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About the Institute
The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.



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A PRELIMINARY PROGRAMME

For a seminar

on

ROOT AND TUBER CROPS

---

to be held at

The Conference Centre
The University of Ibadan

22nd - 26th February, 1971

CO-SPONSORS:

The Ford Foundation,

L'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières,

The International Institute of Tropical Agriculture.

Lagos,
14th December, 1970

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MONDAY, FEBRUARY 22

Opening Session	Chairman: B. BECK
09.00 - 10.00	1. Welcome address on behalf of the Ford Foundation, B. D. A. Beck
	2. Welcome address on behalf of l'Institut de Recherches Agronomiques Tropicales, P. Sylvestre
	3. Welcome address on behalf of the International Institute for Tropical Agriculture, H. R. Albrecht.
10.00- 10.15	Coffee
10.15 - 11.00	The history and the possible future of yam cultivation in West Africa, P. COURSEY
11.00 - 12.30	Discussion
12.30 - 14.15	Luncheon
Afternoon Session	Chairman: P. SYLVESTRE
14.15 - 15.00	The history and possible future for the cultivation of cassava in West Africa, D. JONES.
15.00 - 1530	Discussion
15.30 - 15.45	Coffee
15.45 - 16.30	Possible future use for root crops in West Africa, C. MICHE
16.30 - 17.30	Discussion
19.00 - 21.00	Cocktail party in the Senior Staff Club.

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TUESDAY, FEBRUARY 23

Morning Session	Chairman : W. O. JONES
09.00 - 0945	The economic problems of the intensive production of cassava - B. BECK.
09.45 - 10.30	The economic problems encountered in the intensive cultivation of cassava by IRAT in Togo - M. DELCASSO and S. SYLVESTRE
10.30 - 10.45	Coffee
10.45 - 11.30	The taxonomy of cassava - M. ROGERS
11.30 - 12. 30	Discussion
12.30 - 14.15	Luncheon
Afternoon Session	Chairman : E. CHANT
14.15 - 15.00	The virus diseases of cassava. - G. GALVEZ.
15.00 - 15.30	Discussion
15.30 - 15.45	Coffee
15.45 - 16.30	The cassava improvement programme in Madagascar. - M. ARRAUDEAU.
16.30 - 17.30	Discussion
18.30	"Happy Hour" at the Conference Centre

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WEDNESDAY, FEBRUARY 24

Morning Session Chairman : M. ARRAUDEAU

09.00 - 09.45	The integration of yams in a modern system of agriculture. - C. DUMONT
09.45 - 10.30	The improvement of yam cultivation techniques in Nigeria - [illegible]. CHINWUBA.
10.30 - 10.45	Coffee
10.45 - 11.30	The botanical classification of yams - M. MIEGE.
11.30 - 12.30	Discussion
12.30 - 14.15	Luncheon

Afternoon Session Chairman : [illegible]. HAYNES

14.15 - 15.00	Nematode diseases of yams - J. SMITH.
15.00 - 15.45	Virus diseases of yams - J. CRAIG
15.45 - 16.00	Coffee
16.00 - 16.45	Study on the control of the yam beetle - [illegible]. TAYLOR.
19.00 - 19.30	Drinks at the Senior Staff Club followed by Dinner at the West End restaurant, Ibadan.

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THURSDAY, FEBRUARY 25

Morning Session	Chairman : D. OKIGBO
09.00 - 09.45	The genetics of the sweet potato - T. JONES.
09.45 - 10.30	Research on the sweet potato in Trinidad - C. HAYNES.
10.30 - 10.45	Coffee
10.45 - 11.30	The phytophthora disease of potato - J. NIDERHOUSER.
11.30 - 12.30	Discussion
12.30 - 14.15	Luncheon
14.15 - 17.00	Delegates visit I.I.T.A.
14.30	Meeting of the Drafting Committee in the Conference Centre Library.
18.00 - 19.00	"Happy Hour" at the Conference Centre

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FRIDAY, FEBRUARY 26

Morning Session	Chairman : B. BECK
09.00 - 09.45	Presentation of the report of the drafting Committee
09.45 - 10.30	Discussion of the report
10.30 - 11.00	Coffee and group photograph
11.00 - 12.00	Closing remarks
12.00 - 14.15	Luncheon
14.15	Delegates leave for the Airport Hotel, Ikeja.

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THE FORD FOUNDATION
47 Marina P.O. Box 2368
Lagos; Nigeria

Cables: FORDWAN Lagos Telephone: 27525-9

23/12/70

Dear Delegate,

You have been nominated by your Organisation to attend the forthcoming seminar entitled

"Research on Root and Tuber Crops in West Africa"

and will be held from 22nd - 26th February, 1971 at the Conference Centre, the University of Ibadan, Nigeria.

As a result of your nomination, you will receive a Ford Foundation Travel Fellowship which will provide you with an economy class air passage to and from Lagos with per diem allowances for enroute travel to Ibadan and for accomodation at the Conference Centre. You will be informed of the conditions of your Fellowship in a formal letter from the Ford Foundation Representative in West Africa at a later date.

However, before we can process your Fellowship and air passage, we must have the data listed on the "curriculum vitae" attached to this letter. I would be grateful therefore, if you would fill the "curriculum vitae" and return it, as a matter of urgency, directly to me at the above address.

You should also apply to the Nigerian Embassy for an entry visa and ensure that your vaccination certificates for smallpox, yellow fever and cholera are valid for the dates of the seminar.

.../2.

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If you would also complete and return the attached form giving details of your passport, I will do what I can in Lagos to speed up the granting of your Nigerian entry visa.

Your cooperation in these matters will be much appreciated and I will look forward to meeting you in Nigeria.

Yours sincerely,

Brian Beck

Brian D. A. Beck,
Programme Specialist in
Agricultural Research.

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THE FORD FOUNDATION
47 Marina P.O. Box 2368
Lagos, Nigeria

Cable: FORDWAN Lagos Telephone 27525-9

19th February, 1971

Prof ROGERS, W.
The Department of Biology, Division of Population Studies
The University of Colorado
Boulder, Colorado 80302, U.S.A.
Dear

On the basis of a nomination made by your organization, it is my pleasure to inform you that the Ford Foundation has approved a Travel Fellowship to enable you to attend an agricultural research seminar on "Root&Tuber Crops in West Africa", to be held from the 22nd through the 26th of February, 1971 at the Conference Centre of the University of Ibadan, Ibadan, Nigeria. This seminar is organized jointly by the Ford Foundation, l'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières, and the International Institute of Tropical Agriculture.

In this context, I wish to state, both for your records and for our own, the details of the award and the steps to be undertaken by the Ford Foundation office in Lagos and by yourself.

1. The Ford Foundation will furnish you with a round trip economy class air ticket. You will be informed by cable to which airline office your tickets have been despatched by our travel agent (Scan Travel, Lagos). You are requested to collect your tickets from the airline office prior to departure. Under Foundation travel policies, the air ticket is limited to economy class only.

2. It is your responsibility to be in possession of a valid international passport with appropriate visas for Nigeria and for any countries to be visited en route, and also to have up-to-date vaccination certificates against smallpox, yellow fever and cholera.

.../2.

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3. The Ford Foundation will provide an allowance of $25.00 for each night's stopover, necessary and approved, en route to Lagos. This allowance will be paid either into your bank, or in Nigerian pounds on arrival at Lagos, on completion and signature of the attached form No. 1.

   Paragraphs 2 & 3 do not apply to delegates from within Nigeria.

4. Ford Foundation will also pay $25.00 for each night's stopover in Lagos, necessary to accommodate available airline schedules. This will be paid to you in Nigerian pounds on arrival in Lagos, on completion of the attached Form No. 2.

5. The Ford Foundation will pay you N£ 5-5-0 per day, or N£ 26-5-0 for the full 5-day conference, in Nigerian currency on arrival at Ibadan, to cover your accommodation at the Conference Centre and incidental expenses. You will settle your own room bill. The Centre charges N£ 4-11-0 per day for room and all meals, excluding drinks and laundry.

6. The Foundation will arrange at its own expense to provide you with sickness insurance for the duration of your award, with a $10.00 deductible clause. This means that you will be responsible for the first $10.00 of any medical reimbursement claim you might submit. In addition, the Ford Foundation will obtain accident insurance on your behalf for a total coverage of $25,000.00.

7. It is the Foundation's policy to ask Fellowship recipients to prepare a brief travel report upon the completion of their trip, giving their travel schedule, an account of their time at the seminar, and their observations on the seminar, stating whether the trip was useful to them personally and professionally. These reports are for internal use of the Ford Foundation only and will not be published.

.../3.

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If you are in agreement with the terms of this award, would you please countersign the duplicate copy of the award letter and return it to the Lagos office of the Ford Foundation, or give it to a Ford Foundation officer at the seminar.

I wish you a pleasant and productive trip.

Sincerely yours,

Haldore Hanson

Haldore Hanson
Representative for West Africa

I agree to the terms of the travel award as outlined in the award letter from the Representative for West Africa.

_____ _____

Signature Date

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THE FORD FOUNDATION
47, Marina, P.O. Box 2368
LAGOS

CABLES : FORDWAN,LAGOS TELEPHONES: 27525/6.7.8.9.

7 April, 1971

Professor D. ROGERS
Dept. of Biology - Pop. Studies
The University of Colorado
BOULDER, Colorado 80302
USA

Dear Sir,

Please find enclosed one copy~~xxxxxx~~ of the final Summary Report on the ROOT AND TUBER CROPS Seminar, held in IBADAN/B~~xxxx~~, NIGERIA/S~~xxxxx~~ in February ~~22~~ through 26 1971.

Also papers by HAYNES AND MICHE.

Yours sincerely,

Clay. I. Onah
Assistant to Mr. Brian BECK,
Program Specialist in Agricultural Research.

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A Summary of the Proceedings of the Seminar on "Root and Tuber Crops" held at the Conference Center of the University of Ibadan between 22nd and 26th February 1971.

Drafting Committee

Chairman: D.G. Coursey
Members : F.R. Moorman
P. Silvestre
W.O. Jones
D.G. Robertson
J.C. Dumont
B.N. Okigbo

Co-Sponsors:

International Institute of Tropical Agriculture, Ibadan

Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres, Paris.

The Ford Foundation, West Africa Regional Office, Lagos

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MONDAY, FEBRUARY 22

Morning Session

Chairman: F.W. Moormann

Paper: The history and possible future of yam cultivation in West Africa, D.G. Coursey.

Summary of Discussions.

THE FUTURE OF YAMS

Various opinions were expressed on the future of yam cultivation in West Africa. Some delegates believe that yam cultivation will diminish for various reasons, as there are high labour requirements, difficulties with mechanization and problems of storage and marketing. Cereal crops may well become a preferred food, replacing yams to a large extent. Other delegates, whereas admitting that the yam cultivation has its drawbacks, believe that yam has a definite future in West Africa as a quality food, and is preferred to higher yielding cassava. It is pointed out that many of the drawbacks of yams can, at least partially, be solved by selecting the right cultivars from the very rich variability of available material. Moreover, yams are bound to remain or to even become important as a quality food in areas with an ecology which is unfavourable for cereals, particularly for upland rice.

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THE FERTILIZATION OF YAMS

Many cultivars do respond to nitrogen, but in most of the cases reported the application of nitrogen leads to larger cells in the tubers and, consequently to poorer storage qualities. Of importance is time of application of nitrogen. Response to phosphorus was reported from East Africa, where massive initial doses of phosphorus gave a positive effect. Little is known on the inter relationships between habitat, varieties and fertilizer practices, studies in this field are needed, but it may be expected that "classical" NPK trials will not give much useful information, if other milieu and cultural parameters are not taken into account.

THE STORAGE OF YAMS

The storage of yams is recognised to be an acute problem, and one that hampers large scale marketing of yams. The farmer's method of storage in barns in a cool damp, shaded place appears superior but is not adaptable to large scale operations.

Use of inhibitors against sprouting has had a mixed success, and need certainly more study. Dormancy characteristics of different varieties vary greatly.

Mechanical damage, as well as nematode damage usually lead to secondary infections and consequently to

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losses during storage. Irradiation did not appear promising for improved storage.

THE REPRODUCTION OF YAMS

In traditional plantings, the ratio between planting material and harvested crop is frequently unfavourable (e.g. 1:10). There are, however, indications of varietal differences in this respect, and also some varieties may be reproduced from small sections or peelings of the tuber. More research is required in this field.

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MONDAY, FEBRUARY 22

Afternoon Session

Chairman : P. Silvestre

First Paper : The History and future prospects of the cultivation of cassava in West Africa B. Beck.

Second Paper: The possible uses of tuber crops in West Africa, C. MICHE.

The following problems were raised after the first paper:

THE POTENTIALITIES OF CASSAVA

- Present yields are much higher than those shown in agricultural statistics because cassava is essentially a crop grown at the end of the rotation, and not always harvested if the other food crops have been successful.
- It would however be necessary to consider the life cycle of the plant, in view of the results obtained. Cassava is largely a two year crop, but the time factor is becoming increasingly important in an intensive system where the efficiency of land use must be increased.

THE FUTURE OF CASSAVA

It was admitted that, in spite of the competition with cereals in the diet, as the level of the standard of

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living increases, cassava will remain as a crop both profitable and viable and will continue to play a considerable role, because its yield potential is high, it has a high calorific value and is cheap. But, it should be considered a cash crop if we want to have a stable system of rotation.

It is also necessary that a system of marketing is adopted. For this it was recommended that the economists should study the marketing system of food produced for the consumer. Although cassava is often considered to be a crop which is consumed by the producer, it is already widely marketed in some regions.

FARMING SYSTEMS:

A delegate stressed that the seminar should take into account the man power in-put in the input/output ratio. The family group is likely to encounter labour constraints at harvest time. But another delegate noted that we should not only envisage family labour. To avoid the transportation of products such as cassava which do not have a good keeping quality, we should try to process such crops on the spot and allow this processing to act as a nucleus for the establishment of large-scale profitable markets for export crops.

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SPECIAL RESEARCH PROBLEMS

It was stressed that in the distinction between sweet and bitter cassava there are other factors and besides hydrogen cyanide to be considered.

In the process of fermentation, microrganisms other than Coryne bacterium and Geotrichum play their part.

There should be further study on simple apparatus and methods for determining starch content.

The second paper gave rise to the following remarks:

Priority must be given to the supply of local markets rather than foreign markets in roots and tubers.

Pre-cooked foods are at present prepared traditionally. This can be improved; it has already been improved in certain areas by local artisans. It is therefore unnecessary to envisage for the time being the construction of large factories for making pre-cooked foods like gari, although such factories exist already in some countries.

Attention was drawn to the fact that as towns grow, the city-dwellers will turn away from long and laborious food preparation processes.

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The value of the finished product will condition the success processing operations:- dehydration, packaging of a processed commodity, will make it more expensive, so that in the long run it may not differ so much in cost from the traditional product.

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TUESDAY, FEBRUARY 23

Morning session

Chairman : W.O. Jones

Paper 1 : The Economic problems encountered in the intensive cultivation of cassava by IRAT in Togo.
M. Delcasso & P. Silvestre

Paper 2 : The taxonomy of cassava
D. Rogers

Summary of Discussions

The discussion period consisted essentially of exchanges of informal information among members of the seminar and of amplification of their remarks by the speakers.

There were discussions of the suitability of Manihot glaziovii in cross-breeding for resistance to mosaic. Apparently the species is free of mosaic over many parts of West Africa, perhaps because selection has led to a virus free form. But, it is known from observation elsewhere that M. glaziovii may be susceptible to the virus.

Types likely to be more suitable in breeding for mosaic resistance include about 15 species closely related to M. esculenta.

There is little or no prospect that virus in cassava can be controlled by chemical means because the vectors

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are too widespread.

The classification system presented in the second paper is based on about 50 characteristics, taking principal account of vegetative form, and the shape and structure of flowers and fruit. The classification is based on American specimens, but would probably be little altered if African and Asian specimens were added. There are likely, however, to be differences in the cultivars in the three areas. The method of classification has been applied to cultivars employing characteristics of their morphology.

It was reported that in some parts of West Africa wild (possibly feral) varieties of Manihot are eaten in time of shortage.

Collections of the many species of Manihot are few and quite incomplete.

Relatively simple techniques have been worked out for the rapid germination of cassava seed.

In consideration of the optimum date of planting cassava, optimum date of harvest and time from planting to harvest must be taken into account. It is a rather complex relationship. The optimum time for each operation may also be affected by the timing of other farming operations and by non-economic factors.

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TUESDAY, FEBRUARY 23

Afternoon Session

Chairman : D.G. Robertson

Paper 1 : The Virus Diseases of Cassava
G. Galvez

Paper 2 : The Cassava Improvement Programme in Madagascar -
M. Arraudeau (presented by P. Silvestre).

Summary of Discussions

It was noted that the virus diseases affecting the crop in Africa were of major economic importance, whereas those described from South America did not constitute important disease problems.

Heat treatment was stated to be a method of inactivation of cassava mosaic virus, but it was pointed out that this was not a practical method of control, which could only be effected by the use of resistant varieties.

A number of delegates drew attention to the variation in symptoms caused by cassava mosaic virus infection (suggested as being possibly caused by different strains) and the fact that plants became symptom-less in certain ecological zones and under certain environmental conditions. Natural heat inactivation and the limitation of movement of the virus in the conducting tissues of the plant were suggested as possible explanations of this phenomenon.

