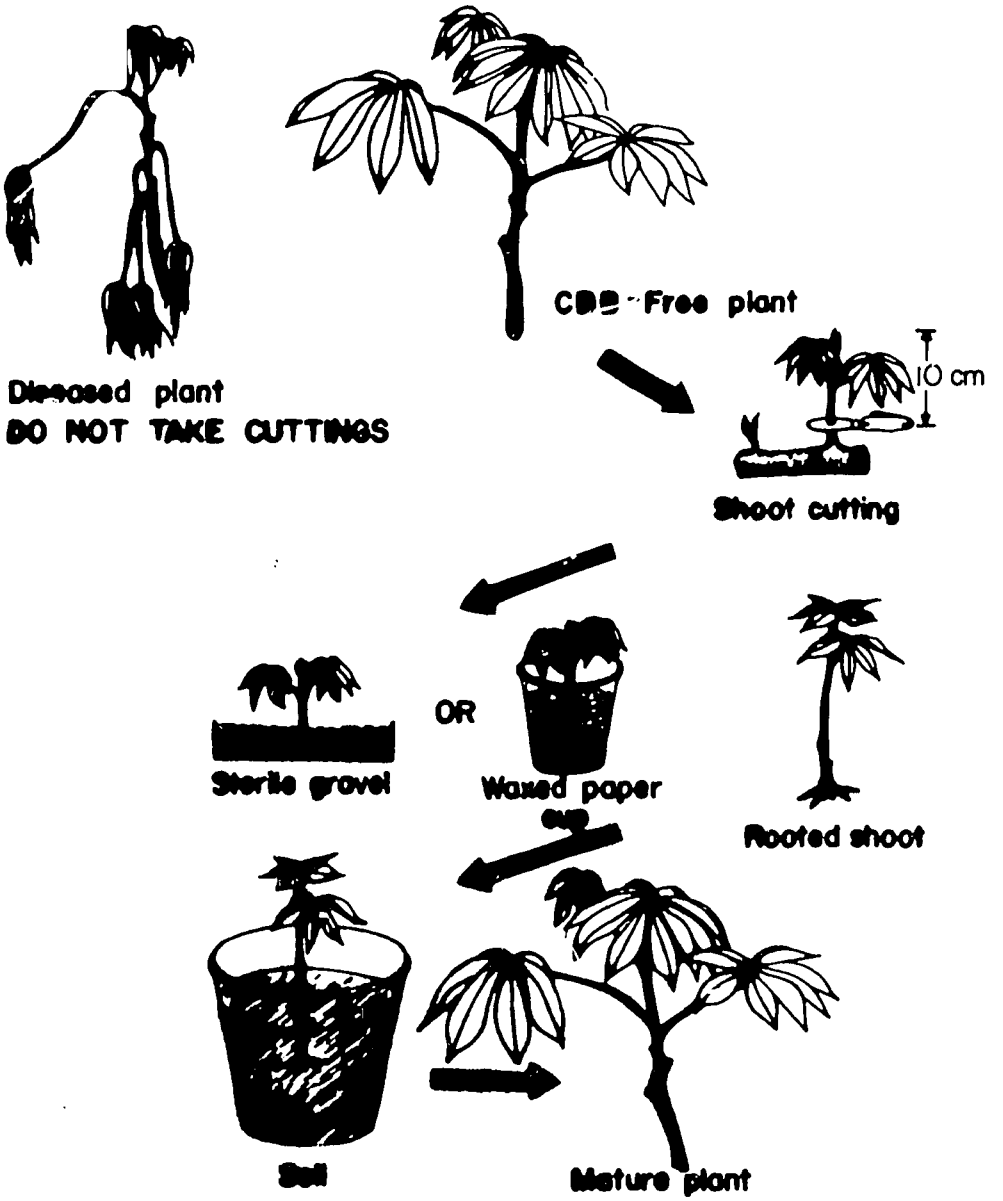

Fig 4. Propagation of CBB-free cassava.

freedom from CBB infection.

The method described above has the advantage of facilitating rapid and accurate detection of CBB infected shoot tips since the environmental conditions in the mist chamber are ideal for CBB development. Thus, if any of the excised green shoot tips were carrying X. manihotis at the time of excision, wilt symptoms appear on these within 7 days of their being transferred into the mist chamber. Such infected shoot tips should be immediately eliminated to prevent rapid cross-contamination.

Table 32. Bacterial diseases of cassava.

Disease	Global distribution	Causal agent	Dissemination
Cassava bacterial blight	Latin America Africa Asia	Xanthomonas manihotis	infected cuttings rain splashing.
Cassava bacterial leaf spot	Africa	X. cassavae	rain splashing
Cassava bacterial stem rot	Latin America	Erwinia carotovora var. carotovora	insects
Cassava bacterial stem gall	Latin America	Agrobacterium spp.	infected cutting infected soil.

Source : J.C. Lozano, 1977.

Due to the many similarities between X. manihotis and X. cassavae with respect to their pathogen - host interrelationships, the technique described above prove just as successful for the propagation of X. cassava-free planting stock.

It has been reported (CIAT, 1977) that bacterial stem gall-free cassava planting material can be obtained from diseased plantations if only symptomless apparently disease-free stem pieces are selected.

Vegetatively-borne cassava fungal pathogens

The information available with regard to the dissemination of fungal pathogenic agents of cassava through infected vegetative planting material has been reviewed by Loazno (1977). The most important fungus in this category is the causal agent of the cassava superelongation disease (Sphaceloma sp.), which grows into the cortex and epidermis and produces spores in epidermal cankers. These spores may, therefore, constitute a source of inoculum for secondary infection.

The superelongation fungus has the ability to sporulate and be disseminated by wind during the wet season and can, therefore, be rapidly spread over long distance (Krausz, 1975).

Cassava stem pathogens, viz., Glomerella sp. Fusarium sp., Sclerotium rolfisii and Botrydiplodia sp., could also be introduced into cassava growing areas in which their incidence

has not been detected, by movement of planting material, because of their ability to adhere to the epidermis of woody stem cuttings.

In the absence of any specific methods for the elimination of these fungal pathogens, the general recommendation is that only cuttings from disease-free plantations should be selected for distribution.

Technique for development and maintenance of cassava pathogen-free foundation stock.

The ultimate goal of the scheme proposed for the production of pathogen-free cassava planting material is to establish a foundation stock for routine distribution to growers. The following principles are, therefore, recommended (Lozano, 1977) to ensure successful implementation : (1) planting material for multiplication and distribution should be selected only from apparently disease-free plants, (2) the stem cuttings selected should be of the best quality in terms of vigor and general health, (3) all foundation stock cuttings should be treated with a fungicide (Thiram - Bis (dimenthylthiocarbanomyl) disulfide) at the manufacturer's recommended dosage, (4) all tools and handling materials should be either heat or chemically sterilized before contact with the stem cuttings, (5) all pathogen-free foundation stock should always be maintained in isolated locations and (6) all plants with recognizable disease symptoms or

any unusual abnormalities should be immediately rogued from the foundation stock.

In conclusion, it should be stressed that the highest standard of sanitation should be observed at all times in the handling and maintenance of a pathogen-free cassava foundation stock.

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A Technique for Detection of the Causal Agent of Cassava Bacterial Blight in Vegetative Cuttings

by

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CBB, caused by Zanthomonas manihotis (Anthand-Berthet) Starr, is known to have an impact on the production of storage roots and leaves. In the case of severe attack, there is a complete loss of vegetative material (cuttings). However, after defoliation and tip die-back, the remaining plant parts are still viable. This is the part used by farmers to produce cuttings.

As shown by Lozano (1974), the pathogen may be present in the cuttings, thus, ensuring its spread and survival. Based on these observations, our preoccupation was to set up a rapid and sure technique for detection of the pathogen in cuttings.

To detect the pathogen in vegetative material intended for production of cuttings, 2 sections of 5cm were taken from top parts of the stem. These were then cut longitudinally into 4 pieces and soaked in 20ml of water in petri dishes. The preparation is left for 12 hours at 5°C to permit the pathogen to come out of the tissues. Three drops of the liquid is then drawn and put on a slide. After drying and allowing alcohol fixation of the preparation, staining was done by the technique of immunofluorescence. This technique, which was set up for Xanthomonas manihotis, allows selective staining of the pathogen

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by the use of specific antibodies, anti-X. manihotis, associated with a fluorescent stain: Isothiocyanate of fluorescin. Microscopic observation is done under U.V. light. The pathogen is isolated on artificial media. The remaining stem collected from the same plant is cut in long fragments and planted in pots for conservation and possible appearance of disease symptoms.

During the rainy season, after the establishment phase in the leaf (epiphytic phase), the pathogen gets into the plant by the stomata and wounds caused by different physical factors or insects. By then, there is the appearance of folial lesions (angular spots, blight). The bacterium then progresses in the plant following vascular systems of petiole and stem. Folial withering and stem lesions occur later.

During the dry season (period of no symptom expression) the bacterium is preserved in woody and nonwooody stem vessels. This is the type of material that will be used for production of cuttings after 10-14 months of age.

Two-thirds of the 300 stems of varieties Nganfono and M'pember from heavily infected zones (plateau region: Mbe and Pool region: Kombe) were found with the pathogen when the immunofluorescent technique was used. Among the infected vegetative material, the pathogen was recovered in one-third of the case in the top and bottom part of the stem. The results were also confirmed by isolating the pathogen in artifical

media. However, the technique of immunofluorescence is particularly more sensitive in the case of abundance of saprophytic bacterial microflora in the preparation.

The vegetative material found free of the disease did not show symptoms when planted in pots. Infected materials express the disease manifestation. The pathogen was recovered from 40% of the cuttings showing cankers by the immunofluorescent technique.

This preliminary study show that the immunofluorescence is a serviceable, rapid and sure method for the recovery of Xanthomonas manihotis in vegetative material destined for planting. Bacterial free stems by this technique also show symptoms of the disease in pots. The method also showed that for susceptible varieties (N'ganfovo and M'pembe) from heavily infected zones, the choice of 'apparently' symptomless bottom parts of the stem for planting is insufficient to prevent the disease from reoccuring.

The detection of the pathogen on the surface of stem cankers, indicates that cankers may serve as survival sites for the pathogen and help in dissemination of the disease.

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Large-Scale Multiplication of Cassava at IITA, Ibadan

by

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The major constraint to cassava development, once high yielding, good quality, disease and insect resistance clones have been identified from a breeding program, is to multiply them up in sufficient quantity so that they can be rapidly disseminated to meet farmers' demands. Farmers methods give a multiplication fate of 1 plant to 10 cuttings. A single plant can produce enough material to plant 1 ha after 4 years. Compared to most crops - particularly those growing from seed, this is very slow multiplication rate.

At IITA, the first elite clones were identified in 1976, and these were put into field multiplication. It was recognized that if these clones were to go out to the ministries of agriculture and to large estates for further multiplication that some rapid method would have to be used if demand was to be met.