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It was noted that the methods of scoring for virus disease resistance in Madagascar and Nigeria were similar and differed from that used in the early breeding programme in East Africa. One delegate pointed out that the degree of contamination (as used in East Africa) should be regarded as an important factor in assessing resistance in breeding material, but it was observed that in Nigeria resistance usually took the form of mild symptoms, sometimes becoming latent, and not in the percentage of plants infected.

It was agreed that breeding for resistance to cassava mosaic virus was one of the major priorities in the improvement of the crop in Africa.

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WEDNESDAY, FEBRUARY 24

Morning Session

Chairman : D.G. Coursey

Paper 1 : The Integration of yams in modern system of Agriculture.
C. Dumont presented by M. Vandevenne

Paper 2. : The Improvement of yam cultivation techniques in Nigeria
P. Chinwuba

Paper 3 : The botanical classification of yams
J. Miege presented by C. Dumont

Summary of Discussions

Mechanization of Yam Cultivation

One delegate pointed out that the basic requirements of mechanization - a compact, medium sized and regularly shaped tuber were also desiderata for storage.

Much discussion took place on the subject of mechanization, several delegates felt that this should have the highest priority for further research, and considered that it was only through the economics of mechanization that the yam would continue as a crop of any importance. Others, however, considered that smaller scale producer, using predominantly manual cultivation techniques, would continue to be important for a long time, and that their problems also needed consideration. A warning was sounded by certain delegates of the social problems that could arise from over

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rapid introduction of mechanization causing gross rural unemployment.

Research Priorities

Much concern was expressed over the awarding of priorities in research. There was a general consensus of opinion that thorough economic studies of the present status and future prospects of the yam crop (and, indeed, of other crops) was needed, but it was equally recognized by most that there existed in West Africa a strong cultural attachment to the yam, which would probably ensure continued interest in production, even when economic reasons worked against the crop.

Research work in the past had paid little attention to the crop, and many farmers were becoming discouraged as a result. However, with the strong interest that is now being shown by some research workers, it would be expected that this position would change in the future.

Several delegates felt that work on mechanization should receive the highest priority: others considered that work directed to helping the peasant farmers was of greater importance. It is therefore desirable that research efforts should be directed both ways. The suggestion was made that individual countries, especially the larger ones could establish committees of workers on yams (and on

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cassava and on other individual crops) to decide national priorities. The effective interchange of ideas between countries through regular personal contacts (such as at the present meeting) was also most desirable.

The botanical classification of yams

A number of delegates agreed that the chemotaxonomic approach adopted in the paper given was a useful one, and that the work could well be extended in scope to establish taxonomic differences at cultivar as well as species level. There was nevertheless a strong feeling that this should be regarded only as an extension of more conventional taxonomy based on morphological features, and that within chemotaxonomy, the study of secondary plant constituents, such as polyphenolics, was likely to be more rewarding than the study of such universal plant constituents as proteins and starches.

The serious need for the proper classification of West African yam cultivars, especially of the complex D. cayenensis/D. rotundata group was generally appreciated, and it was generally agreed that computer analysis would be needed to examine the high degree of variability that exists.

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WEDNESDAY, FEBRUARY 24

Afternoon Session

Chairman : C. Dumont

Paper 1 : Nematodes associated with tuber plants in West Africa
G. Merny

Paper 2 : The control of yam beetles
T.A. Taylor

Summary of Discussions

The following questions were raised with regard to the yams.

The role of fallows

A considerable fall in the nematode population is apparent during the fallow period.

The cultivation of a fallow or cover crop which is not a host plant of the parasite is preferable to a fallow whose composition or exact behaviour towards the parasite is in fact unknown.

Plants having a toxic effect on nematodes

There are many of these but they have not been studied on a large scale in the tropics. The difficulty lies in introducing them into a rotation system. Finally, attention was drawn to the fact that infection through the yam setts is greater than that contracted from the soil.

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Dissemination of nematodes

Water can be a means of dissemination, but agricultural implements are an equally important factor.

Mixed or intercropping

If two host crops of the same nematode species occur rotation cropping will be more harmful than intercropping.

The Control of Yam Beetles.

After the paper on the control of yam beetles, the respective roles of the larvae and the adult beetles were considered with regard to damage caused.

It was emphasised that the role of the wild species of yams as host plants was little known, also the potential differences in sensitivity between the cultivars, had not been examined in detail.

Finally it was confirmed that there is a diapause between the two migratory adult flights. During this period it is difficult to control the yam beetle and for this reason control measures should commence at the moment when they migrate.

It was also confirmed that some insecticide applied to the soil at the time of treatment was translocated into the tuber tissues.

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THURSDAY, FEBRUARY 25

Morning Session

Chairman : B.N. Okigbo

Paper 1 : Joint Institute for Agricultural Research/USAID Nigeria Irish Potato Project - D. Suchomel

Paper 2 : The Potato in the Tropics
J. Niederhauser

Paper 3 : Recent Research on Sweet Potato (Ipomoea batatas (L.) Lam. at the University of West Indies -
P.H. Haynes

Summary of Discussions

Some concern was expressed about the danger of introducing the golden nematode from Europe to the Tropics or the second of the two compatibility groups of Phytophthora infestans from Mexico into the other areas of the Tropics by large scale importation of planting materials. It was suggested that caution should be exercised in the introduction of planting materials from these areas. In this respect it was emphasized that it would be necessary to interchange only clean materials, to minimise the amount of material involved and serious steps should be taken to produce and multiply seed in and for each locality where potato production and research is being conducted.

In response to a question by a participant, it was indicated that one of the advantages of growing potatoes in the Tropics is the possibility of multiple cropping.

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This was stressed by the example that, on the Jos Plateau, of Nigeria potato varieties that took up to 120 days to mature in temperate countries took only from 65 to 85 days on the Plateau.

A lot of interest was shown in the sweet potato as a potential root crop in Africa: it was noted that mechanization is possible with this crop, especially in the West Indies, where labour was the most important limiting factor in the production of the crop.

A participant pointed out the ommision of edible Aroids among the tropical root crops considered in the seminar since they constitute important staple food in certain parts of West Africa.

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ROOT AND TUBER CROPS SEMINAR IBADAN

SEMINAIRE PLANTES A RACINES ET A TUBERCULES IBADAN

22 - 26 February, 1971
22 - 26 Février , 1971

List of Papers Presented

Liste des Communications Présentées

ARRAUDEAU, M.A.	- L'Amélioration du manioc à Madagascar (présentée par M. SILVESTRE) (presented by M. SILVESTRE)
BECK, B.D.A.	- Cassava Production in West Africa - history and future prospects.
CHINWUBA, P.M.	- Review of Yam Production in Nigeria during the last ten years.
COURSEY, D.G.	- The history and the possible Future of Yam Cultivation in West Africa.
	- Histoire et Perspectives de la Culture de l'igname en Afrique de l'Ouest.
DELCASSO & SILVESTRE	- cf SILVESTRE
DUMONT, C & VANDEVENNE	- Intégration de la Culture de l'igname dans un système de culture modernisé.
+ GALVEZ, G.	- The Virus diseases of cassava.

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HAYNES, P.H. - Recent Research on Sweet Potato (Ipomoea Batatas (L) LAM) at the University of the West Indies.

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MERNY, G. - Les nématodes phytoparasites associés à quelques plantes à tubercules de l'Ouest Africain.

- The plant parasitic nematodes associated with some tuber crops of West Africa.

MICHE, C. - Les Usages possibles des plantes à Racines ou à Tubercules.

- Possible Uses of Root and Tuber Crops.

+MIEGE, Marie-Noëlle - Etudes des protéines des graines de quatre espèces de Dioscorea d'Afrique Occidentale.

NIEDERHAUSER, J.S. - Potato in the Tropics (no written document)

- La Patate dans les Tropiques (communication présentée sans document)

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ROGERS, W. - Taxonomy of Cassava (no written document).

- Taxonomie du Manioc (présentée sans document)

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RECENT RESEARCH ON SWEET POTATO AT THE UNIVERSITY OF THE WEST INDIES

by

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RECENT RESEARCH ON SWEET POTATO (IPOMOEA BATATAS (L) LAM) AT THE UNIVERSITY OF THE WEST INDIES

Sweet potato research at the University of the West Indies subsequent to 1967 has been concerned with studies on tuber yield, the production of durable products which are convenient to use, the replacement of onerous tasks by mechanical operations and an understanding of the economics of regional root crop production. This research formed part of the Root Crop Programme [1] of the Faculty of Agriculture, the aim being to increase the production of sweet potato and yam.

This work, although carried out in different disciplines, was integrated to produce information thought capable of overcoming the following limiting factors:

(i) low and inconsistent yields;
(ii) uneven availability of tubers;
(iii) uncertain market demand;
(iv) high labour inputs for production;
(v) the absence of established production systems

The organisation of the overall programme has previously been discussed (Haynes, 1970). For purposes of this paper the structure of the sweet potato research is given below:

I. AGRONOMY	II. PHYSIOL/BIOCHEM.	III. MECHANISATION
A. Yield increase	Mechanisms of yield	Reduction of labour in
Yield variability	Enzyme systems	
Fertilizer response	Process of tuberisation	Planting
Plant spacings		Harvesting

[1] Established by a grant from the Rockefeller Foundation

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Pest control IV. PROCESSING V. ECONOMICS

Weed tolerance

Durability Rational systems

B. Mechanisms of yield Convenience

Canopy structure

Studies on Yield

Yield studies were carried out in two phases. The first of these was aimed at obtaining immediate increases in yield and was mainly concerned with agronomic studies on yield variability, fertilizer response, plant spacings, pest control and weed tolerance. The second phase of yield studies was directed towards understanding the mechanisms of yield. In this, agronomic and biochemical/physiological processes were considered.

I. A. Processes leading to immediate increases in yield

Yield variability

Average yields of sweet potato are about 2 tons/acre, best yields in commercial production about 6 tons/acre and record yields about 16 tons/acre. The discrepances between average and best commercial led to the expectation that an understanding of these yield differences per plant could result in increase in yield through identification of limiting factors. It was also expected that the reduction of variability has important implicatinns for field experimentation and the prediction of yield.

Tuber yield for individual plants was measured from replicated samples in several fields. High levels of variability were noted within and between samples. Indications were that differences in soil, climate and type of planting

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material contributed in different proportions to yield variability, (Haynes and Wholey 1971). The influence of soil environmental conditions on sweet potato tuberisation has been established elsewhere (Togari, 1960). Some influence of the dynamic changes in the soil and its effect on tuberisation can be deduced from tuberisation data. This topic is worth further study.

Fertilizer response

Addition of fertilizer is one of the more obvious means of achieving increases in yield of most crops. Added to this, fertilizers are easy to apply and the return per unit of investment easy to calculate. For these reasons fertilizer studies are favoured in many crop research programmes. Attractive as this may appear, increase in yield does not always derive from fertilizer applications. This has been noted by Russell (1968) in the case of traditionally grown tropical food crops. Rice is a particularly good example of this lack of response. There is some evidence that suggests sweet potato behaves similarly. With this in mind nutrient studies on the sweet potato were started with three objectives:

(i) the evaluation of fertilizer response potential of locally available material;

(ii) the recognition of characters associated with specific response types;

(iii) obtaining maximum response from the standard cultivars.

The evaluation of nitrogen response potential in local sweet potato varieties.

Selections on a visual basis were made from the breeding collection at U.W.I. Care was taken to include the highest yielding varieties together with those of diverse

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habit. These were planted in small plots half of each treated with nitrogen at 80 lbs/acre and half, unfertilized. The yields of the plots were determined 20 weeks after planting. A typical example of these results is shown in Table I.

Table I
Effect of nitrogen
on selected sweet potato varieties

Variety	Tuber in gms/plant -N	+N	Change in tuber yield with N gms/plant	%
C9/9	49.3	177.6	128.3	+260
A28/7	230.0	250.0	20.0	+8.7
049	221.2	198.4	-22.7	-10.3
AI 6/15	206.6	150.9	-55.7	-27.0
03/62	184.6	55.9	128.7	-67.7

It is suggested (Wholey and Haynes, 1969) that the response patterns showed by these varieties are a reflection of sweet potato response potential. These could be separated into the following types:

C9/9	Positive
A28/7 and 049	none
AI 6/15 and 03/62	negative

Attempts to explain these response patterns in terms of foliage type have not been successful. Studies are being continued using material of greater contrast in branching habit than existed in the previously available material. Also the possibility of a relationship between nitrogen response and matebolism of nitrogen in the plant should

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not be overlooked. This may provide a basis for explaining nitrogen response in this crop.

Recognition of characters associated with nitrogen response

In the nitrogen response screening trials such factors as nitrogen content of leaves and leaf thickness were measured. On selected varieties representative of the nitrogen response types detailed measurements of dry matter accumulation and of foliage habit were made. This has been useful in identifying the range of foliage types in the sweet potato.

Obtaining maximum response from standard cultivars

Standard fertilizer experiements were conducted to investigate the effect of addition of N, P and K fertilizers singly and in factorial cultivation on sweet potato (Haynes 1968a). The effects of level of nitrogen and time of application were also studied. In both instances the standard commercial cultivar 049 was used.

From the N, P, K study it was found that 049 gave no tuber yield response to nitrogen. There was a response to 100 lbs K in the wet season. There was some evidence indicating an enhanced response to K in the presence of 40 lbs of N, (Haynes 1968a). The petioles of leaves 1-9 and 10-15 proved to be useful indicators of potassium status and likely indicators of phosphorus (Haynes and Ahmad, unpublished).

A level of nitrogen and time of application study showed that time of application of N had no influence on yield response with 049.

The effects of row width and plant spacing on yield

Traditionally, row widths of 36 inches are used for sweet potato growing in Trinidad. When commercial production

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of this crop was being developed, 27-inch row widths were chosen since this spacing was appropriate to the available equipment (Haynes and Thomas, 1967). Opportunity was therefore taken to determine whether such spacing was justified.

Two cultivars with contrasting foliage size 049 and C-9 were grown on 36 and 27-inch rows and spaced 4, 8, 12 and 16 inches apart. It was found that maximum yields were obtained on 27-inch rows with either cultivar, and at 12 inches along the row for 049 and 8 inches for C-9 (Haynes 1968b).

Pest control

The major sweet potato pests in the West Indies are Euscepes batatae and Megastes grandalis. Surveys of the frequency and distribution of the former together with the extent of its damage to tubers have been made in Barbados and St. Vincent. Insecticides have been evaluated for their effectiveness as a means of control. Chlordane combined with Folidol Lebayeid gave good control (Parasram, 1968). Studies on Megastes have been confined to spray evaluation programmes and the epidemiology of the pest.

Weed control

Two lines of weed control investigation were followed. These included screening herbicides to determine crop and weed tolerance and studies on the effects of level and duration of weed competition.

For general control of sweet potato weeds, Amiben and Diphenamid at 1 and 2 lbs/acre respectively or Dacthal and Amiben each at 2½ lbs/acre were satisfactory. Eptam was

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shown to increase the effectiveness of Amiben/Diphenamid. The difficulties associated with incorporating this into the surface layers of ridged soil limit its usefulness in sweet potato growing in Trinidad.

It is generally accepted that weed control in the first 1/3 - ½ of crop life is most important (Nieto et al, 1968; Kasasian and Seeyave, 1969). Early work with the sweet potato showed that where it was kept weed free during the first 3 weeks yields were as good as keeping it weed free throughout its growing period, and that occasional weedings after the initial weed free period was better than more frequent weeding (Kasasian and Seeyave, 1969). Later work (Seeyave, 1969) showed the initial weed free period to be of greater benefit with crops grown for 14 weeks than with those grown for 20 weeks. With these latter weed control at 3, 6 and 11 weeks was recommended.

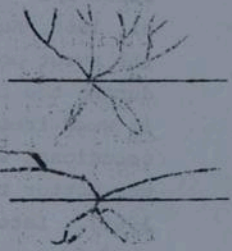
I. B. Studies on the mechanisms of yield

These studies were aimed at identifying the mechanisms associated with high yield. In the long-run it is hoped that this knowledge would be of assistance to the plant breeder in developing high yielding strains of sweet potato. Two lines of approach were followed. The canopy structure was investigated to see which canopy attribute was most closely related to yield (Wholey and Haynes, 1969). These studies on canopy are being supplemented by determinations of the photosynthetic efficiencies of leaves (Spence, 1971). The second line of study was concerned with the process of tuberisation and an evaluation of the enzyme systems in the plant.

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Canopy structure

The existence of different foliage types was established (Wholey, 1968). These foliage types give rise to plants which may vary in response to spacing and fertilizer application. Foliage character is related to stem and internode length and further modified by branch number, different combinations of which produce the following types:-



(i) Bunching foliage
Low stem length
Low internode length
High branch number

(ii) Spreading foliage
High stem length
High internode length
Low branch number

The attributes of foliage which are most directly linked with yield are total leaf surface and the display of the leaf surface. Leaf surface can be measured directly but display is rather more difficult to define. In this study the number of branches per unit length of stem was used as an index of display. Display indices were determined for 4 high yielding cultivars selected from the U.W.I. breeding programme together with the standard commercial cultivar 049 and two of physiological interest 049 and A138. The combined effects of the display index and leaf area on tuber yield (fresh weight) were determined by regression analysis. In only one variety (17/56/1) was there a significant relationship between leaf area and display on yield. Almost 70% of the variation in yield was accounted for by leaf area and display index. In other varieties these factors accounted for just over half (in 049) to 1% (in A138) of the yield variation. It would appear that for some varieties yield is foliage dependent.