Simple multiplication methods for small farmers

Normal practice. At the present time, farmers are only using the mature hardwood to plant and multiply cassava. They cut the mature hardwood into pieces approximately 20cm long, and

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these are planted in the field, in an upright position or at 45°, approximately one-third of the cutting being buried in the soil. In some areas, they bury the cassava completely at a depth of 3-5cm. Farmers planting distances vary, but they are slowly changing to planting 1m apart on the square. Under local practice, little or no fertilizer is used. Usually with cassava grown under these conditions, 1 ha will produce sufficient mature hardwood at harvest to plant 10 ha.

IITA has shown that the whole of the cassava plant can be used to produce cuttings that can be rooted. Cassava cuttings will root easily and do not require rooting hormones nor sterilization of the water, soil or sand medium.

Making 2-node cuttings from mature hardwood. Cut the hardwood, which is used to produce field cuttings, into 2-node cuttings to increase multiplication. The 2-node cuttings are placed in a black polythene bag 12.5cm in diameter and from 22-25cm deep. The bag is filled with soil within 0.5-1.0cm of the top, and the 2-node cuttings are buried flat with the 2 buds toward the surface at a depth of 2-2.5cm.

The bags are placed in a shady place and watered regularly. After 4 weeks, they are moved to lighter shade. After 6 weeks, these are moved outside to harden off. These cuttings can be used for field planting after 10 weeks. They are planted in small holes. All of the soil in the pot is dropped into the hole, the

black polythene container having been removed carefully to ensure that minimum root disturbance is made when planting.

Making cuttings from semi-mature hardwood tops. The plant, above the hardwood, can be used for planting. The lower parts - the more woody parts - are cut into 3- or 4-node cuttings and the higher parts into 5- or 6-node cuttings; all the leaves are removed when preparing the cuttings. Even the apical bud is used, but the last developing leaf and the tip bud should not be pruned off.

All of these parts are planted straight into a field either in 5 lines on a ridge or in a seed bed on the flat. They are planted close together, standing upright to a depth of 3-4cm, so that they are approximately 3-4cm apart on the square.

These cuttings are made as soon as possible after harvesting and only planted after rainfall or under irrigation. After 3 months, there will be good root formation even some small tubers have usually initiated. The rooted cuttings are dug out carefully with a fork and planted at field spacing, 1 x 1m. After field planting, the plants are pruned back to about 20cm above the soil level to reduce transpiration losses and to encourage branching.

In high rainfall areas, it is possible to make cuttings that can be planted directly at field spacing. In drier areas, this can be done successfully under irrigation, but it is advisable to mulch around the plant to reduce the soil temperature. However, in drier areas, it may be safer to foot the cuttings first, and then plant them at field spacing.

IITA can obtain just as many cuttings from the tops of cassava for planting as from the hardwood. Hence, if the plant has been cut into 2-node cuttings and all the tops are used, multiplication can be increased from a normal multiplication rate of 1 plant to 10 cuttings to 1 plant to 60 or 70 cuttings.

Improved multiplication methods for large-scale farmers.

The use of 2-node cuttings to produce rooted cuttings. As soon as the 2-node cuttings have been moved outside to harden off and shoots have developed to about 20cm in height, they are cut off just above the first node of the new growth. The node, which is left, will then produce another shoot after 3 weeks, and this is then cut off leaving another node at the base to develop a further shoot. From 6-8 cuttings from a single shoot are taken in this way. Eventually, they become spindly and are taken to the field and used as planting material.

If both nodes of 2-node cuttings develop, then 16 cuttings from 2-node cuttings can be obtained. If a farmer's cuttings are converted into 5-6 2-node cuttings and if each 2-node cutting gives 8-16 cuttings

a multiplication rate of 40-96 times better than the farmers' rates can be realized.

The cutting is trimmed off its leaves until only the last developing leaf and bud remain. The cutting is planted, under shade, vertically into small glass bottles filled with water or, alternatively, into beds of sand or soil that are covered with a polythene cover to make a humidity chamber to prevent the cuttings from drying out.

The cuttings after 2-4 weeks, dependent on whether or not the weather is hot or cold, develop roots; they should be dug out carefully if rooted in sand or soil and potted off into black polythene bags similar to those used for the 2-node cuttings. These should be kept in a shaded place until they have established themselves. After 2-3 weeks, they can be moved outside to harden off and grow on for field planting.

If delays in planting result in heavy top growth, IITA suggests that the stems be pruned back at planting to leave 3-4 nodes of next growth and the lower leaves be removed to reduce transpiration losses while the plants become established in the field.

<u>The use of semi-hardwood tops to produce rooted cuttings.</u> If the supply of wood of a clone is limited and it must be rapidly multiplied, the shoots produced from semi-hardwood cuttings can be used. The number of shoots that can be cut

will depend upon the vigor of the semi-hardwood cuttings, its soil and nutrient supply. Cuts should be made just above a node.

Taking cuttings from established plants. Once plants have been established in the field, tip cuttings can be regularly taken and rooted. IITA suggests that when tip cuttings are taken in the field, they should be trimmed of leaves and dropped straight into a bucket of water. This will prevent latex coagulating over the cut, and the cutting will remain as fresh as possible until planted into water, soil or sand medium for rooting.

Further increasing multiplication. One-node cuttings can be planted like 2-node cuttings but with the node to the top. In India, even 11-node cuttings have been cut longitudinally through the bud to make half node cuttings.

Naturally, the smaller the cuttings, the greater the attention they will require. On a large scale, where supervision must be limited, 2-node cuttings should be used. They require a minimum of attention after planting. Regular watering each day will be all that is necessary to ensure a high success rate.

Rattoning

In multiplication, hardwood production is important, tuber production is unimportant.

IITA suggests the application of 400kg of 15-15-15/ha in equal split applications, 6 weeks and 12 weeks after planting. The fertilizer should be applied around each plant, 10-12cm away from their stems. The crop is usually for harvesting for farmers cuttings after 7 or 8 months. At harvest, the cassava is cut approximately 20cm above soil level. The remaining stem is again fertilized at the above rate after 3 and 6 weeks, and a second crop is obtained in 6 or 7 months. More than 1 ratoon crop should not be taken as decay is likely, and this will seriously depress subsequent wood production. To prevent the waste of the root stocks after 2 crops, pulling up the plants, pruning off the tubers and planting the root-basal stem give a much better crop of wood than a second crop of cassava in the same location.

Humidity chamber construction

Where sand or soil is used as a rooting medium, cuttings are kept in high humidity to reduce transpiration losses. At IITA, a simple and cheap chamber is used that is constructed of 45cm long x 10cm wide x 25cm high cement blocks end to end to form a rectangle, 6-block long and 4-blocks wide. The blocks should be laid on the level so that the wooden frame, carrying the plastic sheet cover, makes a reasonable seal when laid on top of the blocks.

The wooden frame, which must fit centrally over the blocks, should have a strong construction at each end so

that it will give a 30cm height above the blocks. An inverted 'V' shaped roof is constructed with a peak height of 80cm above the top of the blocks. A panel should be constructed in the roof so that plastic covering can be installed. The wooden frame should be fairly light so that it can be easily lifted by 2 men.

Polythene sheet should be used to make a reasonably air tight canopy over the wooden frame. Polythene sheets last 6 months. The wood should be constructed of hardwood so that it is reasonably permanent, it may then be covered with polythene sheet many times. The plastic sheet is attached to the wooden frame with staples so that it may be easily removed when the plastic goes brittle and starts to crack or tear.

Solving rooting problems at cooler times of the year

The humidity chamber's cover may be dispensed with during periods of cold nights and cloudy days. High humidity combined with the cool temperature appear to depress rooting appreciably. If the rooting percentage falls due to the weather, it is recommended that loamy soil be used as a rooting medium instead of sand.

At lower temperatures, there are great clonal differences in rooting ability. If a clone is found with poor rooting ability under cool conditions and if the above

suggestions in dispensing with the cover and the substitution of soil does not improve the percentage of rooted cuttings, IITA suggests that rooting should be in water.

The development of cassava multiplication at IITA.

In 1976, breeders' material from 2 clones, 30211 and 30395, were field planted. These resulted in 575 mature plants of 30211 and 290 plants of 30395 in the first 3 months of 1977. The demand for this material was such that IITA distributed all the hardwood, except for enough to plant 5,000 2-node cuttings of each clone. As we harvested the hardwood, we kept the semi-hardwood and the green tops, cut these into short lengths (3-5 nodes) and rooted them in sand. Once they had established a good system, they hardened off, and then were taken as very small plants to the field, planted at half the normal field spacing (50 x 100cm) heavily mulched and irrigated for 1-2 hours daily resulting in a 90-95% sprouting rate.

Established plants were fertilized at 200kg of 15-15-15/ha. Young shoots were pruned and were again rooted in sand to give further plants for planting. Having taken an average of 3-4 shoots from each plant, they were fertilized again with 30kg NPK/ha and allowed to grow to maturity as a source of hardwood. This hardwood was sent offsite to help establish other multiplication centers, and again, IITA

utilized young cuttings to build up our own plant population. When the hardwood was harvested, the stems were cut off about 25cm above ground level and the undisturbed root stock sprayed with contact Gramoxone and residual Dual and Kotoran mix herbicide, fertilized around each individual plant and allowed to produce a second wood crop. After the second wood crop was harvested, the whole plant was harvested. Stem base is a very important material for production of hardwood.

Like other institutions, IITA has limited land and money for cassava multiplication. Direct field costs to produce 2 crops of hardwood using the ratooning techniques is $1,000/ha. There are 2 particular items that make up a large percentage of this cost. Residual and contact herbicides take up 40% (no hand weeding is done), the second is fertilizer accounting for 25%, some 120-140kg NPK/ha being applied in the 15-17 month period, which is the time taken to produce these 2 crops of hardwood.

Precautions in rapid multiplication

The advantages of cassava include the fact that it easily roots from all parts of the plant without the use of rooting hormones. Care should be taken not to infect injury on the part of the stem inserted into the soil. Small rooted cuttings should be transplanted into predug

holes and carefully covered. If plants have developed quite a lot of top before they are transplanted to the field, then this should be pruned off to reduce transpiration. It also has the added advantage of making the plant shoot again, and very often more than 1 bud will appear giving additional stems and, therefore, planting material. Allow shoots to harden in the nursery before planting. Shoots that are soft will never give as good a percentage sprout as those that are hard. When cassava is ratooned, it will produce many more stems than the first crop. If you note after the first fertilizer application just after harvest there are many shoots sprouting, then increase the second fertilizer application (5 weeks later) if growth is from cassava hardwood. The first fertilizer application should be after 5 or 6 weeks and the second 5 or 6 weeks later. Be sure to keep the cassava weed-free.

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SECTION IV

Problems and Prospects of Cassava Dispersion in Zaire

Cassava is the most important staple food in Zaire where both the roots and leaves are eaten. Cassava is grown in all the 8 regions of Zaire (Fig. 5). The percentage of cultivated land area devoted to cassava alone ranges from 33% in Kivu and Shaba to 66% in Bas Zaire (Table 33).

Table 33. Distribution of cassava production in Zaire.

	Ha. land in cassava 1000 SE	Production SE	Tons/ha SE	% Cult. Land on Cassava % Tene Cultivei en
	1970-75	1970-75	1970-75	1970-74
Bas Zaire	149.6 ± 8.3	1088 ± 83	7.13 ± 0.13	65.7
Bandundu	252.7 ± 12.0	1794 ± 115	7.10 ± 0.18	51.7
Equator	164.5 ± 8.0	1109 ± 73	6.63 ± 0.09	48.5
Haute Zaire	183.3 ± 6.2	1252 ± 54	6.82 ± 0.11	46.5
Kasai Occidental	199.7 ± 8.8	1396 ± 89	6.99 ± 0.17	42.7
Kasai Oriental	159.2 ± 7.4	1124 ± 63	7.06 ± 0.08	37.5
Kivu	266.0 ± 12.6	1799 ± 90	6.76 ± 0.05	33.4
Shaba	213.8 ± 10.2	1404 ± 88	6.57 ± 0.15	33.4
Total	1588.8	10966	$\bar{X}$: 688	$\bar{X}$: 45.4

Source: GOZ : Department de l'Agriculture. Annuire des Statistiques Agricoles 1970-74; 1975-76.

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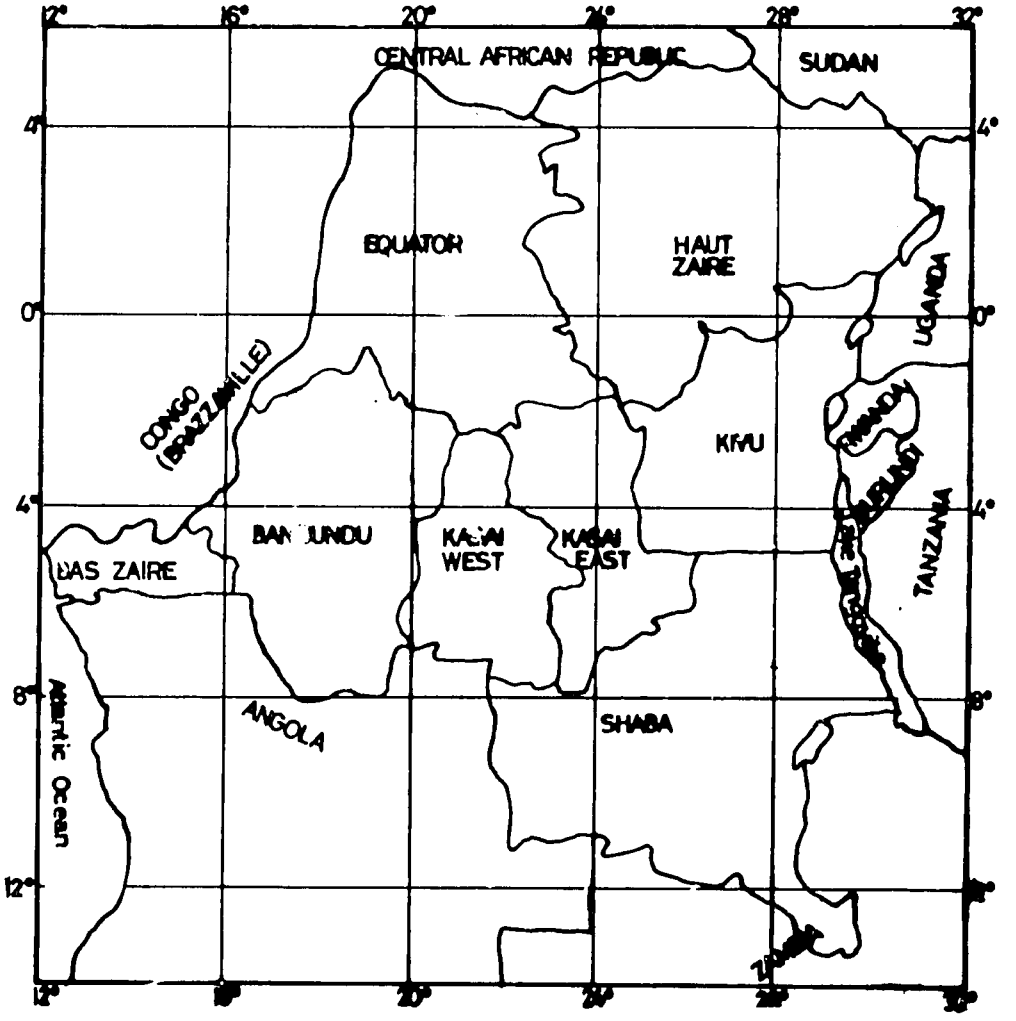

Fig 8. MAP OF ZAIRE SHOWING THE REGIONS

Problems and Prospects of Cassava Dispersion in Bandundu

by

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Bandundu occupies 310,000 square kilometers and is located in southern Zaire (Bourguignon and Vanstraclen, 1969). Two types of climate are recognized (Devred et. al. 1978; Sys, 1964):

1) Type Aw Koppen climate is in the center and south of the region, and area of peneplains and of plateaus rising in tiers around a basin. The vegetation is herbaceous with shrubby savanna on the Kalahari sand. It is very poor in mineral nutrients and organic matter. The riverain forest occupys the valleys along big streams. Under this forest, the soils are hygrokaolisols. Kiyaka, an agricultural research station, is located in the type Aw climate with 2 types of soil and vegetation recognized in that system. The rainfall is about 1,600 mm per year, and the mean annual temperature is about 21°C (PRONAM, 1979).

2) Type Am climate is in the center and north of the region; the soils are also hygrokaolisols under and equatorial forest. The average altitude varies between 200 and 500m in the north and 500 and 1,000m in the south.

Administratively, Bandundu is divided into 4 subregions in which the traditions and ethnic groups are diversified. The total population was estimated at 2 million inhabitants in 1970. Field work is mainly a woman's responsibility. The economy of the central and southern part of the region is based on the marketing of agricultural products through a relatively well developed road network. Fishing and hunting are also important in the network of small rivers that are used for transport. In contrast, the northern part has a poor transportation system and poor, highly eroded sandy soils.

Since 1973, Bandundu is the number 1 cassava producing region in Zaire (Depagri, 1979). In 1978, Bandundu's production was 7,744,291 tons of roots on 553,579 hectares

Cassava has no rival as a source of energy. Rice, plantain and yams are taken as dessert. However, the high consumption of cassava without valid animal proten is very detrimental to humans, particularly to children's health.

As a commercial crop, cassava is no doubt the most profitable in the region because of its permanent presence

in the markets and the long period through which it can be harvested for both roots and leaves. However, it is bulky to carry, and on a per kilogram bases, it is less profitable than maize, rice or peanut.

Agronomy

Cassava cultural practices vary with the type of vegetation. The relief does not influence the location of the fields, and sometimes fields are located as far as 15 kilometers from the village (Mudindi, 1979). Cultivation is possible throughout the growing season, but the best time of planting is between August and March.

In the savannah, the land is cleared and straw debris buried under ridges or mounds. In the forest, the knocking down of the bush is followed by burning, and the cassava is cultivated on the flat. Cuttings 40-70cm long are planted oblically (particularly in Kwango) or horizontally at various spacings. The population density rarely reaches 10,000 plants/ha. Cassava is usually cultivated in association with groundnut, maize and gourd. In the traditional cultural system, cassava comes first in the rotation and this is a deviation from what happens in West Africa (Ezumah and Okigbo, 1980; Depagri, 1978).

Harvesting is spread over 8-10 or 12 months after planting. The average yield is about 7t/ha (Muyolo and Malamba, 1979).

The leaves for consumption are harvested only from young plants (3-6 months).

Most of the varieties cultivated by farmers are local cultivars. The most common are Munjoko, Mumbala, Mundedi, Taoli and Voti. CMD, CBB and AD are the common cassava diseases in Bandundu. Of the 3 diseases, CBB is the most severe, and the farmers of Bandundu's southern savannah have observed the damage sice 1965. The cassava mealybug and green spider mite are not yet spread all over the region (Mayolo and Malomba, 1079).

Research and extension

From colonization to 1963. Cassava research was carried out by the National Institure of Agricultural Research of Congo (INEAC). Seedling nurseries wer established with materials collected from cassava fields at the research center of Yagambi. The objectives of the selection were as follows:

high yielding varieties

- resistance to CMD
- thickness of cassava stems in plateau
- high starch content
- taste properties of flour and leaves (INEAC, 1956).

From 1963 to 1975. Cassava research was stagnated by the Congo (Zaire) wars.

From 1975 to present. Cassava research was revived with the establishment of PRONAM. In Bandundu, PRONAM planted about 21,000 seeds of 254 families and multiplied 16 hectares of high yielding disease resistant clones (Table 34).

Extension is the responsibility of the regional division of Zaire's Ministry of Agriculture. Extension is carried out by technicians spread in different areas. Missionaries and friendly government agencies are also very effective in agricultural extension work.

Table 34. High yielding clones in multiplication at Kiyaka, Bandundu.

Clones	Diseases			Yield (t/ha)
	CMD	CBB	CA	
30577/5	2	2	1	26.26
D 149	2	2	1	28.00
F 150	3	1	1	24.12
F 112	3	1	1	21.75
F 100	2	1	1	19.87
F 162	3	1	1	17.97
F 156	2	1	1	17.39
Local munjoke	2	2	1	12.57

Problems. Many human, financial and technical constraints refrain serious expansion of agriculture in the region. Technically, there are high yielding varieties and improved cultural practices in research stations in Bandundu (Table 34), but these are not yet made available to farmers.

In terms of human constraints, the masses are sometimes conservative. However, they accept innovations depending on the situation. For example, the low yields due to CBB attack made the farmers adopt improved varieties. At the extension level some training and motivation to duty will be helpful. Poor infrastructure and bad road maintenance discourage traders from going to the interior. Farmers will learn and change their attitude if they are taught by well trained confident agents. Farmers can be reached more easily through cooperatives, and resources such as credit and subsidies can also be better obtained and distributed.

Dispersion of cassava requires that people who understand the crop, the aims of PRONAM and the real importance of cassava in Zaire be trained and placed at strategic locations. Much of PRONAM's failure to date is attributed to its inability to secure trained manpower at the extension level.

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Problems and Prospects of Cassava Dispersion in Haut-Zaire

by

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According to Koppen's classification, 3 types of climate are found in Haut-Zaire :

1) the zone inside the central basin with A+ climate characterized by the quasi total absence of dry season.
2) the surrounding boarders with a transition type of climate, Am, characterized by rainfall reduction with 1 or 2 months of dry season.
3) finally, a zone with an Aw climate with a long dry season up to 4 months.