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II. The process of tuberisation in the sweet potato

In a recent review, Wilson (1970) discussed the morphology, anatomy, biochemistry and some aspects of the physiology of sweet potato tuberisation. Use was made of rooted leaves (Wilson, 1967) to study tuber morphology and indications were that tubers were formed on a specific root type. Wilson (1970) showed thick roots to be formed on terminal petiolar callus but roots of petiolar origin to be always thin. He was also able to suppress tuber development by growing sweet potato plants with root systems submerged in water culture even when these were aerated.

In studies on the anatomy of developing tubers, Wilson et al (1969) showed that the parenchymatous sheath formation separating the lignified cells in the stele, was a varietal characteristic. Such a tissue was formed in 049 but not in C9/9. Wilson and associates were also able to confirm the findings of Artschwager (1924) and Togari (1960) that anatomincal differences between the other tuberous roots lie in the degree of lignification of the stele and activity of root meristems.

On the biochemistry of tuberisation Wilson (1969) proposed an examination of the biochemical features common to lignification and cell proliferation and/or cell expansion, likely to be mutually antagonistic to meristematic activity and lignin formation. In this study, peroxidase activity was shown to be lowest in the developing tuber where lignification was minimised and higest in string (non tuberous root) roots and tuber stalk which contained considerable lignin. Wilson and Imbert (unpublished) have shown that exposure of roots to light increases

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peroxidase and IAA-oxidase activities and inhibits tuber initiation. It has also been shown that scopoletin is an effective stimulator of IAA oxidase at low concentrations (Imbert and Wilson, 1970). On the physiology of tuberisation, Wilson et al (1967) are examining the relationship between parameters of tuber development and tuber yield.

III. Mechanisation

Mechanical harvesting and planting have been the two main areas studied by the agricultural engineer. The aim in harvesting has been the development of a robust, easily fabricated and maintained tool, with the capability of lifting normal tubers from the soil with the minimum of damage. So far equipment has been developed in keeping with the concepts of intermediate technology. The machine in question, the tractor mounted side lifter, exposes the tubers on the surface of the soil but hand labour is used to gather the tubers. This reduces the drudgery of harvesting without complete replacement of hand labour (Campbell, 1969).

Work is also in progress on mechanical planting. It is usual in Trinidad to hand plant sweet potato using 12-15 inches vine cuttings. Attempts are being made to make use of a seedling transplanter. Recent trials are promising, but further modifications are required to overcome problems associated with planting on ridges.

IV. Processing sweet potato tubers

These studies are a good illustration of the value of integrated crop studies. The seasonality of supply of sweet potato tubers has already been mentioned. This is a result of the restriction of the growing season by

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drought and the short storage life of tubers. There is, therefore, need for a processed product which is durable and can be stored for long periods without loss of quality. In addition, the demand for sweet potato as a fresh vegetable is declining. This decline in demand, in the opinion of the writer, is partly associated with its lack of convenience as a food. Work on processing was initiated at the outset of the Root Crop Programme with the twin aims of increasing both durability and convenience of sweet potato products. To this end, a survey of the processing potential of sweet potato was made (Sammy, 1969). This included the preparation of sweet potato flour, precooked puree and canned slices. Work on the preparation of snack and protein fortified breakfast type products is projected.

Sammy (1970) has shown varietal differences in the baking characteristics of sweet potato flour. 049 produced flour with superior baking characteristics to that from C9. Flour from 049 was used without difficulty as a substitute for wheat flour up to 15% in bread making and between 20% to 30% in pastries. An acceptable bread was made with 20% substitution. It was shown that peeling the tubers was of no advantage in flour preparation with 049. The colour of the product was improved by additions of sodium meta bisulphite. Levels of SO_2 beyond 100 p.p.m had deleterious effects on baking properties. The addition of 1% glyceryl monopalmitate improved baking properties of the flour (Sammy, 1970). More recently, the flour from 17 cultivars from the plant breeding collection has been evaluated for baking quality.

V. Economics of regional sweet potato production

Attention has recently been drawn by Rankine (1970) to the importance of the sweet potato in the West Indies.

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He showed that in 1958, together with yam, there was a per capita production of some 90 kg (200 lbs) in the region. In the same paper, Rankine also cites as reasons for increased attention to root crops, the need for technical efficiencies within the Caribbean context and the use of agricultural diversification and import substitution within the framework of economic development.

Economic studies are therefore being made of the role and function of root crops in the development of the region. Attention is also being given to the means of rationalising sweet potato production in the different islands. In St. Vincent accurate and detailed costings for commercial production are being collected and in Saint Christopher work is in progress on the minimising of costs through changes in production patterns.

Preliminary indications are that within the region shortage of labour is a major limiting factor in the production of root crops. Small size of market and a lack of credit are also important factors.

Acknowledgments

While the author wishes to thank L.A. Wilson and D.W. Wholey for reading and commenting on the entire script, and the following for reading specific sections: L.G. Campbell - mechanisation, L.B. Rankine - economics and G.M. - processing, he accepts full responsibility for the interpretations contained in the text.

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POSSIBLE USES OF ROOT AND TUBER PLANTS

by

C. Miche

A Paper to be Presented at
A Seminar on

ROOT AND TUBER CROPS IN WEST AFRICA

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I. INTRODUCTION

There are two ways of approaching the study of possible industrialisation of tuber plants in Africa in the future:

--the first is to limit ourselves to transfering to the African starch plant the very advanced technology today applied to potatoes in the highly industrialised nations, several examples of which will be given, and

--the second, to take more into consideration the particular historic and economic context in which this industrialisation is to take place.

It is this second point ~~which we are going~~ to discuss, because what is important is not so much to state what technology will be capable of in twenty to thirty years with an ideal tuber, produced by agronomic research, but more to know in what measure the local conditions will help in applying existing processing techniques.

Various difficulties make any long-term predictions which we could make on the future of tubers in Africa very risky. The major difficulty is lack of precise information on the present human and economic situation, whether at the level of production or that of financial returns, urban and rural consumer tastes, commercial exchange, loss level, etc.

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Also, given the speculative and subjective nature of the subject itself, the lack of definite information at our disposal, and our personal inexperience, we should not try to predict the future.

We will limit our remarks to a rapid, overall view of the various social, economic and technological factors capable of furthering or hindering the development of tuber plants in West and Central Africa, and thus furnish the present assembly with a number of subjects for reflexion and discussion, useful to their future work.

II. REVIEW OF SEVERAL ECONOMIC FACTORS

2.1 Cassava production

In a very general way, tuber plants today, either alone or in conjunction with plantain or certain cereals such as maize and rice, form the basic diet of an important fraction of the Africans of the tropical forest and savannah, as the maps we have borrowed from Dr. Murdock show.

Within the large area bounded by the sorghum and millet producing regions, we will limit ourselves to an examination of the overall economic profile of several West and Central African countries.

It is very difficult to assess the importance of food production in Africa, especially when the various crops are often complexly inter-cultivated, when the crops are root crops,

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when, in addition, a major portion of the production sometimes remains in the ground. Also, it is not rare to find that food crop production figures in Africa vary by one or two hundred per cent, and even more, according to the source of information.

Although perfectly conscious of this lack of precision, we have based our calculations for the evolution of cassava production in West Africa on

--the FAO Production Annual 1969

--figures gathered from other sources by the IRAT Economic Studies Service

Tables I and II, pertaining only to cassava, show that world production, excluding continental China, has tended to increase slightly faster than demographic growth, over the last ten years. In contrast, the inverse is true of production among the major producers of West and Central Africa, where average consumption per inhabitant decreased from around 245 kg/inhabitant/year from 1948 to 1958, to less than 200 kg/inhabitant/year from 1964 to 1968. This last holds true for the whole of Africa where average production per inhabitant has decreased by about 17% during the last decade.

The slight increase in production of 12.8% at the global level could be due to a perceptible increase in yields in Latin America and an extension of production in the Far East.

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Table I seems to indicate as well that the area of cassava production tends to extend towards the countries of the Sahara region, where production per inhabitant has increased by about 30% over the last decade.

2.2 Market for products derived from cassava

The fraction sold commercially after processing is extremely difficult to ascertain due to a lack of information on the precise nature of the products under trade classification. It appears, however, negligible, compared to the fraction consumed or sold locally. In Togo, the Ganavé starch factory produces annually about 5,000 tons of starch; in the Cameroon, two small factories produce 600 to 700 tons of dry chips. A new starch factory has just been set up in Angola, whose present capacity is from 600 to 700 tons per month and should reach 1,500 to 2,000 tons per month during the next few years. We should remember that Angola cassava has a good reputation on the international market. Two other modern starch factories are presently in operation in Kenya and in Uganda.

Two tendancies were clear on the international cassava market after World War II:

--the first was a decreased demand for starch and tapioca for food and industrial purposes. This decrease was due to the considerable increase in the production of corn starch,

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especially in the U.S.A. The U.S.A., which imported 500-600 thousand tons of starch after the second World War, today imports only some 50-60 thousand tons per year, mostly for food.

--the second is a considerable increase in the demand of the Nordic countries of the European Economic Community, in particular Germany, Holland, and Belgium, for dried cassava roots for animal feed. The tonnage imported by the E.E.C. has in fact increased from around 400,000 tons in 1960 to nearly 1,300,000 tons in 1970, the two principal suppliers of the E.E.C. being Thailand and Indonesia.

A potential market thus exists at present in Europe for dried cassava roots, which could inspire African producers to compete with exporting countries in the geographically much less well situated Far East. Angola in particular should plan on adding to its starch factory a factory for the production of cassava granules; but we need to remember that an increase in the import tax on cassava roots could be decided on by the Six at Brussels, under the growing pressure of the cereal producers of the E.E.C. (cassava paying only a 6% duty on entry into the Community as a result of a customs system deriving from the GATT Agreements, while foreign cereals must pay a duty equal to the difference between the world price and the European threshhold price, or, for example, in the case of maize, a duty of around 56%).

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The decline of cassava starch factories must be attributed to various related factors, among which we can cite:

first, the small scale of most of the enterprises which treat fresh roots locally and which do not assure a constant quality to satisfy the analytic standards of importing countries,

second, the considerable progress of basic and applied research in the areas of chemistry and technology of corn and potato starch, which has permitted their application in areas once reserved for cassava starch,

third, the economic support of the U.S.A. and the countries of the E.E.C. for the production and sale of their national products, in particular corn and potatoes.

2.3 Evolution of other tuber plants

It is more difficult to form an opinion on the evolution of the production of yams, sweet potatoes, taro and macabo in Africa and their industrial potential than for cassava because these plants do not enter into international commercial transactions, nor into major industrial processing, and information on them is very limited.

Those on which one finds information are generally grouped under a same heading as tuber plants. It is certain that the sweet potato, although existing everywhere, plays a rather restricted economic role in West Africa where the most valued and widespread tuber is the yam.

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According to the information available at the IRAT, the respective proportions of sweet potato, taro, and yams would be approximately those in Table III in 1968, in the four coastal countries of West Africa.

Going still further, to get an idea of production and consumption, in particular in Nigeria, we have arrived at figures so variable and contradictory that it has been necessary to give up trying to do this for any plant other than cassava.

However, we can estimate without making a really great error that global yam and aroid production has probably followed the demographic progression more or less closely during the last ten years, because these food plants are still very highly valued by the various ethnic groups for which they are the principal or secondary food. Moreover, dietary habits change extremely slowly in the rural areas, which make up the major portion of African populations. FAO predicts, on the medium term, a progress in production perceptibly equal to that of demographic growth, as Table IV shows (published by the World Indicative Plan).

Mssrs Coursey, Rasper and McGregor have noted a slight regression for yams, which are difficult to cultivate, to the benefit of cassava, which is, moreover, much less expensive. We have seen that cassava is effectively progressing in the savannah region.

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Other studies emphasise the spread of plantain into the forested and higher regions. This plant, which requires even less work than cassava and is used in numerous culinary preparations, should everywhere follow the development of the new coffee crop, especially in Cameroon.

Whatever the case may be, it is quite difficult to discover any global tendency in the predictable future of tuber plants in West and Central Africa, at least using only the economic data at our disposal, because these data generally reflect local situations, and are very imprecise.

It is necessary to undertake an in-depth comparative study for each country, of the economic and social factors which determine consumer structures, the seasonal price relations among various food products, governmental measures affecting the consumer structures, international commercial tendencies, etc., to try to some extent to predict medium term developments.

2.4 Development of imported cereals

In contrast, there is less doubt on one point: urbanisation brings, as well as a modification of life style, a parallel increase in the consumption of imported and local cereals, and of course a corresponding decrease in consumption of tuber plants, the price of which can become prohibitive if we bear in mind high transport costs and storage losses. Yams

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initially costing 7 to 10 francs per kilo are currently commanding 20 to 30 francs in the cities.

Table no. V shows the evolution of import of wheat, cereal flour and semolina from different West African countries during the last ten years. We should specify, to make the table more clear, that the extraction rate at the flour mill is around 75%.

Senegal apart, where wheat flour production seems to have stabilised somewhere around 65,000 tons during the last decade, we see that imports have practically doubled in the various large coastal cities consuming tuber plants, while, in the same time, population growth has only been around 27%.

In the Cameroon, the Cameroon Flour Mill Society, established at Douala in 1966, was already in 1967 producing beyond its initial daily capacity of 1,000 quintals, and this society hopes to double its capacity after only four years' activity.

The major cities of the countries mentioned in the table today have industrial bakeries, and it is no longer rare to find wheat bread, if not in the bush, at least in most small isolated villages. The growing taste for bread among Africans, and in some areas, for processed rice, is perhaps explained by the fact that these are products with a certain prestige, but more probably by the fact that bread and rice are edible without preliminary processing.

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We will see further on that the making of bread from blended flours has just about left the experimental stage and could soon contribute to the development of the production of starchy root flours or local cereal flours.

III. PRESENT PROCESSING OF TUBER PLANTS

3.1 - Cassava

As we have already pointed out, only cassava has been industrially processed in Africa, but the starch and tapioca thus produced represent only a negligible fraction of the production of fresh roots.

People have also tried to use cassava as the raw material for other purposes than starch or dry root production: for the fabrication of glucose (Williams, 1933, Samson, 1951, and Subrahmanian, 1952), or the production of butanol and acetone (Tobangui, 1939 and H.A.O., 1957), of dextrine (in a factory of the Staley Manufacturing Company in Maine, U.S.A.), or concentrated protein, but, to our knowledge, there exist only a very limited number of industries for these products, as there exists no real food industry for cooked or semi-prepared products from cassava.

On the other hand, there is around the towns, local preparation of dextrinised or fermented cassava, known in Africa by the names "kokonte" or "gari". Research on the development of local activity in this area has been carried out in Ghana (Jarmai

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and Montford), at the Federal Institute for Industrial Research (Adeyinka and Akran), while the T.P.I. has studied the manufacture of a sort of vegetable cheese rich in microbic protein (Brook, Stanton and Wallbridge).

3.2 Yams and aroids

What has just been said about cassava is true a fortiori for yams and aroids. Yams in particular are an expensive source of carbohydrates, too much so to be employed to the same industrial uses as cassava and maize, although technically nothing serious prevents the processing of yam for alcohol, glucose or starch. The only exception has been the temporary exploitation of wild yams with high sapogenin content, as precursors to the synthetic sex hormones and cortisone.

This activity, which had a certain success from 1950 until recently, in particular in Mexico and South Africa, has, however, disappeared with the recent appearance of entirely synthetic pharmaceutical products.

Traditionally, yams are consumed in various forms, of which the most common is foufou (foutou in Ivory Coast). Foufou preparation is slow and laborious, and is done only in the family because it must be consumed fresh, deteriorating very rapidly.

To prepare foufou, the housewife must first peel the yams and remove the non-edible parts, then cut them into pieces, and boil

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the edible parts. The cooked pieces are then pounded with a pestle in a mortar, with or without the addition of water, until a more or less gelatinous, compact mass is obtained, which can be cut in slices.

The species most appreciated in the "yam belt" of West Africa seems to be the Dioscorea rotundata, the starch grains of which are larger than those of other species equally widespread in Africa (D. alata, D. cayenensis, or D. dumetorum). They give a food of a much firmer consistency than that of other species, as Rasper and Coursey have shown.

It is obvious that the use of the mortar and pestle, so common for all kinds of culinary preparation with a cereal base, oil seeds, starchy roots, . . . or legumes in the rural African environments, tends to disappear in the town, where its use cannot be envisioned in the modern multi-story dwelling. This contributes greatly to the decrease in consumption of certain products, to the profit of wheaten bread, rice, and preserves.

No one is unaware of the relative perishability of yams and the relatively high rate of losses recorded in storage. A simple method of minimising these losses consists of reducing the various enzymatic activities by dehydration. Also, the production of yam flour requires some local activity in the savannah regions, where sunlight is sufficient.

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Macabo are generally consumed in Africa in the same form, and incombination with the other tuber plants.

As for taro, it is particularly well suited to "chips", the quality of which is improved by preliminary boiling, as in the preparation of yam chips". To our knowledge, there is no African culinary preparation using fermented taro as a base, similar for example to the Hawaiian "poi", the production of which could, moreover, be industrialised and commercialised in the U.S.A. as baby food.

Western Samoa likewise now exports taro preserves in slices similar to potato chips.

3.3 Sweet potato and potato

Among the tuber plants known in West and Central Africa, sweet potato, and especially potatoes, are the least popular. These two plants are however very well known in the industrialised countries and, consequently, those for which food technology is most varied. . . . .