Haut - Zaire is an important region for cassava production in which yields are potentially higher than in other regions of the country. The following ecological factors found in Haut-Zaire are important in good cassava yields:

1) The average annual temperature varies between 18-24°C, and cassava gives good yield at an average temperature of 23-24°C. The minimum and maximum annual temperatures are, respectively,

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16 and 31°C. Temperatures above 27°C influence the growth of vegetative material and those below 20°C are detrimental for tuberization.

2) The average annual rainfall varies between 1,000-2,500 mm, and cassava production requires from 500-4,000 mm of rainfall. A high soil humidity is said to reduce the HCN content.

3) Daily annual average light is 10 hours of sunlight, and cassava is an obligatory heliophyte plant that requires long day lengths.

4) The local winds are generally moderate, except those before rains that can reach a speed of 90 km/hr and cause branch breakages. Most likely, cassava fields in the forest zones are planted in "alley cropping" system where the forest belts serve as wind breaks. This means that damages from these winds on cassava plants are of minor importance.

5) The soil distribution follows the same pattern as climate:

   a) sandy-clay soils in the basin;

   b) ferralitic soils in the plateau;

   c) humified soils in the mountainous regions.

Even much of the soils in Haut-Zaire have high moisture

retention capacity and, thus, give high cassava yields. Although Haut-Zaire is an agricultural region, the importance of cassava can be seen from the land percentage occupied by cassava (Table 35).

Table 35. Coefficient of localization (CL) values and percentage of lands occupied by cassava in Haut-Zaire (Nkiere, 1974)

Year	Sub-region	Cultivated areas(ha)		(%)	% area cultivated with cassava
		Total	Cassava	C.L.	
1958	Tshopo	116,256	17,507	0.61	15.06
	Bas-Vele	185,203	22,350	0.47	12.06
	Haut-Vele	187,055	27,110	0.51	14.49
	Ituri	116,246	19,184	0.64	16.50
1970	Tshopo	124,720	31,010	0.05	24.85
	Bas-Vele	173,324	46,900	1.15	27.00
	Ituri	73,179	25,873	1.49	32.00
	TOTAL H.Z.	497,255	116,763	0.99	23.40

Table 35 shows that on the basis of coefficient of localization and of percentage of cultivated areas, the importance of cassava in each subregion, except Bas-Vele, has increased from decade to decade, and also considering the coefficient of localization, Table 35 shows that cassava

cultivated lands are very small with regard to total cultivated areas. The reasons for this trend are as follows:

1) Poor marketing due to bad roads
2) Low population density
3) The feeding habits in which preference is given to rice and plantain
4) The difficulty in storing cassava in a region where the relative humidity is very low.

Haut- Zaire still has low cassava production in comparison with Bandundu and Bas-Zaire although it has fertile soils and land area under cassava increasing from decade to decade. This is due to a relatively lower number of people eating this starchy food, to less areas occupied by cassava because of the difficulty in clearing trees, low inputs in cultural practices and lack of improved marketing channel. Rice and plantain are the main staple foods in the region. All these factors contribute to the low cassava production in Haut-Zaire. Table 36 shows data on cultivated lands, total production and production that goes into commerce.

In general, data from Table 36 indicate that cassava production and yield per hectare are not proportional to cultivated areas during the first decade. But for the last decade, there is a clear increase in production and yield

due mainly to the genetic improvement of varieties released in the rural area through research efforts.

Table 36. Evolution of cassava production in Haut-Zaire.

Year	Area (ha)	Production (t)	Market production (t)	No. of farmers	Yield (t/ha)
1950	103,257	1,007,283	76,718	-	9.75
1951	97,236	943,965	108,544	-	9.70
1952	99,760	864,514	82,893	-	8.36
1953	98,801	836,585	147,929	-	9.46
1954	92,086	801,741	197,264	-	8.70
1955	110,161	820,709	211,059	-	7.44
1956	103,497	811,150	161,239	-	8.43
1957	97,129	788,839	144,742	-	8.12
1958	85,932	736,936	131,150	-	8.57
1959	-	705,264	115,377	-	-
1968	137,092	924,383	-	-	6.74

Adapted from: Nkiere, 1974.

Research and extension

At INERA-Yangambi, especially, there is a collection of 75 clones, 30 of which are local, 17 are from Yahuma and

Basoko and 28 are from M'vuazi. Ten clones are performing well with a yield from 25-65 tons of fresh roots in a well maintained field. The volume of marketed production does not follow the same pattern as the cultivated area and the yield (Table 36). The excess production is used in an alcohol industry.

Problems. CMD seems as old as cassava and though high yield reduction have been reported CBB and AD are also observed. The green spider mite is a serious dry season pest. Its attack is very serious in regions with a long dry season (Mostade, 1977, Nkiere, 1974) and around Haut-Zaire borders, particularly near Uganda. Major root rot occured in 1979 around Yangambi and Yahuma.

Storage is a big problem for cassava production. In the basin smoking of root chips is the method used for storage but the prevalent high humidity induces mould development on the chips. To prevent a fast development of mould, the roots should be sliced longitudinally to promote fast drying. Storage by smoking reduces the market value of the cassava since the color of the roots is unattractive.

Extension. In Haut-Zaire, cassava is grown throughout the year. It is incorporated in every rotation adopted in the different administrative zones of Haut-Zaire. Most of the

times, cassava is at the end of the rotation.

It will be desirable to PRONAM to distribute the 10 best clones found at Yangambi in the INERA stations located in Haut-Zaire, with the stations serving as centers of dispersion.

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Problems and Prospects of Cassava Dispersion in Kasai and Shaba

by

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Cassava production is very low to cover the needs of cassava consumption in Kasai East, Kasai West and Shaba. Kasai West, formerly an exporter of cassava to Shaba, is now importing. The reasons for the decrease or stagnation in production are due to factors such as the following:

- The epidemic of CBB in 1970, which was aggravated by the presence of AD and CMD
- Low input in cultural practices
- Harvesting and processing problems
- Poor soil fertility
- High population increase
- Encroachment on rich farmland by diamond miners
- Government agricultural policy

PRONAM has already solved some of the problems. It has also accumulated sufficient information in various research centers and ecological zones. There is, therefore, a need to create within PRONAM extension services to increase cassava production for the population.

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Problems

At the start of mineral resources exploitation in Shaba and Kasai, the provision of the manpower was a big problem. Cassava was the only principal source of energy for the workers. Because of the high publicity made on cassava and because of the policy of the government to improve some crops, the 3 regions became self-sufficient in cassava. However, from 1948, the importance of cassava as a principal source of energy started decreasing because of its lower profit margin compared to cotton and groundnut but also because of a high consumption of maize flour by the Shaba population. From 1952, cassava cultivated along the Kasai railways was hardly marketed because the Tanganyika subregion was able to provide enough cassava for the Shaba region. The influx of refugees into Kasai-West and the 1960-61 famine created an imbalance between the price paid to cotton and that paid to food crops, maize and cassava. In 1970, CBB caused by Xanthomonas manihotis destroyed more than half of the fields in the savannah zones of Tshikapa and Kabinda. To solve this problem, cassava varieties with high cyanide content were introduced, but most of them were late maturing varieties 18-24 months. The situation resulted in the introduction of early maturing, high yielding varieties with low cyanide content.

Crop rotation and cultural practices imposed on cassava 33 years ago as a result of the introduction of cotton were to be amended in some areas not only because of the high demand of food crop but also because of the need to restore soil fertility and water supply.

Cassava population density on the cultivated areas is sometimes very low. The time of planting and the different intercropping systems contributed to lower the yield per hectare. The control of erosion, bush fire and the choice of suitable productive leguminous plants rich in organic matter are urgent problems that need to be solved.

Climate

All the areas in the south and southeast of the central zone with an equatorial climate are influenced by pre-Sudanese and Sudanese climate. The 2 Kasai regions belong to Aw Koppen type of climate. The average dry season duration varies between 90 and 114 days. It starts about 15 May and ends about 23 August. The rainfall regime has a double trend the maximum is in December (200-250mm) and March (180-230mm) and the subordinate minimum is around February. This minimum is very irregular, and sometimes does not occur. The success of cotton production and the harvest of some crops of the second season depend largely on the beginning, the duration

and the intensity of the subordinate minimum. The monthly average temperature is 23°C during the dry season and 24-25°C during the rainy season. The mean maxima varies from 29°C in the rainy season to 32°C in the dry season while the mean minima declines from 19°C in the rainy season to 15°C in the dry season.

The monthly mean relative insolation is more than 70% in June and varies between 35 and 50% in the rainy season. The land area of Shaba region is 496,965 square kilometers. Its relief is mountanious moving from relatively low plains to high plateaus of 1,600m. In this region, the dry season is generally long, and as we progress gradually toward the south, the dry season becomes longer (4-5 months in the north and 6-7 months in the south).

The average rainfall depends on the latitude and altitude and varies between 800 and 1,600mm. Temperature, which mean is relatively high, shows great local variations with altitude. At the extreme, temperatures below 0°C are observed.

The annual average tmeperature, the total rainfall and the duration of the dry season determine approximately 3 different climatic zones:

1) A sub-equatorial climatic zone with an equatorial forest with trees as dominant vegetation. The massive

forests are separated by herbaceous and shrubby savannahs.

2) Pre-Sudanese climatic zone with gallaries of forests and rice woody savannah as dominant vegetation.

3) Sudanese climatic zone includes all southeastern Shaba extending to the Moero region in the north-eastern zone and along an area bordering the Tanganyika region. The annual rainfall ranges from 1,000 - 1,200mm. The dry season duration also is between 5 and 7 months. The entire region is covered with woody savannah and poor herbaceous savannah.

Cultural practices.

Two cropping seasons, the first starting in August, September and October till January and the second starting in February till the end of May are observed. Shifting cultivation is practiced.

In order of importance, cassava, maize, rice, millet and groundnut are the principal food crops in these regions. Cassava has the most cultivated areas among all these food crops and procures more income to farmers than maize. The average of 4 zones indicates that cassava is grown on 35.4% of land while maize is grown on 21.5% of total cultivated land.

Table 37 show the importance of intercropping and the percentage of cultivated land per crop in 4 zones.

Table 37. Percent of cultivated land per crop and per intercropped crops.

Crop	Z O N E			
	Kanjama	Mweno-Ditu	Gandajika	Tshilenge
Cassava	42.5	35.9	32.0	31.2
Cassava-maize	10.5	6.1	14.8	15.4
Cassava-maize-beans	1.7	0.2	0.5	2.3
Cassava-maize-groundnut	1.0	9.5	2.3	1.0
Groundnut	23.0	20.8	26.1	16.2
Beans	0.4	0.5	5.0	5.7
Cotton	0.2	1.4	1.0	3.1

Cassava is grown in sandy-clay or clayey-sandy soil. It is mostly planted on the slope or sometimes on the crest line and on bottom soil with good drainage. Cassava is generally cultivated in "shamba," which are fields in the bush far from villages and protected by elephant grass (as hedge) from disease and goat attacks.

Time and methods of planting cassava in association with other crops depend on the importance of each crop grown in the region. Table 38 shows the time of planting of cassava

and maize in 4 agricultural zones.

Table 38. Percent of responses per zone on the time of planting cassava intercropped with maize.

Cassava planting time compared to maize	Z O N E S			
	Kaniama	Mwene-Ditu	Gandajika	Tshilenge
More than 2 weeks after maize	6	41	56	45
One or 2 weeks after maize	22	18	6	13
Simultaneously	53	9	0	0
One or 2 weeks before maize	4	20	15	21
More than 2 weeks before maize	3	9	10	17

Table 38 shows that most of the farmers in Mwene-Ditu, Gandajika and Tshilenge plant cassava at more than 2 weeks after maize while in Kaniama (Shaba) most of the farmers plant cassava at the same time with maize. Some farmers plant cassava 1 or 2 weeks before or after maize.

The importance of cassava over maize is mainly due to its cultural cycle and to the fact that it can be harvested over a long time.

The spacing between mounds is from 1.25-1.60m, or from

0.8-0.9m if cassava is planted in a cotton field. The Baluba ethnic group makes large mounds and plants cuttings in an oblique position. They usually plant above the ground. The Lulva ethnica groups makes small mounds and buries cuttings slightly in a horizontal position, 2 cuttings of 25-30cm long at about 12cm deep. The Bapende plant groups of 4 cuttings each, which may be buried or sometimes planted in a slanting position.

SECTION V

State of Art on Cassava Production in Central Africa

All the regions of Central Africa, especially the lowland (below 1,000 feet) areas of Zaire, Cameroon, Congo (Brazzaville), Zambia, Angola, Rwanda, Burundi, Uganda and Gabon, are ideal for cassava growth and development. These regions, which are within 10 degrees N and 15 degrees S of the equator, are widely regarded as being the most important cassava production areas of Africa. The central location of Zaire in this region is illustrated in Fig. 6. The need for a regional approach to solving problems of cassava in the region is emphasized by similarity of constraints in the regions.

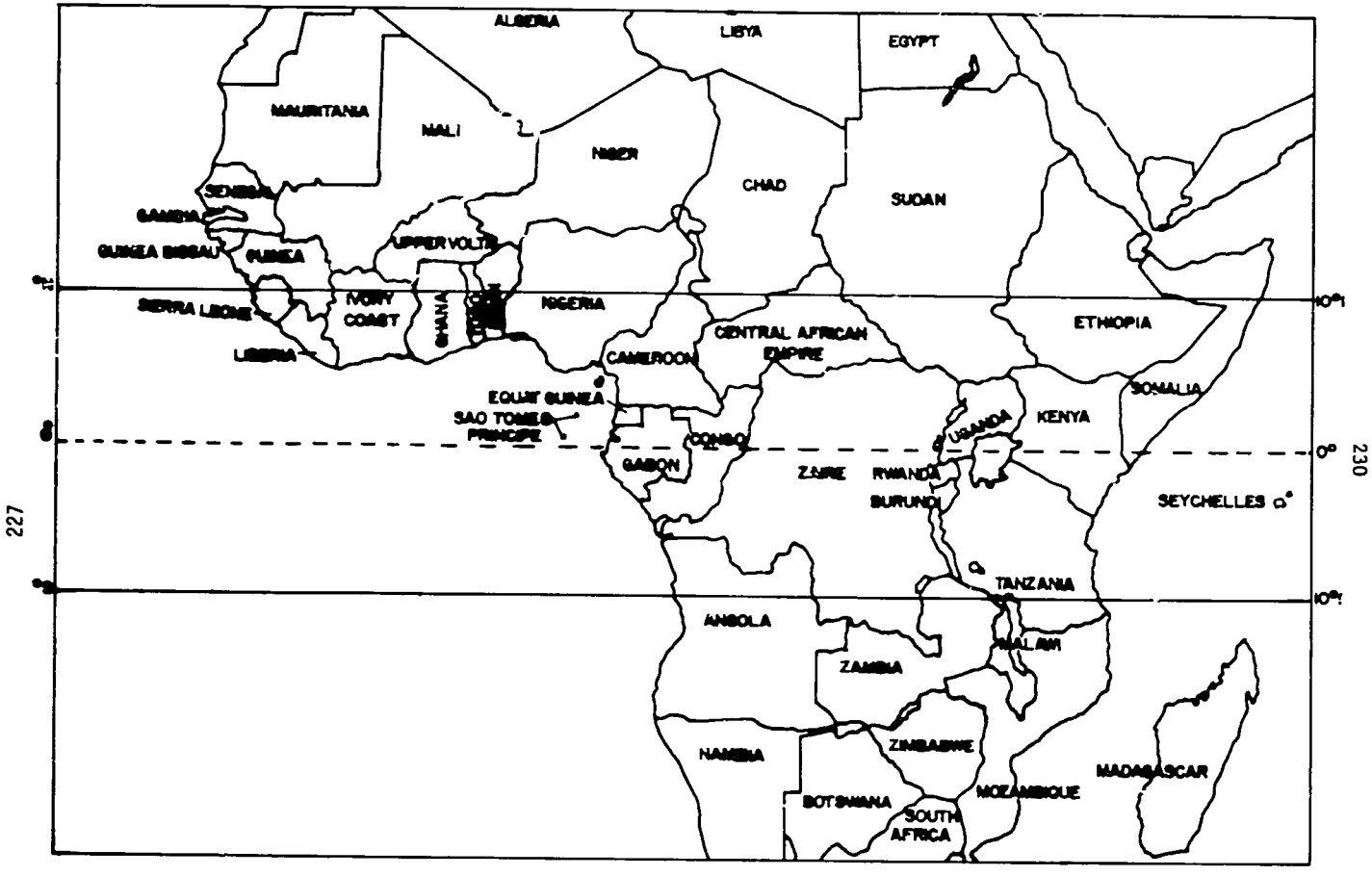

Fig. 6. Map of Africa

State of Art on Cassava Production in Angola

by

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Importance of cassava and adaptation

Cassava occupies one third of the cultivated land of Angola and constitutes the basic food of the people. Cassava is the second most important food crop after maize. Both cassava's leaves and tubers are consumed.

Cassava is widely adapted to many parts of Angola and possibilities of increased production are high. It can be used for human and animal nutrition and has potentials for industrial purposes. The government of Angola is, therefore, planning projects for research on cassava.

Prospects for the future

The most important aspect of economic development projects aims at a transfer at the national level of advanced technologies to rural populations. Presently, there is no industry of cassava processing. Apart from government projects, there are cooperatives supported by the ministry of agriculture. These cooperatives are urged to create favorable conditions for the use of the best available technologies in production and diversification of farm products.

The cassava crop was neglected in research, and, consequently, the Angolan Government experiences some difficulties in establishing and staffing new research stations. To overcome these difficulties and to meet our objectives, a national cassava project has been created and presented to FAO for cooperation. Large-scale cassava production projects are planned, but research will also be done. Presently, 2 technicians are being trained at IITA and scientific cooperation with IITA has been sought after the recent visist to Angola by an IITA team of consultants.

Diseases and pests

Although no sound inventory of cassava diseases and insects has been made in Angola, some diseases and pests and their economic importance are known. Cassava is attacked by a virus disease complex, AD, cercospora and bacteria and also by mites and other insects :

a) The cassava mealybug is well established in Angola. The damages caused, especially during the dry season, are enormous.

b) CBB although identified in the country has not been recognized as a serious disease.

c) The cassava green spider mite might probably be already in the country.

d) In some areas of Angola, AD is becoming a limiting factor for cassava production.

State of Art on Cassava Production in Cameroon

by

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Roots and tubers are major components of the food of Cameroonians, especially the communities in the central and southern parts of the country where cocoyams and cassava form the staple. Cassava flour is competing increasingly with sorghum and millet in the southern region of northern Cameroon.

The importance of root and tuber crops is reflected in Table 43 in which their tonnage far exceeds those of any other group of food crops and their projected annual increases compare well with the others. The tonnage of more than 2 million in 1975 was expected to increase by 1.5 million in 1980/81, which is an average increase of 15% per year.

Cassava production is estimated at over a million tons in 1979 beyond the projection of the Fourth 5-Year Economic Plan and is considered the most important tuber crop, certainly the most widespread.

Table 43: Food production and projected increase in Cameroon (metric tons)*

	1975	Projected 1980/81	% Projected Annual increase
1. Cereals			
Millet & Sorghum	350.000	500.000	8.5
Maize	376.000	500.000	8.0
Rice	24.000	100.000	30.0
Wheat	-	30.000	-
Total	754.000	1,130.000	
2. Roots and Tubers			
Cocoyams	850.171	900.000	4.2
Cassava	811.102	1,000.000	5.0
Yams	363.767	1,324.000	20.0
Sweet Potatoes	150.206	296.000	9.0
Solanum Potatoes	63.326	200.000	21.5
Total	2,237.572	3,720.000	
3. Plantains	1,160.000	2,600.00	14.7
4. Leguminous Crops			
Beans	80.000	90.000	1.9
Groundnut (for local use)	129.000	173.000	5.0
Total	209.000	263.900	
5. Vegetables			
Local vegetables	238.000	276.000	2.7
Gourds (melon pumpkins, etc.)	45.800	76.000	8.8
Exotic vegetables	50.400	120.800	15.6
Total	334.200	472.800	

Source: Fourth, 5-Year Economic Plan of Cameroon, 1976-81.

Most of the cassava crop in Cameroon is from small peasant holdings of about one-fouth-1 hectare, sometimes intercropped, sometimes sole, early or late.

Due to rapid deterioration of cassava roots after harvest, most of the crop is immediately processed into a form of food product that can be preserved for later consumption or local market. These products are also in a form that is more easily transported to local markets or exported to Central Africa.

Peasant cultivation practices and cropping systems

The cultivation of cassava in Cameroon involves many cultural practices and cropping systems. These practices and systems depend largely on the prevailing ecological factors, the food needs and the agroeconomic activities of a particular community. Thus, the place of cassava in the culture of Cameroonian growers varies from a monocrop, through a main-intercrop, a minor-intercrop, a fallow crop, a catch crop to a nurse crop.

Early cassava or cocoyams + cereals + vegetables. This is a popular combination in the hot, humid lowlands with cassava or cocoyam as the main intercrop. After land preparation, the cassava and maize are planted in March

or early April.

Local vegetables (amaranthus, huckleberry, etc.) are sown a month later. The cassava is usually harvested in February of the next year just in time for more cereals or fallow.

Cereals + vegetables + legumes + late cassava continue to next season.

This association is usually practiced where cassava cannot normally mature in 12 months in the cool highlands. Maize is the main crop. Cassava, which is sown as a late crop in September, continues on the land most of the following year and may be followed by a bush fallow. The practice of burning or vegetative trash underground ('ankara') during land preparation may be adopted.