We give here only a brief glimpse of the transformations to which potatoes are today subjected in industrialised countries, recalling that particular varieties and specific means of conservation have been studied for a specific industrial purpose.

Whatever the final food product to be obtained, potatoes must be peeled before washing. The industrialist today has several different ways of doing this:

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--abrasion peeling on a rough surface. This technique is reserved for potatoes which are round, thin skinned, and smooth, without eyes, and intended for chips.

--lye peeling by submerging potatoes (sometimes pre-heated) for a definite time in a caustic soda solution, hot or cold, then washing and neutralising them

--steam peeling, under pressure with superheated steam

--Hot brine peeling

--flame peeling, at more than 1,000° for 15 to 30 seconds

--oil peeling, or immersion in hot oil

At present the battle against environmental pollution has led the Americans to research a method of dry thermal and chemical peeling, because most of the methods cited above consume a large quantity of water, the purification of which poses difficult problems. Research to this end, combined with recovery of protein contained in residual industrial waters, is being conducted in the research laboratories of the U.S.D.A. in Philadelphia and New Orleans, under the direction of Cording, Talley and Deobald.

According to her needs, the American housewife can today choose among a remarkable number of different products requiring only a few minutes' preparation. It would be tedious to list them all, from the simple, pre-peeled potato to freeze dried flour, and including chips, instant cubes, puff potatoes, pre-cooked

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mashed potatoes, frozen french fries, and all manner of cooked and frozen dishes.

The techniques developed to obtain these various products have also evolved remarkably these last few years and we have ever more elaborate processes at our disposal. In the area of dehydration of food products alone, for example, we use today, besides chambers, tunnels and band dryers, such processes as:

--drum-drying: one or two cylinders, using high atmospheric pressure followed by vacuum, largely used to prepare potato or sweet potato flakes,

--explosive puff drying, developed by M. Cording and M. Eskew at Eastern Laboratories, the principal method consisting of the expansion of a product by the rapid vaporisation of the water it contains, and an almost instantaneous lowering of the pressure. This process, which we are trying to make continuous, is used in particular to dehydrate vegetables to be made into dried soups,

--foam mat drying, invented at Western Laboratories and applied particularly in the preparation of mashed potatoes,

--micro-flake drying, derived from the preceding, permits short-cycle, low-temperature drying (one minute at 77°C.) for delicate products,

--drying by "lit-fluidisé", used, for example, to finish potato granules, by which the pieces to be dehydrated are kept in

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suspension in an ascending air current, the speed of which is, at each level, equal to the rate at which the particles fall, the latter being homogeneous and small,

--vacuum puff drying, which is drying by expansion under a vacuum, of a narrow fluid layer, and a method deriving from this: vacuum foam drying,

--spray-drying, a well-known process in which the evaporation at the boiling stage is instantaneous due to the micronisation of the product being dried in a current of hot gas. The process is used for mashed potatoes, glucose and dextrines. Milk and products sensitive to oxidation are also treated by processes derived from atomisation, such as jet spray drying, vacuum spray evaporation or foam spray drying. As for products which must retain high qualitative and biologic value, they can be dehydrated at the surrounding temperature by atomisation in a column 70 m. high, by the BIRS method.

--di-electric drying, with short waves, fairly costly, but nevertheless already widespread in the U.S.A., especially for the manufacture of potato chips and also used for freeze-drying,

--drying by infra-red rays, used to make fried potatoes

--drying by freezing, which combines the respective advantages of drying and deep-freezing

--freeze-drying, consists of completely freezing the water in a product, then heating in a vacuum container, and finally eliminating in a pressurised vacuum and at a higher temperature (20° to 60°C.) any water still contained in the tissues.

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The remarkable diversity of techniques used to peel or dehydrate agricultural products in the highly industrialised countries, in particular in the United States, where most of the processes described above have been developed by the laboratories of the U.S. D.A., do not necessarily answer the question of lower processing costs. Quite often the major requirement in a so-called "consumer society" is rather to allow a more and more demanding and sought after clientele to satisfy its smallest wishes and to economise --rightly or wrongly--on the precious time spent at table or in the kitchen.

IV. POSSIBLE USES OF AFRICAN TUBER PLANTS

Keeping in mind what has already been said, it does not seem very reasonable to envision, in a short or medium term, the setting up in Africa of industrial processing units based on exportation to industrialised nations. There remains the internal market, which should be more closely examined, but for which two paths at first seem open to tuber plant processors:

--that of cassava starch extraction for local industrial uses
--that of preparation of pre-cooked or instant traditional dishes for local urban markets.

4.1 Industrial uses of starch

In the first instance, native or modified cassava starch could be used by the textile industry to size cotton, as stiffening, or in the form of dextrine adhesive in the plywood and furniture industries.

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The paper industry, which uses large quantities of starch, must be excluded as a possible outlet for the present, as the threshhold capacity of the paper suppliers exceeds the potential needs of local markets.

The growing food industry could also provide an outlet for cassava starch, in particular, the bakeries, if the techniques of bread making with blended flours developed by Slim and Ruiter at Wageningen, by Dendy and Clarke at T.P.I, and by Perten and others at the I.T.A. in Dakar, should be extended in the near future.

Changed into glucose, starch could also find markets in the soft drinks and lemonade industries, in pastry and candy shops, so long as the legislation of the francophone countries does not follow French legislation forbidding its use as food.

Cassava flour as starch could also serve as substrata to micro-organic cultures for the preparation of various protein-rich foods, or go into the composition of dietetic flours for weaning, enriched with protein, vitamins, and mineral salts, of which there are so many different combinations which international organisations have been trying for years to promote.

We see that almost all the possible uses mentioned above are only conditional. If we restrict ourselves to the present needs alone of all the countries of West and Central Africa, we would doubtless discover that a single starch factory whose profit-earning threshhold is around 70,000 tons of treated roots, would

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cover the needs of the countries concerned in the near future.

We have intentionally left out the production of alcohol as a possible use of tuber plants, as the sugar refineries, which are multiplying, can better satisfy the needs of the states, and the importation of alcohol, synthetic or no, constitutes a source of customs revenue which the states are not inclined to disregard.

4.2 Preparation of traditional cooked dishes

Chances for the success of factories offering to urban consumers instant traditional dishes are obviously greater than the chances of numerous projects which consist of marketing in Africa all sorts of preparations, of various origins, high in protein content certainly, but which have the major inconvenience of not corresponding to consumer tastes; as, for example, a quantity of fermented products of asiatic origin, composed essentially of fish, rice, soya, cocoa, etc., such as tempeh, ontjom, idli, miso, or nuoc mam.

Research has been carried out by various institutes in several West African countries for the development of techniques for industrial manufacture of foufou, gari, or kokonte, using cassava or yams as a base. Projects exist on paper in Ghana, Nigeria, Ivory Coast, awaiting private promoters.

Lacking promoters, it will undoubtedly be up to the governments concerned to promote pilot units with the help of external financing, as in the case of the blended flour bakeries.

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We do not believe that the technical procedures proposed by technologic research are responsible for the reticence of industrialists. The essential reason for their fears is the uncertainty of outlets and limited markets.

We cannot blame them for their caution because it is logical and well-recognised that many developing countries have reason to base their industrial development on processing of their own agricultural products. Also, the factors which contribute to the success or failure of an industrial project are not always fully understood.

Keeping in mind the relatively large number of failures or partial failures among agricultural processing enterprises in the non-industrialised countries over the last decade, we believe it is useful to recall briefly the most common causes.

V. FACTORS WHICH CAN HINDER THE RAPID INDUSTRIALISATION OF TUBER PLANTS

Table no. VI, established by Mittenduf, shows the frequency of the principal causes which have led to the failure of 70 agricultural undertakings in various developing countries. This FAO inquiry involved only technically well-conceived enterprises which did not succeed in fully utilising their production potential.

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5.1 Sales and supply to the factories

The possibilities of securing a supply satisfactory in quantity, quality, price and regularity must be known to any agricultural industry.

It is quite evident that a continuous manufacturing procedure destined to produce at the lowest price a finished product of a constant quality requires a regular supply in quantity and quality.

These two imperatives are all the more difficult to meet as the raw material is more perishable and difficult to store, and the supply dependent on a high number of small-scale, ill-trained cultivators.

In the eyes of traditional cultivators, who only rarely see the importance of the maximum utilisation of their production potential in order to sell more and at a lower price, the factory very often represents, by the drastic limitations of quality and punctual delivery which it imposes, a source of problems which secure sales do not always justify. In addition, keeping in mind the considerable charges with which the factory must assure its supply, it prefers often to manage its own industrial area (the example of sugar refineries) rather than go directly to the thousands of suppliers who have arranged to not have, in the end, more than the least responsability (training of agents, the distribution of seeds, plant protection, rural credit, etc.).

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5.2 Demand and commercialisation beyond the factory

We will not speak here of the export markets of the industrialised countries. Any attempt to understand this requires an extremely detailed analysis of the market, involving various things: technical norms, quality, form, processing, price, credit, delivery, legislation, customs regulations and procedure. As for the internal market, a major cause of failure in the new industrial installation trying to introduce a new food product is obviously the overevaluation of demand.

It is often very difficult to evaluate what will be the real demand of a group of consumers, to know its particular tastes, its real buying power as regards processed goods, by definition always more costly than fresh products.

As we have already discovered for gari and foutou, it seems, at a first glance, logical and reasonable to manufacture traditional cooked dishes destined for the potential urban market. It would, however, be necessary to refrain from excessive optimism about the demand because:

first, the population of African cities is made up of individuals of various ethnic origins, with different tastes, while an industrial product is by definition of constant quality,

second, sources of fixed revenue, which are theoretically sufficient to allow for the purchase of processed products, are very often dispersed in the maintenance of numerous relatives who are only slightly productive, or not at all, so that the real purchase power of wage earners is, in fact, very small,

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third, urban markets are supplied by a whole range of finished products which are widely consumed, and therefore not too costly although imported.

Unable to use modern methods of promotional marketing, it will be necessary to predict in a first phase of industrial development low capacity pilot units destined to establish in vivo what the real demand of the market will be.

This elementary precaution cannot always be observed because the unit capacity of the material furnished by industrialised countries answers much more extensive markets. However, to answer the restricted needs of developing countries, certain Japanese and German agencies in particular provide at present small-scale factories, at viable cost prices, such for example as the breweries providing 8 to 15,000 hl/year, while normal European factories are expected to produce several hundred thousand hls per year.

The choice and establishment of a commercialisation network, well supported by sales promotion, is also of very great importance to the success of an enterprise. The price of packaging and processing units should in particular be adapted to the low purchase power of the consumers, so as to avoid the product being divided and sold at prohibitive prices, as is too often the case in Africa.

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5.3 Management and other factors

In principle, a factory for agricultural processing must be installed near the area of production into which it should be completely integrated.

The relative isolation of an agricultural factory sometimes poses personnel and management problems that should not be underestimated in countries where the highway system and means of communication are often limited and inefficient.

In addition, the judicious choice of a location designed not only to minimise processing and commercialisation costs, but also to retain the people who come to work there, is essential. The choice of a site dictated mainly by political reasons generally proves as unprofitable as the choice of an administrative and technical team founded on criteria only distantly related to the competence of the individuals.

To these problems of places and personnel, with which the suppliers of complete factory units are generally not very concerned, we should add the lack of credit and, in particular, the lack of a sufficient circulation of capital to allow for a satisfactory supply of raw materials through loans to farmers, and the storage of finished products to last until the next harvest, including the necessary credit to the distributors of these products.

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Customs protection of a young industry can be beneficial in the short term, but the state should progressively reduce all protectionist restrictions as the enterprise becomes competitive. Otherwise competitiveness is reduced.

Another internal factor which contributes to numerous recorded industrial failures in third world countries is--outside a financial management which is irrational or founded on outdated concepts--the absence of productive incentives to an overabundant labour force.

State enterprises are in this respect more difficult to make profitable than private enterprises, the latter being free to select personnel. It is important not to lose sight of the fact that raw material delivered to the factory represents in general a very great portion of the cost price in the food industries, such that these industries are forced, to remain competitive, to fight the pressures of generally high unemployment rates in the non-industrialised countries, and often to automate their production to the maximum.

VI. CONCLUSIONS

Can we, after this rapid survey of the various aspects of a possible development of tuber crops in West Africa, foresee what will be the industrial future of some of them?

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We do not see too well, in the present state of affairs, why the highly developed countries should suddenly develop a taste for the modified African starch roots, while at the same time they are doing everything in their power to substitute their own starch products for those of third world suppliers. These are less and less able to understand and satisfy the growing needs of the industrial markets, which are subject to fixed and opposing laws.

We also cannot see how the very laborious traditional culinary preparations of tuber and root crops can resist the growing challenge of cereals, the price of which per unit of energy in the towns is no greater than for yams.

There is, however, one path which several West African countries may wish to take: that of the industrial manufacture of traditional pre-cooked dishes, in particular instant yam foufou, or gari, or cassava kokonte, the manufacturing techniques for which are already established.

A potential market exists in this area in Africa, more limited perhaps than we generally think, and certainly very difficult to satisfy, but which will obviously develop with the progressive growth of the buying power of the citizens.

The factories which will be called upon to manufacture traditional African dishes will meet not only all the classic difficulties encountered by agricultural industries in the under-developed countries, but will moreover, have to build on a raw material which

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has not been the object of as advanced studies as sweet potato, potato, or the large-scale export crops.

Varieties of yams, cassava, taro or macabo remain to be discovered by agronomic research, to satisfy particular industrial ends. Whatever these ends, one can, without making a grave error, assign from the start as criteria for selection:

1. roots of small size and uniform dimensions (these characteristics are also sought for mechanised cultivation)
2. roots of simple form without eyes or malformations, or as "fingers" as in certain yam varieties
3. a thin, smooth skin, giving a minimum of loss on peeling
4. a root with a high dry matter content, no toxic substances, but as rich as possible in the various nutrients
5. tubers the colour and taste of which correspond to the tastes of the majority of the people
6. tubers which are easy to store

As the techniques of storage and processing are refined and diversified, other criteria for selection will arise for the consideration of plant breeders.

But what we especially hope is that African countries will find as soon as possible, in the manner of industrialised countries, the means by which starches will give way to cereals and proteins of animal origin.

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SOURCES OF TABLE VI (Problems of commercialisation encountered in the full utilisation of the capacities of certain enterprises for the processing of agricultural products, established recently in various developing African nations.)

FAO, Products Committee, 38th Session. Provisional Report. The Economic Incidences of the Evolution of Milk Production in Developing Countries (CCP 65/9/3) and FAO, Products Committee, 40th Session (CCP 66/11/2).

D.G. Tilgner. "Kritische Betrachtungen zur fleischwirtschaftlichen Entwicklungshilfe für Westafrika," Die Flesichwirtschaft, Jg. 46, H.11, Frankfurt, 1966. Data gathered from in-the-field studies by the author and FAO specialists in commercialisation attached to the United Nations Technical Assistance Programme.

1. Problems of supply: underestimation of supply and incentives to producers, overestimation of competition from existing enterprises and commercialisation networks, absence of support services for farmers (extension of credit, for example).

2. Commercial demand. Overestimation of the probable commercial demand, errors in judgment of tastes, preferences and habits of local consumers, underestimation of competitive ability of products offered by other sources and replacement products, underestimation of obstacles to access to markets.

3. Commercialisation methods. Lack of installations and rational methods of purchase, transport, storage, processing, and distribution. Absence of initiative in educating consumers and promoting sales; insufficient financial means, in particular capital for circulation; overabundant labour force; and official interference. All these inconveniences appear as excessive processing and commercialisation costs, in contrast to costs of competitive enterprises.