Yam + early vegetables followed by late cassava. This system is fairly new with a purely economic outlook. The yam (*Dioscorea* spp.), early vegetables (melon) and cassava are produced for sale, and the combination is out for maximum crop output.

It is practiced in the hot humid zone with sandy sedimentary soils of the littoral southwest and central-south provinces.

The cassava is a late crop that continues during the second year, being harvested about 18 months later to be

followed by a short fallow.

Cassava as a soie or monocrop. This is common in the less humid zone of the southern part of north cameroon. The cassava is sown in May-June, during the rains and continues to the following year. A bush fallow usually follows.

Nurse or catch crop to perennials. This practice is found in parts of the central-south and eastern provinces where the cassava forms an early shade to the young cocoa or coffee usually planted about 2 months later. This usually involves the housewives who plant the cassava and men who later plant the economic crop. This practice is declining due to the difficulty in eradicting the cassava later, and the untested belief that cassava rapidly impoverishes the soil.

Different methods of planting cassava are practiced by peasants. Mature brown stems are cut into cuttings of 20-35cm and may be sown upright (two-thirds buried as in parts of the central-south) or slanting (two-thirds buried as in littoral southwest and west) or horizontally immersed (as in parts of the north). Agronomic trials are currently testing these methods. Weeding with hand tools is done about 2 or 3 times until a canopy is formed.

Cassava production is currently expanding at the expense

of other root crops because of much lower cost of production, about 150-200 mandays/ha as against 400-500 mandays/ha for yams. Cassava needs less expertise and care to grow, and it is more adaptable to different ecological areas. The processing by peasants of the roots into different products also enhances the increase in production of this crop.

The Cameroon National Root Crops Improvement Program (CNRCIP)

A national research program was established in 1977 within the Institute of Agriculture Research (IRA) to improve the main root crops, with the partial funding of the International Development Research Center (IDRC) of Canada and the General Administration for Cooperation and Development (AGCD) of Belgium and the technical collaboration of IITA.

The main objectives are to improve the quality and quantity of those crops through breeding and selection for yield, disease and pest resistance, better nutritive value and to train a cadre of Cameroonian researchers and workers to sustain the program.

The present team consists of 4 researchers (2 agronomists and 2 phytopathologists), 2 of whom are IITA staff and 8 intermediate technical workers. Five Cameroonians are currently receiving degree training overseas for the program.

Below is some of the work done by the team:

The Root Crops Survey (1978). The purpose of this was to study the situation of the main root crops throughout the country in respect of diseases and pests, agronomic practices and farming systems and to collect germplasm for cassava and sweet potato.

It was undertaken between October and November 1978 by 3 researchers and many technicians who inspected 542 farms, covering over 7,000 kms, interviewing farmers and agents of the ministry of agriculture.

Cassava was found in all the ecological zones of the country - the most widespread of the root crops. The important diseases identified included CMD, CBB, AD, leaf spots and root rots.

CMD occurs in all the ecological zones although less so in the drier north due to low incidence of Bemisia spp. fly.

Fortunately, CBB is not widely distributed; it is found mainly in the savannah zone although a few isolated cases were identified in the southern forest zone.

AD is mild in Cameroon - causing only cankers on woody stems and lesions on petiole bases. The more severe symptoms of distortion and wilting of shoots tips was not found. This mild form is, however, fairly well-spread in

the southern part of the country.

Leaf spots were widespread especially on mature plants. The following 4 types are prevalent:

- Brown leaf spot - C. henningsii
- Blight leaf spot - C. vicosae
- White " " - C. caribaea
- Concentric ring leaf spot - Phyllosticta sp.

The Cercosporas can cause severe defoliation and reduce the photoactive area.

Root rots were rare but a few cases of Rigidoporus lignosus and Phytophthora sp. were identified.

Germplasm collection. As a result of this survey and subsequent collection, about 120 local accessions are now available at Nyombe (littoral) and Nkolbisson (central-south) stations. Identification into cultivars and production of clones will be undertaken later. The main groups available (based on the color of young shoots and tuber underskin) are the green types, red types, upright and spreading cultivars.

Cassava selection. Cassava families are received yearly from IITA and are screened for disease resistance, yield and quality to achieve the goals already outlined. This screening passes through the following stages:

- clonal evaluation

- preliminary yield trials
- advanced yield trials
- uniform yield trials (in multilocations)
- multiplication

Some progress has been made as indicated in Table 44.

As disease incidence was low in general, clones were selected mianly for growth habit, leaf retention, tuber characteristics and yield.

38 of 173 clones = 22% were selected.

The best clones CMD 7631 yielded 32 t/ha, and this was 85% more than the local control.

Agronomic studies. Agronomic trials undertaken are as follows :

- Cassava intercropping - with cassava as the main crop.
- Cassava mixed cropping - with maize as the main crop.
- Planting methods of cassava - using 2 local cultivars.
- Cassava time of planting

Tables 45a and 45b show the results of the 2 mixed cropping trails. the yield of cassava, maize and sweet potatoes declines when each of them is mixed with another crop, more so if there is competition for a longer period of time.

It would appear the best combination does not interfere with the maximum growing period of either crop. However, the combined yields of both crops in a plot should be compared with the pure yield of each crop to find the maximum returns per unit area of land, on labor invested and on time taken to grow.

Table 44. Results of clonal evaluation and preliminary yield trial (1979-80).

Trial No.	No. of clones	Av. wt. of local variety (10 plants kg)	Av. wt. clones (10 plants kg)	No. of selected clones	% selec-tion	Av. wt. of sel-ected clones (10 plants (kg)	Increment over local variety
NYOMBE							
I (1976)	88	17.2	17.9	22	25	23.7	37.7
II (1977)	39	19.5	15.4	8	20.5	26.4	35.4
III	28	24.8	15.9	4	14.2	28.7	15.7
BABUNGO							
(1977)	18	6.5	10.0	44	22.2	13.6	109.2
Total/ Average	173			38	21.9		

Table 45a. The effect of intercropping cassava at Ekona (600m, 1979).

Treatment	Cassava (t/ha) fresh tuber	Maize (t/ha) dry grain	Sweet potato (t/ha) fresh tuber	Cowpeas (t/ha) dry beans
1. Cassava (10,000 plants/ ha)	16.8	-	-	-
2. Cassava (10,000 plants/ha) + maize (20,000 plants/ha) 1st season	7.5	2.8	-	-
3. Cassava (10,000 plants/ha) + maize (40,000 plants/ha).	7.5	2.9	-	-
4. Cassava (6,666 plants/ha) + maize (40,000 plants/ha) + Cowpeas 2nd season	10.1	2.3	-	0.3
5. Maize (50,000 plants/ha 1st season ---------- + cassava (10,000 plants/ha) + sweet potato (30,000 plants/ha 2nd season	Growing	3.7	12.9	-
6. Sweet potatoes (30,000 plants/ ha)1st season ---------- + cassava (10,000 plants/ha) + cowpeas 2nd season	Growing	-	18.0	1.0

Table 45b. The effect of mixed cropping cassava at Ekona (600m, 1979).

Treatments	Cassava (t/ha) fresh tuber	Maize dry grain (t/ha)	Sweet potato (t/ha) fresh tuber	Cowpea (t/ha) dry beans
1. Maize (75 x 75 cm) pure + Cowpeas 2nd season	-	3.4	-	0.26
2. Maize (100 x 100 cm) 3 plants/hill + cowpeas 2nd season	-	3.0	-	0.42
3. Cassava (100 x 100 cm) pure	17.2	-	-	-
4. Maize (100 x 25 cm) + cassava (100 x 100 cm 4 weeks after maize	9.9	3.8	-	-
5. Maize (100 x 100 cm) 3 plants/ + cassava (100 x 100 cm) hill	11.5	2.3	-	-
6. Maize (75 x 25 cm) 1st season + cowpeas + cassava (100 x 100 cm) 2nd season	Growing	3.8	-	-
7. Maize (75 x 25 cm) 1st season 3 plants + cassava (100 x 100 cm) 2nd season	Growing	4.4	-	-
8. Maize (100 x 100 cm) 3 plants/hill + sweet potatoes (100 x 100 cm) at silking stage)	-	2.8	9.1	-
9. Sweet potatoes (1000 x 10000 cm) pure at silking stage	-	-	16.9	-

The following 4 planting methods using 2 types of cultivars were tested:

- Single slanting (45°) and buried two-thirds
- Double slanting (45°) crossing and buried two-thirds
- Upright and buried two-thirds
- Complete burial (Horizontal)

The 2 cultivars used were local spreading type (red) and unspreading type (green).

Table 46 shows that the method of planting seems to have influenced the yield of the green unspreading cultivar and not the spreading one. In former variety, the upright and buried methods appear to have performed better than the slanting methods.

Table 46. Effect of cassava planting methods at Ekona (600m, 1979).

Treatment	Branching cult. (Red) tubers (t/na)			
	Total yield (fresh tubers)	Marketable tubers	Total yield (fresh tubers)	Marketable tubers
1. Single slanting	18.4	10.2	11.3	5.1
2. Double slanting	17.8	9.2	11.7	4.3
3. Upright	16.2	9.2	15.3	8.8
4. Complete burial	15.9	10.70	16.0	7/5

This trial is repeated this year for confirmation of results. Results of the planting dates trial are not yet ready as the last treatments are yet to be harvested.

Problems

The extensive spread of cassava in all the many ecological zones of the country calls for a larger number of researchers and workers than now available. The trianing component of the program is trying to bridge this gap, which will take some time to fill.

There are still large potential areas not yet growing cassava due to prejudice or lack of impulse to change. To ensure its spread to these areas - which step is necessary to meet the carbohydrate requirements of the country in a cheap way - there is the need to mount an educational campaign to convince prejudiced but potential communities that cassava does not impoverish the soil anymore than other root crops and should be grown. This is an area that requires an integrated approach between the sociologist and the agricultural extension agent.

CMD is a major problem both in spread and severity. Preliminary results of imported families show that resistance or tolerance is often broken down when tested in an ecology different from

where they were selected. This fact leads to considerations: (1) the need to screen in the various ecological areas which is very difficult to realize now due to shortage of workers and difficult infrastructure and (2) the need for basic research to establish "pan-tolerant" elites suitable to most ecologies.

Another priority area of research seems to be the mechanization of cassava cultivation, especially harvesting, which is labor consuming. The efforts of CIAT and IITA in this area are lauded but should be stepped up.

The peasant growers must be lauded as well in their efforts to process the perishable cassava tuber and must be aided at different levels to do better. Work on storage of fresh roots by research institutes must not overlook this more logical approach to the problem.