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A N N E X E S

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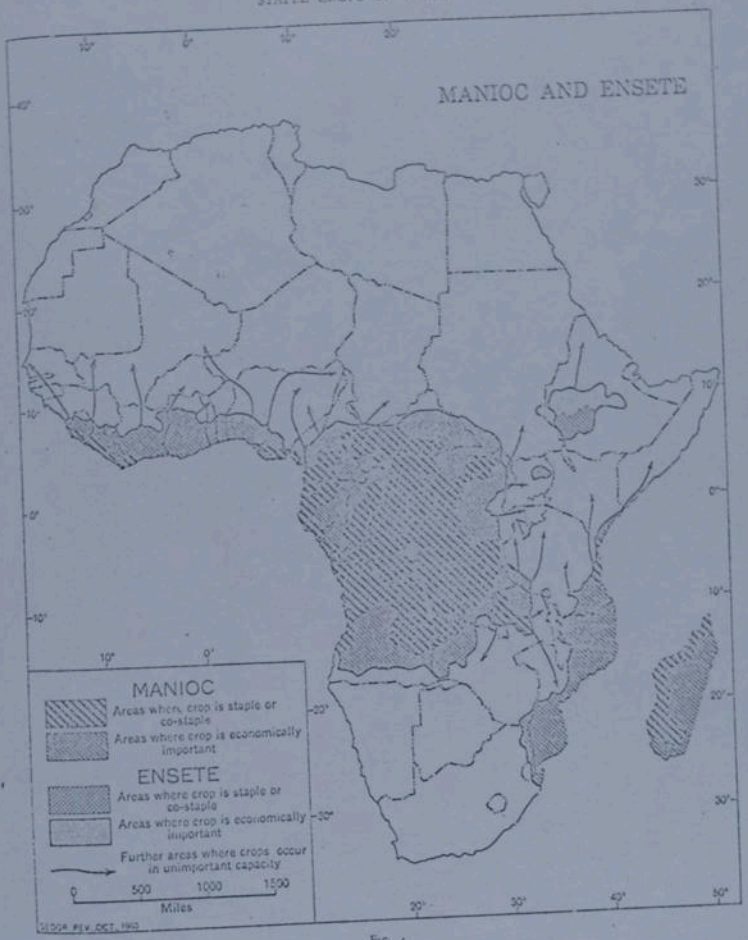


FIG. 4

a P. Merrick, "Staple Subsistence Crops of Africa", The Geographical Review, Vol. 4, No. 4, 1960

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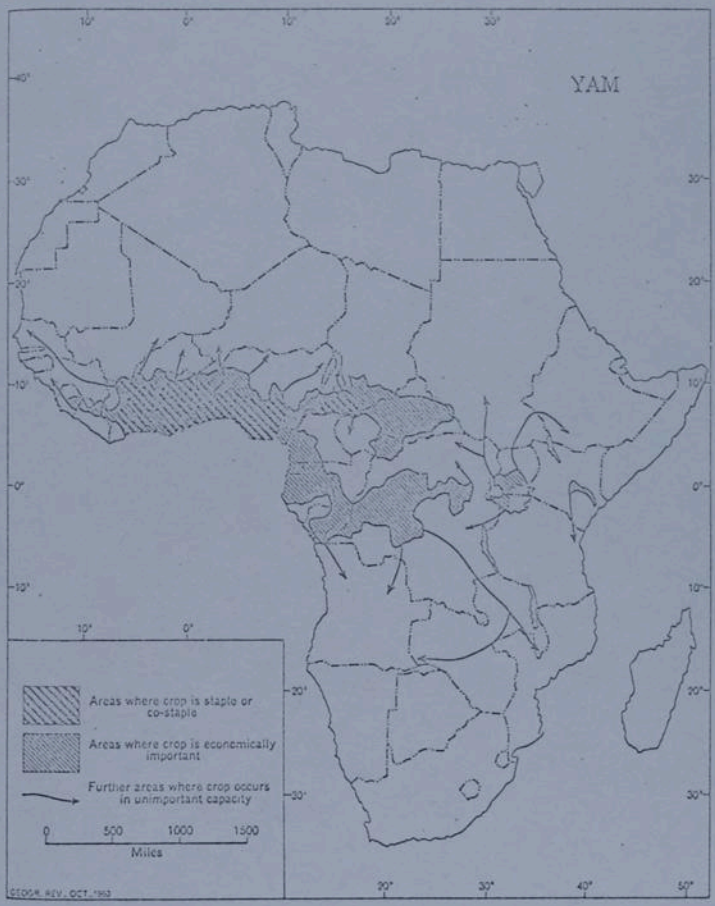


FIG. 12

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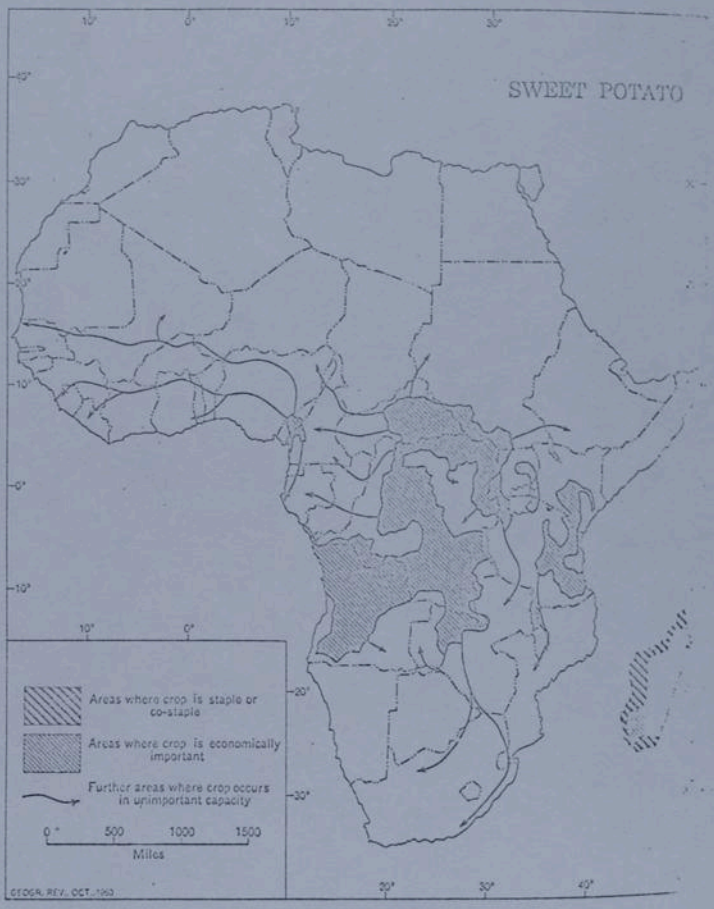


FIG. 9

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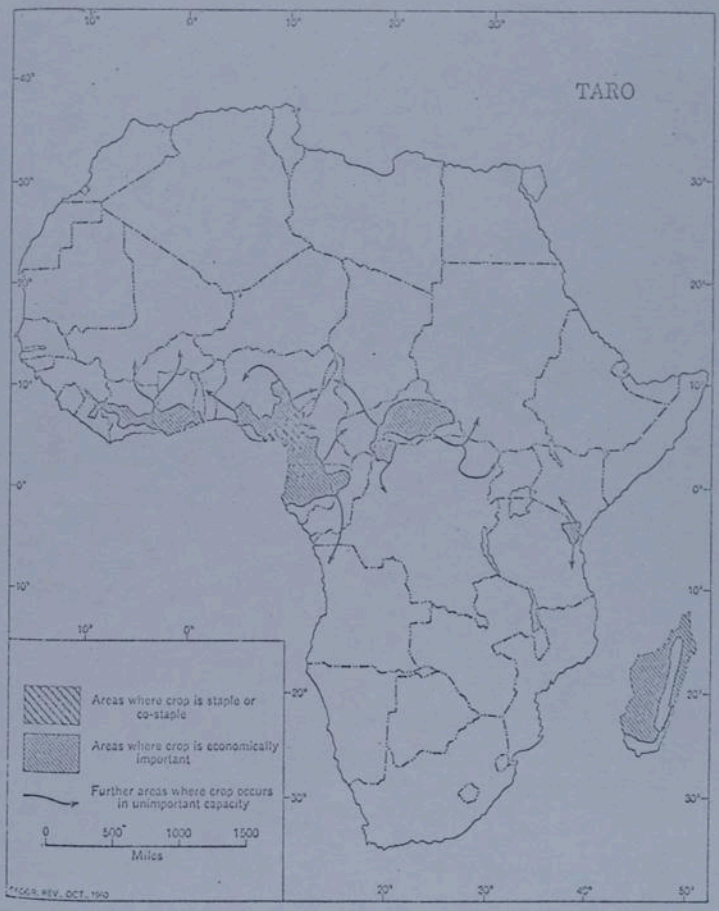


FIG. 10

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EVOLUTION DE LA PRODUCTION

Tableau I

	1948 - 1952			1952 - 1956			1964 - 1968				Prod.kg/an/hab.		
	Prod.	Sup.	Pop.	Prod.	Sup.	Pop.	Prod.	Sup.	Rdt.	Pop.	1948/52	1952/56	1964/68
I	1000 t	1000ha	1.000	1000 t	1000ha	x1000	1000 t	1000ha	Qx/ha	x 1000	kg	kg	kg
Cameroun	1102	96	3921	948	105	4029	740	111	67	5344	281	235	138
Congo Brazzaville	500	70	658	560	79	702	480	104	46	850	760	798	565
Congo Kinshasha	5935	655	11297	7063	598	12307	7557	691	109	16000	528	574	472
Côte d'Ivoire	623	127	2612	438	124	2926	511	208	25	4336	238	150	118
Dahomey	693	142	1571	831	158	1735	1067	171	62	2430	441	479	439
Gabon	60	12	409	60	12	423	125	50	25	468	147	142	267
Ghana	512	66	5191	574	66	5778	1122	153	73	7945	99	99	141
Guinée	218	56	2247	265	56	2580	435	30	145	3608	97	103	120
Liberia	397	55	860	401	60	906	425	64	66	1084	462	443	388
Nigeria	5800	997	37606	6440	1079	42018	6900	1160	59	56230	154	153	115
R.C.A.	650	140	1046	740	158	1104	500	100	50	1366	621	670	366
Togo	233	46	1190	359	61	1279	1011	139	73	1680	196	281	602
Total/moy. I	16723	2462	68608	18679	2556	75787	20873	2981	70	105351	244	246	198
II													
Haute-Volta	20	4	3676	24	4	3937	30	5	60	4805	5	6	6
Mali	142	14	3440	190	19	3628	189	12	157	4565	41	52	41
Niger	21	7	2417	64	14	2655	153	20	76	3608	9	24	42
Sénégal	61	33	2482	82	40	2830	204	52	39	3560	25	29	57
Tchad	20	2	2665	20	2	2811	52	15	35	3360	7	7	15
Total/moy. II	264	60	14680	380	79	15861	628	104	60	19898	18	24	32
Tot./Moy. I + II	16987	2522	83288	19059	2635	91648	21501	3085	69,7	125249	204	208	172
Tot/moy. AFRIQUE	23337	3672	188804	26544	3827	206491	29401	4588	64	275767	124	129	107
Tot/moy. MONDE*	48775	6408	1951009	56164	6850	2107815	79725	9218	86,5	2651161	25	26,6	30

* - Chine Continentale exclue.

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EVOLUTION COMPARATIVE DE LA PRODUCTION DU MANIOC

Tableau 11

		Principaux Forêt	Marginaux Savane	Ensemble Ouest/C.	AFRIQUE	AMERIQUE LATINE	ORIENT (Pr.+Ext)	Tot. Mondi. (- Chine Co.
1948/1952	Production	16.723	264	16.987	23.337	15.624	9.814	48.775
	Superficie	2.462	60	2.522	3.672	1.336	1.409	6.408
	Habitants	68.608	14.680	83.288	188.804	161.866	861.469	1.951.009
	Rdt (Qx/ha)	68	44	67	64	117	70	76
1952/1956	Production	18.679	380	19.059	26.544	17.344	12.275	56.164
	Superficie	2.556	79	2.635	3.827	1.479	1.544	6.850
	Habitants	75.787	15.861	91.648	206.491	180.379	931.459	2.107.815
	Rendement	73	48	72	69	117	80	82
1964/1968	Production	20.873	628	21.501	29.401	30.474	19.850	79.725
	Superficie	2.981	104	3.085	4.588	2.308	2.328	9.218
	Habitants	105.351	19.898	125.249	275.707	253.146	1.324.846	2.651.161
	Rendement	70	60	69,7	64	132	85	86,5
kg/an/hab.	1948/1952	244	18	204	124	96	11,4	25
	1952/1956	246	24	208	129	96	13,2 (12,0)	26,6
	1964/1968	198	32	172	107	120	16,2 (14,7)	30
Variation 10 ans		- 19,5 %	+ 33 %	- 17,3 %	- 17 %	+ 25 %	+ 22,7 %	+ 12,8 %

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Tableau III

PRODUCTION DE PLANTES A TUBERCULES
EN AFRIQUE DE L'OUEST (x 1.000 t)

Source :	Service Economique IRAT 1970			Annuaire Prod. FAO 1969
Pays	Patates	Ignames	Taros	Ignames + patates
Dahomey	60	632	?	500
Togo	8	1.050	122	1.160
Côte d'Ivoire	52	1.870	132	1.400
Cameroun	120	160	170	300

PRODUCTION DE PLANTES A TUBERCULES ET DE
RACINES EN NIGERIA

Source / Produit	Monogr. n° 39, FAO, 1965, inter-relations écon. entre les céréales et le riz		Annuaire de la production FAO			
			Vol. 19 1965		Vol. 23 1969	
	x 1000 t	kg/hab.	x 1000 t	kg/hab.	x 1000 t	kg/hab.
Manioc	3.520	94	12.800	225	6.700	105
Igname	6.400	172	-	-	-	-
Taro	510	14	-	-	-	-
Igname + Patate	-	-	15.400	271	12.500	196

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Tableau IV : Objectifs de production pour les racines et tubercules (plantain non compris) en 1975 et 1985

	1961-1963 : Chiffres réels			Chiffres proposés pour 1975			Chiffres proposés pour 1985		
	Superficie (milliers d'ha)	Rendement (t/ha)	Production (milliers de tonnes)	Superficie (milliers d'ha)	Rendement (t/ha)	Production (milliers de tonnes)	Superficie (milliers d'ha)	Rendement (t/ha)	Production (milliers de tonnes)
UDEAC	630	6,0	3 811	714	6,0	4 300	791	6,1	4 844
Congo-Kinshasa	712	10,5	8 811	1 030	10,6	12 424	1 344	10,6	16 055
Afrique centrale	1 342	9,4	12 622	1 744	9,6	16 730	2 135	9,8	20 849
Afrique de l'est	2 368	4,2	9 983	3 047	4,4	13 476	3 550	4,8	17 013
Zone de savane	107	4,8	512	133	5,2	685	154	5,8	887
Zone sud	1 650	4,7	7 718	2 225	4,7	10 522	2 582	4,9	13 997
Nigeria	3 101	6,8	21 049	3 895	7,4	29 145	4 250	9,0	38 350
Afrique de l'ouest	4 858	6,0	29 279	6 253	6,5	40 352	7 286	7,3	53 244
Afrique : total	8 568	6,1	51 884	11 014	6,4	70 558	12 971	7,0	91 105

Taux de croissance (pourcentage annuel)

	1962-1975			1975-1985			1962-1985		
	Superficie	Rendement	Production	Superficie	Rendement	Production	Superficie	Rendement	Production
UDEAC	1,0	--	1,0	1,0	0,2	1,2	1,0	0,1	1,1
Congo-Kinshasa	2,9	0,1	2,7	2,7	--	2,6	2,8	0,1	2,6
Afrique centrale	2,0	0,2	2,2	2,0	0,2	2,2	2,0	0,2	2,2
Afrique de l'est	2,0	0,4	2,3	1,5	0,9	2,4	1,8	0,6	2,3
Zone de savane	1,7	0,6	2,3	1,5	1,1	2,6	1,6	0,8	2,4
Zone sud	2,3	--	2,4	2,6	0,4	2,9	2,5	0,2	2,6
Nigeria	1,8	0,7	2,5	0,7	2,0	2,8	1,4	1,2	2,6
Afrique de l'ouest	2,0	0,6	2,5	1,5	1,2	2,8	1,8	0,9	2,6
Afrique : total	2,0	0,4	2,4	1,6	0,9	2,6	1,8	0,6	2,5

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EVOLUTION DES IMPORTATIONS DE BLE, DE FARINE ET DE SEMOULES DE BLE DANS QUELQUES PAYS COTIERS DE L'AFRIQUE OCCIDENTALE

(x 100 t)

Tableau V

Pays	Produits	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Sénégal	Farines	28	13	4	2	4	2	2	7	25	10
	Blé	909	632	741	572	665	632	612	760	622	624
Cameroun	Farines	167	140	171	162	155	153	222	224	248	112
	Blé	-	-	-	-	-	-	-	1	72	374
Côte d'Ivoire	Farines	55	48	54	41	128	130	3	3	2	3
	Blé	-	-	-	-	22	710	636	1126	617	640
Nigeria	Farines	511	616	621	590	31	21	17	37	15	4
	Blé	-	-	-	264	485	360	541	1728	1218	1059
Togo	Farines	25	15	15	36	46	46	52	73	52	59

Source : Annuaire du Commerce, FAO, Rome, 1969.

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Tableau VI

PROBLEMES DE COMMERCIALISATION RENCONTRES POUR UTILISER A PLEIN LA CAPACITE DE CERTAINES ENTREPRISES DE TRANSFORMATION DES PRODUITS AGRICOLES IMPLANTES CES DERNIERES ANNEES DANS DIFFERENTS PAYS AFRICAINS EN VOIE DE DEVELOPPEMENT.

Entreprise	Nature du problème rencontré		
	Offre (1)	Demande (2)	Méthodes de commercialisation (3)
1. Abattoirs et usines à viande			
1.			X
2.	X		
3.			X
4.			X
5.	X		
6.			X
7.	X	X	
8.	X		X
9.			X
10.			X
11.			X
12.			X
2. Laiteries			
13.			X
14.		X	X
15.	X		
3. Usines de transformation des fruits et légumes			
16. Fruits et légumes	X	X	
17. " "	X	X	
18. " "	X	X	
19. Concentrés de tomate	X		
20. Agrumes	X	X	
21. Ananas	X		
22. "	X		
23. "	X		
24. Séchage des oignons	X		
25. " "	X		
4. Autres usines			
26. Arachides	X		X
27. "			X
28. Sucre	X		
29. Huile de palme	X		X
30. Cacao		X	

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Entreprise	Offre	Demande	Commercialisation
31. Anacardes	X		
32. Riz	X		
33. "	X		
34. "	X		
35. "	X		
36. "	X		
37. "	X		
38. Aliments composés pour animaux	X	X	

Sources :

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1. Problèmes de l'offre. Surestimation de l'offre et des stimulants offerts aux producteurs, sous-estimation de la concurrence exercée par les entreprises et réseaux de commercialisation existants, absence de services de soutien au bénéfice des agriculteurs (vulgarisation de crédit par exemple), etc.