State of Art on Cassava Production in Congo (Brazzaville)

by

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Among root and tuber crops in Congo (Brazzaville) (cassava, sweet potato, yam and cocoyam), cassava is the most important and the most widespread. Consumed in different forms (leaves and tubers), cassava is the principal source of energy and the basic food. Diseases are a major constraint in the cultivation of cassava. They include CBB, AD and root rots. The cassava mealybug and other widesparead diseases, some of which have not yet been identified, are also serious problems. Studies done on cassava at ORSTOM were directed toward the study of cassava mealybug and its parasite-predator complex and the study on the transmission of bacterial and fungal diseases by insects.

After a year of laboratory and field studies, results were as follows :

Bioecological parameters of the cassava mealybug development as time of development of the different stages, female longevity and fecundity and intrisic growth rate were studied in the laboratory and under field conditions. The

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influence of thermo-hygrometric factors on those parameters were analyzed.

The succession of generations in nature and the role of physical factors of the environment were critically studied. The different types of mealybug were quantified, and the importance of rain in their behavior clarified.

The role of some sucking bugs (Pseudotheraptus devastans) was established (toxic action of saliva and penetration of fungi). The possible role of some coleoptra that are not phytophagous in the mechanical transmission of the bacterium is under wider investigation.

Studies have been made at ORSTOM to clarify the epiphytic phase of the CBB pathogen during its life cycle. Epidemiological study of the disease is important because it allows one to explain the sudden appearance of the disease and its recurrence in infected fields after the dry season. Studies on the distribution of the disease show that the disease is present in savanna zones, but scarce or not present in forest zones (Mayumbe region). This was also observed in other countries like Cameroon and Nigeria (Persley, 1977). The finding of a technique for detection of the pathogen (immunofluorescence, immunopersoxydase) has helped to develop a program of studies on the pathogen penetration and to approach the comparison of susceptible

and resistant varieties. The same techniques have helped in accessing the survival of the pathogen in cuttings.

Experiments on the transmission of bacterial blight by insects are under investigation with the cooperation of the laboratory of entomology. Research work being undertaken at M. Ngauabi University are directed toward histopathological and systematic studies as follows :

1. Systematic study of the pathogen

Previous work on Colletotrichum manihotis did not show the biological relationship between the asexual and sexual form that may be Glomerella angulata. This study was done using 3 types of isolates: sexual isolates, asexual isolates and isolates yielding perithecia and acervuli at the same time.

For the moment, observations indicate that the obtained sexual form may be Glomerella ungulata in spite of the systematic distance separating the plant hosts (cassava and coffee).

2. Study on artificial inoculations

An inoculation technique was found and parameters involved in the establishment and development of the pathogen were investigated.

3. Histopathology

The reaction of 30 local varieties to artificial

inoculation of the pathogen was observed. The pathogen was found under the epidemis for some varieties while it was intravascular in others. The growth of mycelia through plant tissues was also found to be very rapid in some varieties than in others.

Finally, biological study showed that light was able to stimulate acervuli and perithecia differentiation. It was also able to stimulate or to inhibit mycelia growth. Studies were also undertaken at ORSTOM center in order to find out the repartition of the incidence of bacteria-anthracnose complex when both are present.

Root rot diseases

The most widespread root rots are decay caused by Armillarialla tabescens and Sphaenostilbe repens. Recently, the decay caused by a polyparaceae of a leptporus genus was observed. These root rots are mostly widespread in forest zones. In savannah, they are found in nondrained zones. In forest as well as in savannah areas, severe damage was observed in 2-year-old fields. Keeping tubers for a long time in the ground favors the decays. This type of cultural practice is a strong obstacle to establish measures for the control of root rots.

Other diseases and pests

Leaf spots caused by cercorpora spp. CMD, green spider mite and some other unidentified diseases such as root rots are also widespread in different cassava production areas. Studies done on cassava are mainly based on a wide cassava breeding program guided by scientific research to which many international organizations like FAO are cooperators.

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State of Art on Cassava Production in Gabon

by

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In 1978, Gabonese farmers produced from 230,000 to 250,000 tons of cassava roots on an estimated area of 116,000 ha. This production figure for a country as small as Gabon shows the importance of cassava in human nutrition as well as in terms of economic potentials. For local consumption, cassava processing varies from region to region.. Most of the common varieties cultivated in Gabon originated from local sweet cultivars. But since the discovery of root rot and CMD, other resistant varieties have been introduced into Gabon from the Ivory Coast and IITA. These varieties are crossed with local varieties to find good hybrids for distribution to farmers. Almost three-fourths of the people in Garbon consume cassava in some way. The leaves and roots are parts mostly eaten.

Improvements needed

Nothing has been done in the area of cassava improvement (breeding), advanced processing and marketing.

Important areas in which research is badly needed include the following:

- improvement of the present mode of preparation and production losses in traditional processing.
- to establish structures for an industry for animal feed.
- to develop projects aim at studying different forms of storage of roots.
- study losses during storage and finding simplest economic storage methods.

Research program and extension

Trials. CIAM (Centre of Introduction, Adaptability and Multiplication of vegetative materials for food crops and fruits) and IRAF (Institute of Agricultural Research and Forestry) started trials with several local and imported cassava varieties. Generally, the local cassava varieties are well adapted to prevailing climatic conditions, have low cyanide content and are tolerant to mosaic virus and root rot diseases. Their growth is slow. Those varieties can be left in the ground for 2 years without significant losses due to rot or lignification. CB and H43 varieties introduced from the Ivory Coast are early maturing varieties though they produce up to 20 months. But after the rains of the second cropping season, these varieties become susceptible to root rot leading to severe yield losses.

CN1 is also an early maturing variety and offers better storage ability after 12 months of cultivation than CB and H43. These 3 high yielding varieties (CB, H43, CN1) reach their maximum yield potential in 10-14 months if planting is done at the beginning of the rainy season (from middle to end of September). Thus, the late maturing local varieties can be supplemented by the high yielding and late maturing varieties, in considering that the time of planting is September. This time of planting has been practically imposed by the prevailing cultural practices in which land clearing is routinely done during the dry season.

New entries

In 1976, cassava seeds from Brazil and IITA were established in Gabon. Out of 160 plants obtained from the seedling nursery, plants susceptible to CMD were elimited. South American clones were extremely susceptible to the local strain of cassava mosaic virus. After the first selection, 60 clones were retained and the selection classed according to the following criteria:

- High yielding roots with low cyanide content
- Resistance to cassava mosaic virus
- Resistance to cassava bacterial blight
- Early maturing varieties resistant to root rot

During the second year of multiplication, of 60 varieties retained, 13 varieties from IITA were resistant to cassava mosaic virus 10 months after planting. 9 varieties produced 20-30 t/ha. All the Brazilian introductions were dropped because of their susceptibility to CMD. The selected varieties from IITA had low cyanide content and were resistant to root rot. They also had low canopy and, thus, cover the soil quickly. These 2 characteristics are important in an area where soils need to be protected from erosion hazzards, where lodging is a serious problem and where weeds grow very fast.

Eight months after the third multiplication, in September 1979, 2 clones were highly resistant to mosaic disease, but 22 were tolerant. The selected IITA and the Ivory Coast varieties and some local varieties constitute the materials for extension. The next move is to organize and build up an efficient network for the distribution of these materials.

State of Art on Cassava Production in Nigeria

by

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IAR & T entomologist and IITA/PRONAM agronomist/
project leader

Cassava is by far the most important staple food crop in Nigeria. In 1974, the production figure was about 10 million tons, making Nigeria the second largest producer in Africa, after Zaire. The crop is very popular among farmers because it is relatively drought resistant, requires minimum care after planting and stores well in the soil for 6-10 months.

Utilization

Unlike in Zaire where cassava is grown for both the roots and the leaves, which constitute the main source of carbohydrate and protein, respectively, the crop is grown for only its roots in Nigeria. These roots are processed into a wide range of food items as Fufu, Gari, Lafun, etc. Because of the high starch content of the roots, they also form an important source of raw materials for the starch industries. The waste products such as the peals are also used as livestock feed for small stocks such as goats, pigs and sheep.

Agronomy

Most of the cassava production in Nigeria is done in the

southern part of the country by the peasant farmers with small holdings of less than 1-4 ha of land (Ezumah and Okigbo, 1980). In most cases, cassava is intercropped with other crops like maize and melon. In recent years, more and more people and cooperative societies are going into large-scale production with several hundreds of hectares of land cultivated. Such big time producers grow cassava as monocrops. This category of farmers also mechanize their production system and use herbicide for weeding instead of the peasant farmers method of hand weeding. The processing of the crop is also highly mechanized, a condition that makes them produce their Gari under more hygenic conditions. Nothing is wasted under this system as the waste products are used as animal feeds.

Constraints of production

Cassava production in Nigeria is limited by such factors as lack of capital, low yielding,local cultivars (Umanah, 1976), diseases and pests. To solve the problem of capital, the federal government established the Agricultural Credit Bank, which grants loan to prospective farmers after a careful scrutiny of their project proposals. In addition, all the banks in the country are also mandated to devote a certain amount of their loan scheme for prospective farmers. These loans are supposed to be granted to cooperative bodies to

allow the small-scale farmers to benefit from such loans. By this system, the risk involved is equally shared by all members of such cooperative societies, and it is easier for the bank to recover such loans. Through this system, some farmers have been able to increase their production in recent years.

In order to solve the problems of low yielding varieties as well as diseases and pests, the federal government established the National Root Crops Research Institute (NRCRI) at Umudike and also mandated the Institute of Agricultural Research and Training (IAR & T) of the University of Ife to conduct research that will lead to the development of high yielding and disease and pest resistant cultivars for distribution to farmers in the country through the ministries of agriculture. These ministries are responsible for the multiplication and distribution of the improved and resistant cultivars to the farmers. Both IAR &T and NRCRI are also to collaborate with IITA in their effort to achieve these objectives. At the moment, several high yielding varieties of cassava, which are resistant to CMD, CBB and AD have been developed in the country by these institutions.

The greatest threat to cassava in the country, at present, are the 2 newly introduced pests, the green spider mite and the cassava mealybug (Akinlosotu and Leuschner, 1979). These pests are now spreading rapidly in the southern part of

the country.

Before the discovery of the 2 pests, which are dry season pests, the most troublesome pest of cassava in the country is the variegated grasshopper Zonocerus variegatus F. which causes extensive losses to cassava growers every dry season, particularly in the southwestern part of the country. The other pests of minor importance include the red spider mite Oligonydrus gossypii, the lagrid beetles Lagria villosa, the whitefly Bemisia tabaci, which are the vectors of termites and CMD, respectively.

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State of Art on Cassava Production in Rwanda

by

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Cassava or Unwumbati as it is locally called is one of the most important staple foods in Rwanda. It was introduced in this country around 1936 by the agronomists with the aim "Agronomes de la Totelle" to relieve the hungry seasons which were more pronounced at that time. Since then, cassava has played a very important role in the feeding of the population and has become the hungry season crop.

Several clones from Venezuela, Uganda, Kenya, Java and Zaire have been introduced and evaluated in Rwanda. Cassava can be grown everywhere in Rwanda below 1,800m altitude except in the Zaire-Nile Crest, Buberuka and in the highland areas. Good yields are obtained between 1,300 and 1,600m altitudes.

Rwanda is divided into 12 distinctive agricultural regions, 4 of which are zones of cassava production:

1. Highly productive zones: Bugesera and Impo
2. Productive zones: Mayaga, Eastern plateau and Eastern savannah.
3. Fairly good productive zones: Impara, Central plateau sandstone dorsal.

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4. Poor productive zones: or no production: Kivu lake banks, lava lands, Zaire-Nile crest and Buberuka.

Production

Cassava is very important in Rwanda where it is second to sweet potato as human food in the country Table 47.

Table 47. Distribution and production of root crops in Rwanda (after ministry of agric. circular, 1978).

Culture	Area (ha)	tons/ ha	Annual production (tonnes)	Price/kg (Rwanda Franc)
Sweet potato	96,603	8.03	772,944	4.9
Cassava	38,874	14.03	373,044	9.5
Irish potato	32,169	6.80	218,703	12.6
Colocasia	5,090	3.61	18,202	9.3
Yam	1,012	5.49	5,396	12.0

An ISAR (Institut de Science Agronome du Rwanda) selected variety, EALA 07, is now being released on a large scale. Its yield varies from 10-15 t/ha in 18-24 months.

Rwanda's population prefers sweet cassava mainly because it does not need fermentation. ISAR has released 2 such clones Bukarasa and Maguriyinkware with an average yield of 8-10 t/ha in 12-15 months. The quality of cassava is taken into consideration

during selection. Cassava is mainly a calorific food rich in starch. It contains a fair amount of ascorbic acid but is very poor in lipids, mineral salts and proteins. Dieticians in Rwanda are, therefore, recommending mixing cassava meals with other supplements rich in proteins such as green vegetables, beans, green peas, fish and meat and sorghum flours.

Cassava leaves, which are seldom eaten in Rwanda, are very good palatable vegetables rich in proteins, calcium, total minera' salts and vitamins. Except in the capital territory, cassava leaves are not commonly eaten as vegetables.

Cassava extension and distribution

As for any other crop in Rwanda, cassava extension is carried out by an ad hoc service of the ministry of agriculture called "service des semonces selectionnees S.S.S." (Selected Seeds Unit), which works in collaboration with ISAR, the zonal heads and zonal agronomists.

To meet the country's demand in planting material ISAR has established some permanent multiplication plots of 5 ha of EALA 07 and of 2 ha of Bukarasa. Depending on farmers need for cuttings, the areas under multiplication are extended or reduced. In 1979, ISAR distributed 41,000 cuttings of EALA 07 and 13,000 cuttings of Bukarasa as supplemental materials to the S.S.S., which also maintain their own multiplication plots

intended for production of cuttings for distribution.

Limiting factors for cassava production in Rwanda

Diseases and insect pests are the main constraints to cassava production in Rwanda.

Diseases. CMD is the major disease in Rwanda. All the farmers' fields are infected with mosaic at about 40%. Mosaic attack can be maintained at low levels by a sanitary selection of planting materials. Farmers are advised to take cuttings only from plants which are free of CMD. As can be observed from ISAR multiplication plots, this method has shown very successful results.

Some other diseases such as CBB, cercospora and phylloslicta are present in Rwanda but are of minor importance since they do not cause a substantial cassava yield loss.

Pests. The green spider mite is actually the most important limiting factor to cassava production in Rwanda. This pest was first reported in Africa in Uganda (Nyiira, 1972) from where it rapidly spread through Kenya, Tanzania and Burundi.

In Rwanda, it was first found in October 1976 in a rural area of Nkanga near ISAR Karema. Now it has spread all over the areas of Rwanda where cassava is grown. The symptoms of its attack are as follows: yellow spots on the leaves followed

by reduction in size of new leaves and dropping of formerly attacked leaves. Complete defoliation and progressive death of terminal bud and shoot. In Rwanda, damages caused by the green spider mite have not yet been evaluated. However, studies conducted by Nyiira (1975) at Kawanda-Uganda have indicated a yield loss of 40% on the Kukarasa variety. It was also reported that damages caused depend on the environment, climatic conditions, variety and the plant age at the moment of attack. Incidence and severity are higher during the dry season.

Proposed solutions to major problems of cassava in Rwanda

To find an efficient solution to CMD and the green spider mite problems, a breeding program for resistance is needed.

CMD. From 1978, a nursery was established from local seeds and from seeds introduced from IITA. These seedlings were evaluated by successive observations of the seedlings at 3, 6, 9 and 12 months of age. From the observations, some conclusions are drawn as follows :

- More than 10% of the local seedlings showed mosaic symptoms (class 4) and the presence of the vector *Bemisia tabaci* was observed every morning between 7 and 10 a.m.
- None of the seedlings from IITA showed mosaic symptoms. This means that selection done at IITA against mosaic still holds in Karema environmental conditions.

Further observations on clonal evaluation trials are still going on for the confirmation of earlier results. Rwanda expects collaboration from IITA in building up its breeding program, which will also facilitate exchange of materials and information.

Green spider mite. The green spider mite is a recent pest. A search for resistance to this pest will be accelerated. ISAR cannot undertake such a study alone, but hope to collaborate with specialized agricultural research organizations and universities to solve the problem.

At present, ISAR tries to identify plants tolerant to the green spider mite, make crosses between them and selected clones with the hope of selecting resistant plants.

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SECTION VI

Workshop Summary and Recommendations

Following a review of the papers presented and the concerns expressed by participants, 4 general areas were identified as major areas of constraint in cassava production and extension in Central Africa: (a) cassava selection for resistance against diseases and pests and multilocational trials, (b) production and distribution of planting materials, (c) logistics and evacuation of farmers' produce and (d) cultural practices employed. By far, participants expressed greatest concerns in the following areas: inadequacy of trained manpower for research and extension, lack of materials and adequate budget with which to work, diseases and pests, a need for exchange of information between researchers in the region, bad roads and lack of transport and transportation facilities for extension work and the common practice of encouraging the few trained personnel to work in areas for which they are not trained while leaving unfilled, the positions for which they are fitted. These constraints were studied in some detail and recommendations were adopted under the title of "Workshop summary and recommendation" presented in this section.

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I. Cassava selection and multilocational tests:

Selection

1. The selection should be carried out with aim to develop high yielding cassava varieties resistant to major diseases and pests.
2. Prior to a breeding program, local material already adapted to local conditions should be identified, collected as local germplasm and screened.
3. An exchange of material and experience between interested countries is very important for an efficient breeding program. Representatives should let their different governments know of the decisions of this meeting and urge them to encourage regular professional contacts between scientists of the region.
4. The breeding program should recognize the need for good cassava quality in terms of high starch content in storage root, low cyanide content and high protein content in leaves and roots (if possible).
5. The breeding program should seek for early maturing varieties and clones with plant types suitable for mixed intercropping. It should also seek clones with plant types adapted to mechanization and which in future will respond positively to fertilizers.

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Multilocational tests

Multilocational tests are important and are endorsed. They should be based on availability of resources, on production factors present in different agroclimatic zones as described below:

1. availability of collaborators within existing organizations such as research stations, agricultural missions; rural development centers, etc.
2. agroclimatic zones of a region, the importance of cassava in the area and the production constraints limiting cassava production in the area. Factors being tested should be well defined and as far as possible, plot layouts should be uniform and similar as well as number of replications and types of observations.

II. Production ofplanting materials and their distribution

1. Short-term recommendations

All the high yielding varieties with acceptable quality and which are available in national programs should be multiplied with adequate propagation method and then distributed free of diseases and pests.

Considerations should be made on:

a) Selection of regions free of diseases and pests for multiplication of varieties to be distributed.

b) A maximum phytosanitary measure should be maintained for the control of insects in multiplication areas.

c) Establish quarantine service in each country to prevent the pest movement from one country to another.

d) Establish special fields or nurseries, clean and well maintained for production of planting materials.

2. Long-term recommendations

All the high yielding varieties with acceptable quality and free of diseases and pests should be multiplied and distributed everywhere it is economically and scientifically possible. Governments should aim at continuous establishment of well maintained disease and pest-free fields purely for production of planting materials.

III. Logistics and its role in agricultural development

As extension structures are still undeveloped in most participating countries, considering the difficulties in the transfer of new technology from researchers to farmers, and as there seem to be no coherent strategy for extension, the following recommendations have been made:

The organization or establishment of a regional extension service monitoring all the existing services in the region such as projects, rural development centers, religious missions, and other organizations and training of personnel from the region

for extension work. It is also recommended that relevant materials and financial support for work be made available to the extension services. As much as possible, extension agents should have easy and direct access to their administrators. There should be a close collaboration between researchers and research institutes and extension services and also regular feedback from extension workers to researchers should be encouraged.

The improvement as soon as possible of infrastructures by governments to facilitate the movement of products and people, storage and processing of produced products and marketing, should be given attention. The views of extension workers and researchers should be invited by policy makers during the planning phase of extension strategy.

IV. Cassava cultural practices

Considering the economic, pedologic and climatic conditions of Zaire and of the region covered in this workshop, the following recommendations have been made on cassava cultural practices:

1. Planting time

To plant early at the beginning of the rainy season for a maximum utilization of favorable growth conditions. This will allow the plant to be vigorous enough to stand the critical period during insect and disease attacks.

2. Land preparation

It is generally recommended to plough in grasses to improve the soil structure and the soil organic matter, allow time for the grass to decay and then plant especially in savannah areas. Lots of wood accumulate in forest zones, therefore light burning could be practiced. On heavy soils, planting on heaps or ridges will facilitate a good root development and a good drainage. Planting on the flat is adequate for light soil where there is not drainage problem. Mulch can be used if available.

Weeding

It is generally recommended to weed 2-3 times at appropriate intervals during the first 3-4 months.

Planting density

The optimal population is 10,000 plants per hectare, variation from 10,000 to 15,000 plants/ha is accepted. The recommended spacings are, therfore, 1.0 x 1.0m and 0.75 x 1.0m, respectively.

Live mulch cover

It is recommended to use a live mulch cover plant which has an economic value to the farmers such as groundnut and sweet potato. Further research on live mulch, in situ mulch and other surface covers was endorsed. Research organizations

should identify the type of live mulch crops that offer the possibility of improving soil fertility and are easily accepted by farmers. Some studies on intercropping are needed.

Layout of ridges on slope

As ridges laid out along slopes promote soil erosion, it is recommended to lay out the ridges across the slopes. Terracing should be studied and applied in the sloppy farms often seen in Central Africa.

Cuttings

Twelve to 18 mos. hardwood cuttings, 20-30cm long should be used. Planting position vary with local conditions and recommendations should be based on these.

Rotation

At least 2 cropping seasons were recommended in a given location. Participants were reminded that exhaustion of the soil may degrade it beyond regeneration. More work is needed and should be done on fertilizer response. Economics of fertilizer use should be included in such studies.