2. Demande commerciale. Surestimation de la demande commerciale probable, erreurs de jugement sur les goûts, les préférences et les habitudes des consommateurs indigènes, sous-estimation de la capacité concurrentielle des produits offerts d'autres sources et des produits de remplacement, sous-estimation des obstacles à la pénétration des marchés.

3. Méthodes de commercialisation. Manque d'installations et de méthodes rationnelles en ce qui concerne le ramassage, le transport, l'emmagasinage, la transformation et la distribution : absence d'initiatives en vue d'éduquer les consommateurs et de promouvoir les ventes ; moyens financiers insuffisants, en particulier fonds de roulement ; personnel pléthorique, interventions inopportunes des autorités. Tous ces inconvénients se sont traduits par des coûts de transformation et de commercialisation excessifs par rapport à ceux d'entreprises concurrentes.

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N.B. : Les opinions exprimées dans cet article sont personnelles à l'Auteur et ne sauraient être considérées comme une indication de la politique ou des intentions de l'I.R.A.T.

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International Institute of Tropical Agriculture
P.M.B. 5320
IBADAN, NIGERIA

FIELD TOUR INFORMATION SHEET
February 17, 1971

1. I.I.T.A. SITE

The I.I.T.A. Site occupies a fenced area of 1000 hectares (2300 acres). About 200 hectares (500 acres) of the land are reserved for buildings reservoir, roads and other non-agricultural uses. Only about one quarter of the remaining area can be used for the cultivation of food crops, because of stoniness, steep slopes and disturbed soil conditions. The majority of the cultivated land is limited to land with less than 7% slope. Experimental land use will be based on the best land capability, while strict soil and water conservation practices will be followed.

The first land clearing was done in 1967 to establish the ornamental nursery and horticulture area. At present 80 hectares (100 acres) of land has been cleared and is available for agricultural use.

With the construction of the Awba River Irrigation Dam and small dams in Block A, most of the agricultural land on the east bank and selected areas on the west bank will be provided with irrigation facilities. These facilities will enable the growing of more than two crops per year and will supplement rainfall during a two crop year.

2. What you will see on the field tour.

Stop 1. The Threshing and Crop Drying Building has a floor area of 25,000 square feet. Equipment for handling crops at all seasons of the year is available to research personnel. Note the bank of eight drying oven in the north wall.

Stop 2. The swimming pool is the heart of the recreational area for senior staff and trainees. The dormitories will have the capacity for housing 95 trainees with dining facilities in the cafeteria and Social Center Building. Senior staff personnel will be housed in 31 and 12 flats.

The hazardous chemical disposal area will receive surplus and discarded dangerous chemicals for deactivation and burial.

A second rice paddy area (Block B) is being constructed and will be ready for planting later this spring.

Stop 3. Rice Paddy area, (Block B) the paddy covers two hectares (5 acres) The paddy has full irrigation and water control and is used primarily for experimentation with rice grown under flooded conditions.

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Stop 4. Awba River Irrigation Dam.
The dam and reservoir will provide potable water and water for irrigation and recreational uses. At normal pool level the reservoir contains 982 million liters (260 million gallons) of water. This can be increased to 1,474 million liters ((390 million gallons) at the supplementary pool level. The embankment has a crest width of 6.1 m (20 ft.), a maximum height of 12.2 m (40 ft.), a length of 359.8 m (1,180 ft.) and an earth volume of 69,230 cu m (90,000 cu yrds). The maximum length of the impounded area is 2.5 km (1.6 miles), with a total water surface of 70 hectares (175 acres).

The pumping plant will supply water for agricultural and domestic use.

A crocodile has been seen by four people but its existence is doubted by many others.

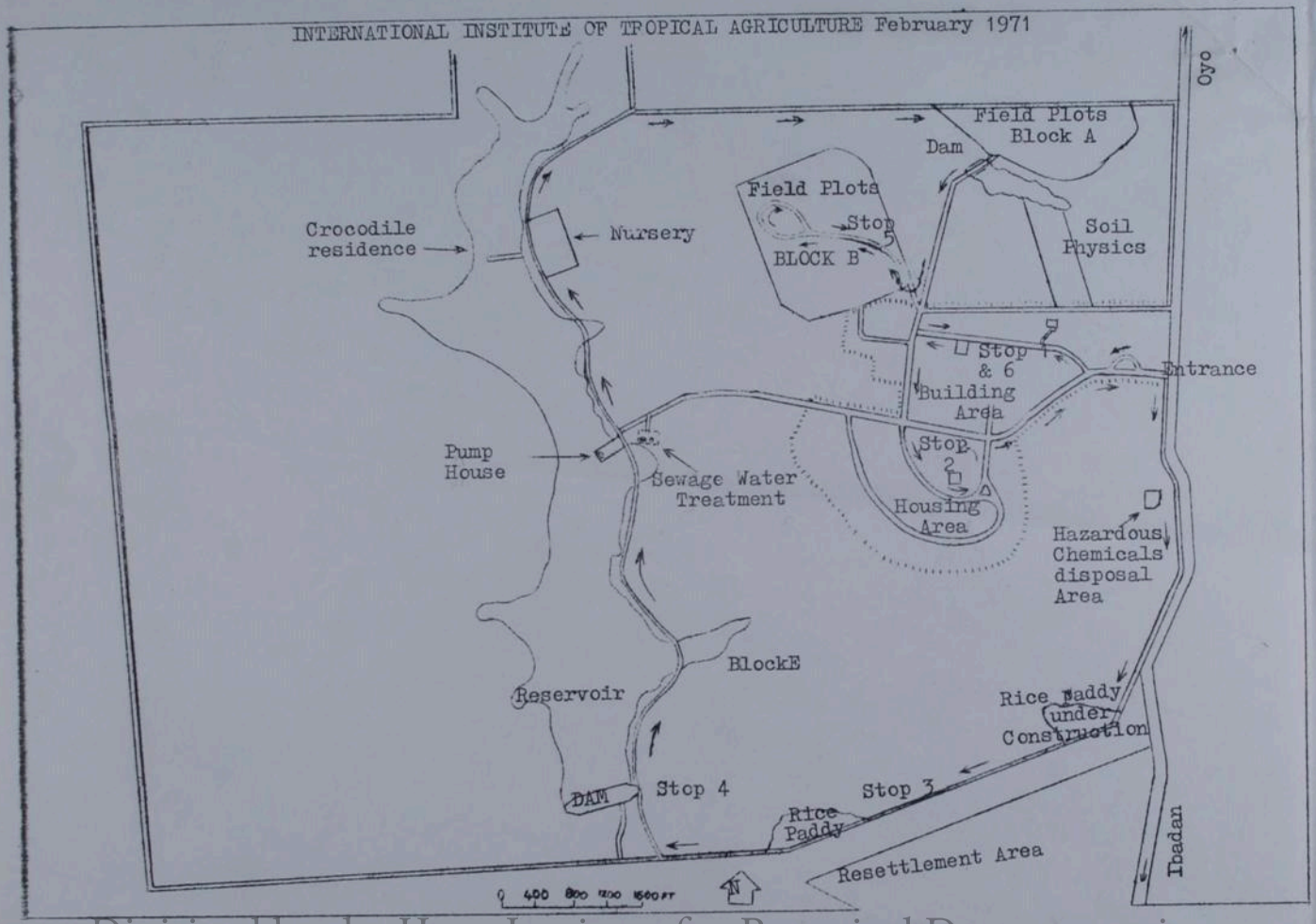
The nursery covers an areas of two hectares (5 acres). Over 100 species of ornamental and fruit plants are grown here. These plants are used primarily for landscaping the I.I.T.A. site.

Block A contains 13 hectares (30 acres) and was cleared of during the 1969-70 dry season. Experiments with upland rice, maize cowpeas, soybeans, other grain legumes, root, and tuber crops have been carried out in this area. The pond provides supplemental irrigation.

Stop 5. Block B was cleared during March and April of 1970. A maize uniformity trial was grown last spring and was followed by specific cowpea plots. Block B covers 25 hectares (63 acres).

Stop 6. Threshing and Crop Drying Building for refreshments.

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I.I.T.A. FACT SHEET

Q. What is the main purpose for establishing I.I.T.A.?

A. The main objectives of I.I.T.A. are to:

1. Increase as quickly as possible the output of food crops in the tropics and to improve their quality.

2. Offer research and training opportunities in tropical agriculture in basic and up-to-date methods for students, technicians, and visiting scientists.

3. Distribute, on a world-wide basis, improved plant breeding materials to other research centers and governments for local improvement programs.

4. Serve agricultural researchers in the tropics around the world through comprehensive library and documentation facilities.

5. Stimulate the interchange of ideas and knowledge through publication of research findings and recommendations of the Institute and through organized conferences, forums, seminars and symposia.

Q. Who is running I.I.T.A.?

A. The I.I.T.A. is an autonomous, non-profit corporation under the terms of Decree No. 32 of the Federal Republic of Nigeria, issued 24 July 1967. Formal organization of the Institute was achieved at the first meeting of the Board of Trustees in July 1968 in Ibadan. The I.I.T.A. is a truly international agency with international objectives and an internationally-drawn Board of Trustees and staff.

Q. What countries will I.I.T.A. serve??

A. The I.I.A. will serve through research, training, plant breeding materials, library facilities, and interchange of ideas and knowledge, all people and countries of the world, especially nations of the tropics.

Q. When was construction started and when will it be completed?

A. Construction began in October 1968 and is scheduled for completion in Mid 1972.

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Q. Who provided the funds for development of I.I.T.A.?

A. Capital assets of the I.I.T.A. have been provided as land by the Federal Republic of Nigeria, and as buildings and site development by the Ford Foundation. Base support of the research operations will be supplied by the Ford and Rockefeller Foundations, the Canadian International Development Agency, and the U.S. Agency for International Development. The British Ministry for Overseas Development is interested in supporting specific projects.

Q. Will I.I.T.A. be a permanent institution?

A. It is the intention of the Board of Truste s that I.I.T.A. will have a long and successful history of service to the nations of the tropics. By the terms of the government Decree No. 32, I.I.T.A. is permanently established as an agricultural research institute even if outside support ceases to be a major factor.

Q. What will be the total cost of the installation?

A. The total cost of buildings, external works and furnishings and equipment is expected to be in the neighborhood of N£6.25 million ((U.S. $17.5 million).

Q. How many professional men will be on the staff?

A. As authorized by the Board of Trustees, there will be thirty-two professional level positions, with a considerably larger supporting staff. The I.I.T.A. will eventually have the capability to accommodate up to ninety-five (95) trainees at any one time.

Q. When will the professional staff begin work?

A. Eighteen specialists are already at work on the I.I.T.A. program with four more expected to arrive by the end of summer. The remaining scientists will be recruited as facilities are developed to utilize their training and skills.

Q. What will be the total number of I.I.T.A. employees?

A. The number of professional, administrative, technical, junior, and supporting personnel will be about 250 employees.

Q. How much land is there and how was it acquired?

A. The Federal Government of Nigeria assumed responsibility for providing a 2300-acre tract for I.I.T.A. and compensating residents for their crops, buildings, and land.

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Q. Who determines policy for I.I.T.A.?

A. The I.I.T.A. is a self-governing body through its Board of Trustees which provides policy and direction for the Institute.

Q. Who are the members of the Board of Trustees?

A. The Board of Trustees of the I.I.T.A. is comprised of persons who are among the world leaders in education and research in the tropics. The chairman of the board is Dr. F. F. Hill, Senior Consultant, T The Ford Foundation, New York.

Representing Nigeria are: Dr. Bukar Shaib, Permanent Secretary of the Federal Ministry of Agriculture and Natural Resources; Dr. H. A. Oluwasanmi, Vice Chancellor of the University of Ife; and Dr. L. K. Opeke, Director, Cocoa Research Institute of Nigeria.

Other members are: Dr. A. Hugh Bunting, Dean, Department of Agricultural Botany, Reading University, England; Mr. Jean Nya Ngatchou, Director of Human Resources and Scientific Research, Ministry of Planning and Development, Yaounde, The Cameroun; Dr. S. S. Peters, Canadian International Development Agency; Dr. D. Umali, Vice President of the University of the Philippines at Los Banos and Undersecretary for Agriculture in The Philippine Government; Dr. Sterling Wortman, Rockefeller Foundation; Dr. Guy Camus, Director General, Office de la Recherche Scientifique et Technique Outre-Mer, Paris, France; Mr. Y. K. Lule, Principal, Makerere University College, Kampala, Uganda; Dr. Robert K. A. Gardiner, Executive Secretary, United Nations Economic Commission for Africa, Addis Ababa, Ethiopia; and Dr. Herbert R. Albrecht, Director of the I.I.T.A., who serves as an ex-officio member.

Q. How will research findings be disseminated?

A. Research findings and recommendations of the I.I.T.A. will be disseminated by way of the Institute's own publications, international journals of science, conferences, forums, symposia, and words and deeds of its trainees.

Q. What is the relationship of the I.I.T.A. with other international agricultural research institutes?

A. The I.I.T.A. is one of four international agricultural research institutes receiving core support from the Ford and Rockefeller Foundations. The others are: The International Rice Research Institute, Los Banos, The Philippines; The Center for the Improvement of Maize and Wheat, Chapingo, Mexico; and The International Center for Tropical Agriculture, Cali, Colombia. Each of the institutes has its own board of trustees and functions as an autonomous corporation of the country in which it is situated.

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Q. What are the principal research programs which the I.I.T.A. will emphasize?

A. The research effort will be limited mainly to food crops of the tropics such as the cereals, grain legumes, root crops, vegetables, forage, and soil-conserving species. The main immediate projects will be maize, rice, grain legumes, and cropping systems.

Q. Will the I.I.T.A. serve any functions other than research?

A. Although the I.I.T.A. has research on food crops production as its main objective, training at the professional and technical level, dissemination of information, and bringing together leading agriculturists in conferences will receive strong support.

Q. Why is a dam and reservoir being constructed?

A. The I.I.T.A. site offers a distinct advantage for crop breeding work in that the climate normally offers two crop seasons per year. With supplementary irrigation from the Institute's new 350 million gallon reservoir it will be possible to produce three harvests in a single calendar year, thus speeding up not only the plant breeding work, but but research on insect and disease control, cultural practices, irrigation, and soil science.

Q. How many office and laboratory buildings will be on the site?

A. There will be twelve major structures on the site, -- three research laboratories, the research services building, the threshing and crop drying building, the plant growth and headhouse building, the engineering services building, the utilities building, the administration building, the auditorium and conference center, the cafeteria social center, and a chemical storage building. In addition there will be housing, apartments, and dormitories for staff, visiting scientists, and trainees.

Q. Why was Nigeria chosen as the site?

A. The reasons were multiple --

1. The Ibadan area offered a reasonably cosmopolitan environment.

2. The site could be adjacent to a university.

3. A well established international school would meet the education requirements of the families of the international team of scientists to be recruited.

4. Ibadan was already a well-established agricultural research center.

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5. The Federal Government early agreed in principle to support the I.I.T.A. by providing land meeting the requirements in area and other specifics.

6. The survey team for determining the site for the proposed I.I.T.A. visited a number of places in West Africa and recommended Ibadan over all other places, even other places in Nigeria, because the soils were considered representative of many areas of lowland tropics and water in large volumes could be impounded for irrigation purposes. Fortunately, the Federal Government accepted their recommendations.

* * *

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INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

P. M. B. 5320
IBADAN, NIGERIA

Existing Professional Staff

(February 17, 1971)

1.	Abifarin, A. O.	-	Rice Breeder (on study leave at IRRI)
2.	Albrecht, H. R.	-	Director
3.	Briggs, R. A.	-	Associate Director
4.	Caveness, F. E.	-	Nematologist
5.	Curfs, H. P. F.	-	Associate Expert (FAO) Engineering
6.	Harrison, M. N.	-	Maize Breeder
7.	Hedley, D. D.	-	Agricultural Economist
8.	Juo, A. S. R.	-	Soil Chemist
9.	Kang, B. T.	-	Soil Scientist (Fertility)
10.	Lal, R.	-	Soil Physicist
11.	Lamey, H. A.	-	Plant Pathologist
12.	Lawani, S. A.	-	Librarian
13.	Mehta, P. N.	-	Associate Specialist (Grain Legume breeding)
14.	Moody, K.	-	Agronomist (Weed Science)
15.	Moomaw, J. C.	-	Agronomist
16.	Moormann, R. F.	-	Soil Scientist
17.	Sadik, S.	-	Plant Physiologist
18.	Whitney, W. K.	-	Entomologist
19.	Williams, R. J.	-	Plant Pathologist
20.	Zuckerman, P. S.	-	Associate specialist (Agric. Economics)

/RFA

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THE INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

LIBRARY & INFORMATION CENTER

On behalf of the entire staff of the International Institute of Tropical Agriculture, I am most grateful for the opportunity to meet with you today and discuss the development of the Library and Information Center at I.I.T.A.

To describe our existing position would be most unfortunate as our task has just begun in the building of a Library and Information Center. Rather I must take the inherent risk of crystalball gazing and become a prophet and look toward the future. Even planning at this time is in its initial stages so I must discuss with you today in terms of hopes and dreams. It is to the building of a capability of service to agricultural research that I must address my remarks.

The International Institute of Tropical Agriculture has been developed for the express purpose of closing the gap between the tropical worlds food-raising potential and its actual productivity. Its thrust will be toward the improvement of food crops, both quality and quantity, for the lowland humid tropics of the world. It is aiming, in a development sense, at the acceleration of the effort toward improvement along a broad front of research, training and communications.

I must start from an assumption that there exists much basic technology for accelerated improvement of food crops in the world today. The concepts, the theories, the methodology, and techniques of agriculture research abound in the vast pool of the worlds research workers. Unfortunately, the usefulness of this pool of basic technology has been limited by improper preparation of scientists, by the depth of research, by over-extended research programs and simply by the lack of fruitful exchange of research.

The International Institute of Tropical Agriculture is attempting to marshal its resources so that it may assist in increasing the usefulness of the world's existing technology. But our resources will be limited and we at best can only strive to have a catalytic effect on the improvement of food crops in the tropics.

Our team of scientists will address themselves to a multi-discipline approach in the analysis of problems and will attempt either themselves or cooperatively with other scientists to solve or to seek the solutions to those problems which prove to be the most limiting in the improvement of food crops.

By all standards of comparisons, the scientific staff is small but it is our hope that none of them will function as an isolated researcher but rather part of a cooperative team of scientist which can expand their work greatly as well as expanding the work of their colleagues, the national research scientists working anywhere in the world.

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One of the keys to achieving this altruistic goal lies, we believe, in the library and information center development, and in the resulting interchange of ideas and knowledge directly between research scientists working on similar problems throughout the world.

To do this, IITA has formulated the following objectives for its Library and Information Center.

1. The Library will acquire, catalog, and maintain library collections embracing as much as possible of the pertinent literature of tropical agriculture representative of the priorities of the research effort of IITA.

2. The Library will assume responsibility for such documentation services as the development, publication and dissemination of indexes and bibliographies of pertinent subjects for institute staff members and other tropical research workers.

3. The Library will provide services in both English and French, and will attempt, on demand, to obtain translations of relevant papers written in other languages.

4. The Library will enter into agreement for inter-library cooperation.

IITA has a concern for and will make a special effort to secure relevant research reports that are not formally published but which appear in station annual reports, conference reports as mimeographed hand-outs at meetings, and elsewhere. The collection as envisioned at this time will comprise materials in all possible forms including microfilm and other reproductions of rare and generally inaccessible publications. This special collecting effort, in itself, will be useless without the development of copying facilities and provisions for dissemination to interested and identified scientists.

IITA is also concerned over what might be called the "time-lag" between research and the final formal publication of that research. Every attempt will be made by IITA to find ways and means to quickly release this "new generation" technology so that it becomes available to a broad spectrum of research workers.

IITA plans to develop a "Research Newsletter" which will not only report the research effort of IITA, but hopefully will function in the role of releasing interim reports and progress reports from other research workers in an effort to reduce the

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existing "time-lag" from research to publication. To achieve this end, it will take a massive cooperative effort among all research workers but it is our belief that we can no longer afford the luxury of the delay as the problems of human nutrition are already with us, and will increase as the populations of the world continue to increase.

The International Institute of Tropical Agriculture has, in addition to the objective of establishing and operating an information center and library collection, the general objectives:

1. To develop and provide professional research training for men and women interested in tropical agriculture.

2. To distribute improved plant material to national research centers where they can be used in breeding or improvement programs.

3. To publish research finding and recommendations of the Institute.

4. To organize conferences and seminars to discuss current problems and progress in the fields of tropical agriculture.

It is IITA's intention to develop the capabilities to reach these objectives. It cannot be done by ourselves and we must look to your cooperation and assistance if we are to reach our goals.

The International Institute of Tropical Agriculture Library and Information Center is a dream now. Construction has just begun on the library building but when it is completed in mid 1971, it is our intention that we will have the start of the basic collection, the microfilm readers and printers, the copying facilities, and the off-set printing presses. Above all, we shall have the human resources necessary to make the library and information center a vital functional part of the International Institute of Tropical Agriculture.

RODNEY A. BRIGGS
ASSOCIATE DIRECTOR
INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE
IBADAN.

29 JANUARY, 1970

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Agricultural Research Seminars

Seminar VI
Root and Tuber Crops

22 - 26 February, 1971.

Conference Centre
University of Ibadan

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The Vice-Chancellor

on
behalf of the

Entire Community of this University

W E L C O M E S

All Delegates At The

Seminar on

Root and Tuber Crops Research

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SPONSORS:

The Ford Foundation, Lagos
Institute de Recherches Agronomiques Tropicales
et des Cultures Vivrieres, Paris (IRAT)
The International Institute of Tropical Agriculture, Ibadan
(IITA)

INSTITUTIONAL HOST

The University of Ibadan,
Professor T. A. Lambo, Vice-Chancellor
Dr. S. H. O. Tomori, Acting Head, Department of Adult
Education and Director, Conference Centre.
Mr. S. M. Winsala, Conference Officer, Conference Centre.

PURPOSE

An Examination of Agricultural Research Strategies for the increase and improvement of food crop production in West Africa; attention will be focused on Root and Tuber Crops.

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1. Venue for Seminar	The Seminar will be held in the Conference Centre, Chapel Road (opposite Chapel of the Resurrection), University of Ibadan. There are simultaneous interpretation facilities.
2. Registration & Checking in at the Guest House	This takes place from 17.00 - 17.30 hours on Sunday 21 February, 1971, both at the Reception, University Guest Houses and in the delegates' room of the Conference Centre. Participants will be directed by the porter on duty in the reception area of the Conference Centre and are therefore requested to report to the porter having checked in, in the Guest House Reception.
3. Conference Secretariat	There is a Conference Secretariat within the building of the Conference Centre. This is under the overall supervision of Mr. S.M. Winsala, Conference Officer, University of Ibadan, and a team of officials specifically earmarked for servicing the seminar. Participants may call there on matters relating to Health, Secretarial help etc.
4. Residential Accommodation.	Participants will be accommodated in the University Guest Houses. The reception is in the temporary wooden block directly opposite you as you drive into the premises of the Conference Centre. Delegates should go there and check in on arrival. GUEST HOUSE: DO NOT FORGET TO SWITCH ON FOR HOT WATER BEFORE GOING TO BED. Delegates are advised to ask the bedroom steward for drinking water, rather thatn use the water in the taps.

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5. Meal Times

i. Meals will be served at the following times in the University Guest Houses:

Breakfast	:	07.30 - 09.30 hours
Lunch	:	13.00 - 15.00 hours
Dinner	:	19.30 - 21.30 hours

ii. Coffee/Tea : Coffee/Tea will be served in the Lounge of the Conference Centre as follows:

	Morning	Afternoon
Monday	10.30 - 10.45	15.30 - 15.45
Tuesday	10.30 - 10.45	15.30 - 15.45
Wednesday	10.15 - 10.30	15.30 - 15.45
Thursday	10.15 - 10.30	-
Friday	10.30 - 11.00	-

6. Cocktails

There will be a cocktail party on Monday 22 February, 1971 in the courtyard of the Conference Centre from 19.00 - 20.30 hours.

7. Happy Hour

Venue for Happy Hour: Senior Staff Club, University of Ibadan.

Time:	Sunday	- 18.00 - 19.00
	Monday	- 18.00 - 19.00
	Tuesday	- 19.15 - 19.45
	Wednesday	- 18.00 - 19.00

8. University of Ibadan Senior Staff Club

By kind permission of the Manageress of the Senior Staff Club, the bar and other amenities of the Club will be open to participants at the Seminar. The Club's swimming pool may be used without charge.

9. Laundry

Laundry facilities will be provided. Details may be obtained from the Manager, University Guest Houses.

10. Postal Facilities

Letters for posting should be left with the Conference Officer who will keep a small stock of postage stamps and air letter cards. Incoming mail will be distributed by the Conference Officer as received.

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11.	Foreign Exchange	Arrangements are already made to enhance Convenience with regard to foreign currency by advancing every delegate a reasonable sum of money. Any problem in spite of this should be referred to the Conference Officer.
12.	Return Travel	The Ford Foundation Travel Agency will handle return flight arrangements.
13.	Conference Office	The Conference administration and all secretarial activities are located on the ground floor of the 2-Storey Block of the Conference Centre complex.
14.	Venue for sessions	All plenary sessions of the seminar will take place in the Conference Hall.
15.	Medical attention	By kind permission of Dr. A.M. Boyd, Director University Health Service, delegates who get ill during the seminar will be treated at the dispensary in Jaja Avenue, University of Ibadan. Such delegates should carry their conference Name Badge for identification.
16.	Theatre	Notice will be given of any play coming up in the University Arts Theatre during the Seminar.
17.	Places of Interest	the following places may be of interest to conference members:

At the University of Ibadan

(i) Ben Enwonwu's Carvings in the Chapel of Resurrection (Protestant Chapel);

(ii) Pakeye's Carvings in the Catholic Chapel;

(iii) Paintings by Demas Nwoko in Tedder Hall;

(iv) The Botanical Gardens;

(v) The Zoo; and

(vi) The University Computing Centre.

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At the University of Ife (Ibadan Branch)
(2 miles from the Conference Centre)

(i) The Biological Gardens; and

(ii) The Institute of Administration.

At Ibadan Town

(i) Mapo Town Hall, from where a panoramic view of Ibadan can be seen.

(ii) Agodi Gardens

At Ile-Ife (57 miles from the University of Ibadan)

(i) University of Ife.

(ii) Museum of Antiquities

(iii) Ife Shrine

At Oyo (30 miles north of the University of Ibadan)
Wood and Calabash Carvings, leather works and so on.

At Lagos (92 miles from the University of Ibadan)

(i) University of Lagos and Lagos University Teaching Hospital.

(ii) National Museum;

(iii) Oba Oyekan's Palace;

(iv) Ikeja Industrial Estate.

18. Bookshop — The University Bookshop is open between 8.30 a.m and 4.00 p.m. on week days and between 8.30 a.m. and 12.00 noon on Saturdays. Books not immediately available may be ordered for postal delivery.

19. Library — Participants can use both the University and the NISER Libraries. They are open daily from:

8.00 a.m. - 6.00 p.m. Monday to Friday

8.00 a.m. - 12.00 noon Saturday.

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20.	University College Hospital	The University College Hospital is situated about 5 miles from the University Campus and can be visited at any time by arrangement with the Conference Officer.
21.	General	Mr. S. M. Winsala, the Conference Officer University of Ibadan, will be in charge of the general social welfare and special needs of the participants, such as health, arrangements for return travel, changing money, accommodation queries, transportation, typing of papers for participants, etc.

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A PRELIMINARY LIST OF DELEGATES

Attending a Seminar
on

RESEARCH ON ROOT AND TUBER CROPS IN WEST AFRICA

---

to be held at

The Conference Centre
The University of Ibadan
22nd-26th February, 1971

CO-SPONSORS

The Ford Foundation

L'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières

The International Institute for Tropical Agriculture

LAGOS
12th February, 1971

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DUMONT, R.
Institut de Recherches Agronomiques Tropicales/Dahomey
Secteur IRAT/Nord Dahomey
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PARAKOU, Dahomey

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.../7

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Soile, T.

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Lagos, Nigeria

Secretary to Mr. Beck

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A PRELIMINARY PROGRAMME

For a seminar

on

ROOT AND TUBER CROPS

---

to be held at

The Conference Centre
The University of Ibadan

22nd - 26th February, 1971

CO-SPONSORS:

The Ford Foundation,

L'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières,

The International Institute of Tropical Agriculture.

Lagos,
14th December, 1970

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MONDAY, FEBRUARY 22

Opening Session	Chairman:	B. BECK
09.00 - 10.00	1.	Welcome address on behalf of the Ford Foundation, B. D. A. Beck
	2.	Welcome address on behalf of l'Institut de Recherches Agronomiques Tropicales, P. Sylvestre
	3.	Welcome address on behalf of the International Institute for Tropical Agriculture, H. R. Albrecht.
10.00- 10.15		Coffee
10.15 - 11.00		The history and the possible future of yam cultivation in West Africa, P. COURSEY
11.00 - 12.30		Discussion
12.30 - 14.15		Luncheon
Afternoon Session	Chairman:	P. SYLVESTRE
14.15 - 15.00		The history and possible future for the cultivation of cassava in West Africa, W. JONES.
15.00 - 1530		Discussion
15.30 - 15.45		Coffee
15.45 - 16.30		Possible future use for root crops in West Africa, C. MICHE
16.30 - 17.30		Discussion
19.00 - 21.00		Cocktail party in the Senior Staff Club.

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TUESDAY, FEBRUARY 23

Morning Session	Chairman : W. O. JONES
09.00 - 0945	The economic problems of the intensive production of cassava - B. BECK.
09.45 - 10.30	The economic problems encountered in the intensive cultivation of cassava by IRAT in Togo - M. DELCASSO and [illegible] SYLVESTRE
10.30 - 10.45	Coffee
10.45 - 11.30	The taxonomy of cassava - M. ROGERS
11.30 - 12. 30	Discussion
12.30 - 14.15	Luncheon
Afternoon Session	Chairman : S. CHANT
14.15 - 15.00	The virus diseases of cassava. - G. GALVEZ.
15.00 - 15.30	Discussion
15.30 - 15.45	Coffee
15.45 - 16.30	The cassava improvement programme in Madagascar. - M. ARRAUDEAU.
16.30 - 17.30	Discussion
18.30	"Happy Hour" at the Conference Centre

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WEDNESDAY, FEBRUARY 24

Morning Session Chairman : M. ARRAUDEAU

09,00 - 09.45	The integration of yams in a modern system of agriculture. - C. DUMONT
09.45 - 10.30	The improvement of yam cultivation techniques in Nigeria - [illegible]. CHINWUBA.
10.30 - 10.45	Coffee
10.45 - 11.30	The botanical classification of yams - M. MIEGE.
11.30 - 12.30	Discussion
12.30 - 14.15	Luncheon

Afternoon Session Chairman : [illegible]. HAYNES

14.15 - 15.00	Nematode diseases of yams - J. SMITH.
15.00 - 15.45	Virus diseases of yams - [illegible]. CRAIG
15.45 - 16.00	Coffee
16.00 - 16.45	Study on the control of the yam beetle - [illegible]. TAYLOR.
19.00 - 19.30	Drinks at the Senior Staff Club followed by Dinner at the ~~West End restaurant~~, Ibadan. Cancelled because of cholera!

Briggs 6:30-8 -

Digitized by the Hunt Institute for Botanical Documentation

THURSDAY, FEBRUARY 25

Morning Session	Chairman : E. OKIGBO
09.00 - 09.45	The genetics of the sweet potato - A. JONES.
09.45 - 10.30	Research on the sweet potato in Trinidad - D. HAYNES.
10.30 - 10.45	Coffee
10.45 - 11.30	The phytophthora disease of potato - J. NIDERHOUSER.
11.30 - 12.30	Discussion
12.30 - 14.15	Luncheon
14.15 - 17.00	Delegates visit I.I.T.A.
14.30	Meeting of the Drafting Committee in the Conference Centre Library.
18.00 - 19.00	"Happy Hour" at the Conference Centre

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FRIDAY, FEBRUARY 26

Morning Session	Chairman : B. BECK
09.00 - 09.45	Presentation of the report of the drafting Committee
09.45 - 10.30	Discussion of the report
10.30 - 11.00	Coffee and group photograph
11.00 - 12.00	Closing remarks
12.00 - 14.15	Luncheon
14.15	Delegates leave for the Airport Hotel, Ikeja.

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(7)

REVIEW OF YAM PRODUCTION IN NIGERIA DURING THE LAST TEN YEARS

by

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A Paper to be presented at

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REVIEW OF YAM PRODUCTION IN NIGERIA DURING THE LAST TEN YEARS

Most of the features associated with peasant agriculture have to a great degree impeded the implementation of agricultural research findings in Nigeria. The farmers still work their yam fields with hoes and matchets just as their fore-fathers did for many centuries. An average Nigerian farmer cultivates 2 to 3 acres annually and it is from this farm that he obtains his sole means of livelihood. A subsistence farmer must necessarily grow his own food and consequently practise intercropping. Since he has not got money to buy commercial fertilizer to restore soil fertility, he must abide by the traditional pattern of farming the soils - a shifting system known as "bush-fallow". These various methods of farming are not conducive to progressive agriculture because results obtained from research are not readily applicable under those conditions. Thus results obtained from Moor Plantation and other research organisations in Nigeria have seldom been utilized by the average farmer.

Most of the important efforts made to improve yam production in Nigeria were concentrated on developing methods of producing hybrids by artificial cross-pollination. So much attention was paid to this aspect of work by A.W. Waitt, formerly Senior Research Officer (Botanist) of the Nigerian Federal Department of Agricultural Research, that he had very little time devoted to agronomic aspect of yam improvement[1]. Waitt conducted a series of experiments over a number of

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years in an attempt to produce yam hybrids. The results obtained from these experiments were not successful because yams seldom flower, and whenever they do, the flowers are too scanty, irregular and transient. The fertility is also very low and only a small percentage of flowers produce capsules in open-crosses.

Another major handicap to yam breeding work is that it is time consuming. It took Waitt at least four years to multiply a quantity of clones sufficient for a yield trial from hybrid capsules. These new hybrids never performed significantly better than, and were generally inferior to, established varieties. Perhaps the picture of yam production in Nigeria would have been much brighter if Waitt had concentrated more on agronomic rather than on breeding aspects of yam research. But one should not lose sight of the fact that he was a botanist by training.

Increases in yield of yams have, however, been achieved in the farm settlements and on government farms where effective agronomic practices developed in various agricultural research centres are being applied. These practices include primarily the following:

1. Optimum Time of Planting
2. Economic uses of Planting Material
3. Optimum Use of Fertilizer
4. Insect and Disease Control
5. Other recommended cultural practices.

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TIME OF PLANTING :

It is still traditional practice in many riverine areas to plant yams about three or four months before the onset of the rains. Waitt[1] at Umudike reported that planting by the Department in November and December was stopped because of the high infection of eelworms (nematodes) and poor germination. Studies carried out at Umudike between 1956 and 1959 have clearly shown that the optimum time of planting is at the onset of the rains (mid-March) and that delayed planting two to three weeks after the first rains, resulted in progressively decreasing yields.

ECONOMIC USES OF PLANTING MATERIAL :

Various studies carried out at Ibadan and Umudike have clearly shown that the best planting material is the seed yam; the next best is the top of tuber, followed by setts cut from the bottom and those cut from the middle, in that order.

Planting material has always been very expensive, and in order to obtain optimum nett yield, a number of experiments with various sett weights and spacing distances, were carried out. These experiments were conducted in different ecological areas, using different varieties of yams. The results invariably showed that a spacing distance of 3ft on 4ft ridges with a sett weight of 16 ounces normally gave the best yield.

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OPTIMUM USE OF FERTILIZER:

Because of the high value placed on yams, they are generally planted in the alluvial deposits, or where there are no alluvial deposits, as a first crop after the bush fallow. The degree of nutrient absorption by yams has not actually been worked out. Records of fertilizer trials on yams are also scattered, somewhat fragmentary and in most cases unreliable. Tentative fertilizer recommendations made by various Ministries of Agriculture of the three former Regions of Nigeria were merely based on the fact that fertilizer has some beneficial effect on yams. Thorough research has to be carried out to determine the actual nutrient requirements of the yams and the optimum application rates at various soil fertility levels.

INSECT AND DISEASE CONTROL:

Before 1960 the losses caused by yam beetles were estimated as much as 50 per cent or more in some years. Four important yam-beetle species belonging to two genera of the family DYNASTIDAE have been recorded by Dr. T.A. Taylor[2]. The severity of yam beetle attack varies considerably from year to year. It was reported that after beetles caused serious damage in the Benue Province about 1908, no more damage occurred till 1919[3]. Other serious incidence of beetle attacks was reported intermittently being very serious in 1925 and 1926 and none at all in 1957. The most effective and practical control of beetle attack has now been discovered by the Federal Department of Agricultural Research who has since

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1964 been recommending various types of insecticides. Yam beetles have for the past decade ceased to be a major threat to farmers who have now been able to translate this aspect of research results into agricultural practice.

The nematodes usually invade the tuber to a few centimetres below the skin. Favourable climatic conditions such as high temperature and humidity favour secondary infection with fungi and perhaps bacteria which cause skin blemishes, shriveling, unattractive appearance and actual decay. The tubers so affected are either rendered useless or unsaleable. It is hard to estimate the amount of damage caused by nematodes but it is known from general observations that the damages are indeed staggering. Unfortunately the farmers have no answer to nematode invasion as no recommendation for control has so far been made.

OTHER FAVOURABLE CULTURAL PRACTICES:

Germination rate is of major importance and inorder to enhance higher germination percentage it is always necessary, particularly in the arid areas, to mulch or cap yams after planting. Waitt[1] reported 50 per cent difference in germination and a 1.5 ton difference in yield in favour of capped over non-capped treatments. He believed that the main object of capping was to protect the sett and young shoot from being scorched by the sun.

Staking plays a major role on yield of yams. A number of experiments conducted at various locations in the former Eastern Region and at Ibadan have clearly shown that yields of yam crops increased by 35 to 66 per cent in favour of staking.

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Staking has always a beneficial effect but more so with only three species of D. alata, D. cavenensis and D. rotundata.

Brown reported that weeds played an important part in lowering the yield of unstaked yams[4]. Where the yams were staked, unstaked, and unstaked but given an extra weeding, the yield for unstaked were 60 per cent below that of staked, but where the extra weeding was given the yields were only slightly lower than the staked yams. Differences in heights of stakes appeared to influence the yields of D. cavenensis and D. rotundata but not of D. alata. With D. alata increase in height of stakes up to 12ft resulted in increase in yield.

For a number of years, Mr. A.W. Waitt, has made detailed studies of agronomic characteristics of white yam (D. rotundata) and yellow yam (D.cayenensis) at Ibadan and Umudike[5]. These studies were made with honest attempt to provide an easy key for proper classification and identification of yam varieties. The validity of the criteria used in this work was unreliable, and as Waitt himself admitted, "open to further examination" because these agronomic characters are subject to environmental changes and are in many cases arbitrary. As a result a number of strains belonging to a single variety are described and classified as separate varieties. Thus many of the Federal Research Officers working on yams at Umudike and who have attempted to use Waitt's "Key" have not found it easy.

In view of the encountered difficulty, Mr. V.A. Azih of the Federal Department of Agricultural Research has since the end of the civil war started to collect yam

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varieties for critical identification. It is believed that proper identification of individual varieties must be accomplished first before further attempts for classification are made. Local names, agronomic characters, ecology, biological drawings and photographs of the varieties are some of the criteria which are being used for identification.

Perhaps with the exception of cassava there is no other crop which is more evenly cultivated in all the ecological areas in Nigeria as yam. According to the report published by the Consortium for the Study of Nigerian Rural Development (CSNRD), the estimated harvested acreage for the whole country in 1968 was 2,451,000 acres of which 919,000 acres were in the former Northern Region and the remaining 1,432,000 from the area formerly known as Southern Nigeria[6]. These figures show the dominant importance of yam in the moist areas and also the widespread distribution of the crop all over the country.

It has been suggested in a report by the Consortium for the Study of Nigerian Rural Development (CSNRD) that yam production in the tree crop zones would decline if the production campaign for cocoa, oil-palm, and rubber are pushed forward as advocated by the Consortium[6]. The author does not seem to agree with this report. It is believed that there will be no radical changes in the pattern of staple food production in Nigeria as long as the traditional system of multiple-crop cultures exists. There are no areas of concentration under the peasant system of farming. Each area and most farms must continue to produce a major part of their food

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requirements. In view of this, it becomes therefore inevitable that instead of decline in production in certain areas, the output of yam crop has to grow at about the same rate as population in all areas. Assuming therefore that the average yield of yam has been 3 tons to the acre, the total production for the country in 1968 was approximately 7 million tons. By this year (1971), with 2,679,400 acres in yield, output is estimated to reach 8.0 million tons.

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6

SEMINAIRE SUR LES PLANTES
A RACINES ET TUBERCULES

Ibadan 22-26 Février 1971

FONDATION FORD
IITA
IRAT

INTEGRATION DE LA CULTURE DE L'IGNAME DANS UN SYSTEME DE CULTURE MODERNISE

C. DUMONT, G. RENAUT, R. VANDEVENNE

IRAT - COTE D'IVOIRE

FEVRIER 1971

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L'expérimentation relatée dans le présent exposé a été effectuée en Côte d'Ivoire, à la Station Agricole de Bouaké, dans la zone de savane à pluviosité annuelle de 1 150 mm, répartie en deux saisons :

- une saison de mars à juillet : les précipitation moyennes sont de 412 mm (mais variant de 250 à 600 mm).
- une saison du 20 août au 10 novembre avec des précipitations moyennes de 417 mm (variant de 180 à 660 mm).

Cette zone est le domaine privilégié de la culture de l'igname, puisqu'elle assure à elle seule la moitié de la production nationale qui est de 1 500 000 tonnes.

Actuellement, cette culture de l'igname est essentiellement traditionnelle et itinérante.

Or, des systèmes de culture modernisée (partiellement motorisée) où interviennent notamment coton et riz pluvial s'installent petit à petit dans cette région.

- D'une part, il est difficile d'écarter l'igname de ces systèmes de culture, car elle constitue la nourriture de base de la population. L'expérience a montré que les paysans continuent à pratiquer sa culture traditionnelle en dehors des systèmes modernisés et qu'en conséquence ils ont tendance à négliger ceux-ci.

- D'autre part, il est difficile de l'intégrer sous sa forme traditionnelle dans un système partiellement motorisé, car sa culture exige des disponibilités en main d'oeuvre très élevées, comme le montre le tableau ci-dessous :

Tableau I

TEMPS DE TRAVAUX EN CULTURE TRADITIONNELLE D'IGNAME

Nature des travaux	Unités travail homme par ha
Confection des buttes	50 à 60
Plantation et préparation des semenceaux	12
Sarclages	80
Récplte	40 à 50
Total	182 à 202 jours

C'est donc ce dilemme que nous avons tenté de résoudre en étudiant dans quelle mesure une mécanisation quasi totale de la culture de l'igname permettrait de l'intégrer dans un système de culture modernisée.

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On examinera donc successivement :

- le comportement de l'igname en assolement et rotation
- la mécanisation de la préparation du sol
- la mécanisation de la plantation
- la diminution des façons manuelles d'entretien
- la mécanisation de la récolte.

Les études de mécanisation n'ont été possibles que grâce à l'appui apporté par le Comité du Machinisme Agricole de Côte d'Ivoire qui a fourni les prototypes de machines, a procédé rapidement aux modifications nécessaires et a collaboré aux observations sur le comportement du matériel.

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ASSOLEMENT ET ROTATION

En culture traditionnelle, le système d'exploitation du sol comprend une succession de cultures pendant deux à quatre ans, selon les disponibilités en terres, puis huit années de jachère en moyenne.

L'Igname est, dans ces conditions, toujours cultivée en première année sur défriche de forêt, de savane ou après jachère naturelle.

Dans un système de culture modernisé, il convient d'obtenir une productivité maximum du sol, grâce à des rendements élevés et des coûts de production aussi faibles que possible.

Pour atteindre cet objectif, la culture continue - avec ou sans jachère régénératrice de courte durée - s'impose, à condition de se fixer un assolement et une rotation au niveau de l'exploitation agricole.

+ Le Choix de l'Assolement dépendra plus de l'intérêt économique de telle ou telle culture à un certain moment que de considérations agronomiques.

Mais, il semble logique d'exclure la monoculture et particulièrement celle de l'igname qui pourrait amener certains déboires dans le cas d'infestation parasitaire grave (exemple de l'anthracnose en 1968 ayant réduit de 2/3 les rendements de l'igname).

+ Le Choix de la Rotation a fait l'objet d'une expérimentation menée à la Station de Bouaké de 1960 à 1970.

Dans ce système d'exploitation partiellement motorisé (labours et pseudo-labours), plusieurs types de rotation ont été testés sur trois catégories de sols d'un bassin versant de la Station de Bouaké et differant par leur position topographique, leur texture et leur teneur en matière organique.

L'igname était présente dans les trois rotations suivantes :

Tableau II
TYPES DE ROTATION

ROTATION	I Quadriennale	II Triennale	III Quadriennale
SOL	Haut de pente limon sableux à argilo-sableux 18 à 20 % d'argile 3 % mat.organ.	Milieu de pente limon sableux 14 à 15 % d'argile 2,5% mat.organ.	Bas de pente sablo-limoneux 10 % argile 2 % mat.organ.
Année 1	Igname	Igname	Igname
Année 2	Maïs - coton ou arachide-coton	Maïs - coton ou arachide-coton	Maïs - coton ou arachide-coton
Année 3	Riz pluvial	Jachère artific.	jachère artific.
Année 4	Jachère artific		jachère artific.

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On voit que, dans tous les cas, l'igname occupe la tête de la rotation après défriche de jachère artificielle (à base de Desmodium asperum ou Stylosanthes gracilis).

Les rendements obtenus sont collationnés dans le tableau III. La moyenne de ces rendements pour la période 1960-70 est satisfaisante (13,4 T/ha), compte tenu de la faible fumure minérale appliquée par ha (N = 38 à 40 - P205 = 22 à 24 - K20 = 27 à 30).

On peut donc affirmer que l'igname peut s'intégrer dans un système de culture en rotation comportant une sole régénératrice de courte durée.

On ne connait pas encore le comportement de l'igname dans un système de culture continu sans jachère. L'expérimentation en ce sens n'a en effet débuté qu'en 1967 et est par conséquent trop récente pour apporter des résultats valables.

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Tableau III

Rendements de l'igname en rotation (t/ha)

Parcelles \ Années		1960	1961	1962	1963	1964	1965 (x)	1966	1967	1968 (xx)	1969	1970	Moyenne
BA 1	HAUT de PENTE		16,5						15,0				15,75
BA 2		11				14,1		12,4				15,3	13,20
BA 4				24,0			7,4			9,5			13,60
BA 5	MILIEU				15,9								15,90
BA 6		8,8				13,3							11,00
BA 9	BAS DE PENTE				14,1			9,3					11,70
BA 10				18,8					9,7				14,20
BA 11			13,0								18,3		15,60
BA 12				17,8			7,2			3,9			9,60
MOYENNE													13,40

(x) 1965 : Plantation très tardive en fin Juin.

(xx) 1968 : Sevère attaque d'anthracnose.

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PREPARATION DU SOL

Comme on l'a vu plus haut, la préparation des buttes en culture traditionnelle exige une main d'oeuvre importante (50 j/ha).

On a donc essayé de mécaniser cette opération en remplaçant les buttes par des billons.

La préparation du sol comprend alors trois phases :

Le Labour

Lorsque la culture de l'igname - comme dans les rotations décrites précédemment - succède à une jachère naturelle ou artificielle, il est possible d'effectuer ce labour en automne, en profitant des dernières pluies de la saison (fin octobre - début novembre).

Les premières précipitations de la saison suivante pénètrent alors mieux dans le sol et on peut immédiatement procéder aux opérations ultérieures (épandage d'engrais - pulvérisage - billonnage).

Le labour de 25 cm de profondeur est facilement effectué à la charrue tridisques ou bisoc réversible, attelée à un tracteur de 60 CV SAE.

L'Epandage des engrais et Pulvérisage

L'épandage de la fumure minérale est effectué sur terrain labouré peu avant le billonnage et est suivi d'un passage de pulvériseur pour :

- enfouir l'engrais
- faciliter le travail ultérieur de la billonneuse.

Le billonnage

Les premiers essais de billonnage mécanique ont été entrepris en 1969 avec deux disques de 70 cm de diamètre montés sur une barre porte-outils, réunie par un attelage trois points à un tracteur de 60 CV.

Cet assemblage a permis de réaliser des billons de 50 cm de hauteur, espacés de 1,25 m. (Ce travail est éventuellement complété par le cloisonnement manuel des billons afin de lutter contre l'érosion possible).

Le temps de travail par hectare (sur des parcelles de 150 m de longueur) est de l'ordre de 4 heures, représentant une somme de 4 000 CFA.

Cependant, certains défauts ont été constatés dans la réalisation du travail :

- hauteur irrégulière des billons
- billons non rectilignes et non parallèles.

La cause principale de ces défauts est la variabilité de la texture et de la structure du sol : en particulier, la billonneuse a tendance à déraper et à se soulever aux emplacements d'anciennes termitières.

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On espère qu'en 1971, on pourra pallier à ce défaut par :

- l'adaptation de coutres circulaires à l'avant de la billonneuse.
- l'essai d'une autre billonneuse, associant disques et corps butteur.

x

x x

La comparaison de cette technique de préparation du sol à la confection des buttes traditionnelles avec un outil manuel, semble montrer l'effet bénéfique de la profondeur de travail du sol sur les rendements de l'igname, comme l'indiquent les résultats reportés au tableau IV

Tableau IV

RENDEMENTS DE L'IGNAME DANS TROIS SYSTEMES CULTURAUX (T/ha).

Fumure minérale / Système de culture	Fo nulle		F 1 N = 40kg/ha P205= 30kg/ha K20 = 60 kg/ha		F 2 N = 80 kg/ha P205=60 kg/ha K20 =120 kg/ha	
Buttes à la main	1969	8,7	1969	10,2	1969	9,6
	1970	11,6	1970	19,0	1970	21,9
Labour et billons en culture attelée	1969	4,5	1969	10,2	1969	11,8
	1970	12,7	1970	18,8	1970	18,9
Labour et billonnage motorisé	1969	7,0	1969	13,3	1969	16,2
	1970	15,0	1970	22,8	1970	24,6

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PLANTATION

Abordé en 1969, ce problème a revêtu deux aspects :

- l'obtention de semenceaux adéquats pour la plantation mécanique,
- la mise au point d'une planteuse d'ignames.

Les Semenceaux

En culture traditionnelle, les paysans utilisent comme semenceaux :

- Pour les variétés tardives des fractions de gros tubercules mères.

  Cette technique présente deux inconvénients :
  . elle provoque un étalement de la levée par suite des vitesses de germination variables selon que le semenceau provient de la tête ou de la queue du tubercule.
  . elle nécessite un travail manuel de préparation des semenceaux qui doit être obligatoirement effectué peu de temps avant la plantation.

- Pour les variétés précoces à deux récoltes, des petits tubercules provenant de la deuxième récolte sont utilisés entiers. Mais, ces tubercules ont toujours des formes irrégulières et il est difficile d'envisager leur plantation mécanique.

  D'autre part, dans un système de culture mécanisée, il est impensable de continuer à effectuer deux récoltes sur ces variétés précoces.

C'est pourquoi nous avons essayé de dissocier production d'igname de consommation et production de semenceaux.

Pour cette dernière, nous avons tenté d'obtenir par pied, un grand nombre de petits tubercules susceptibles d'être utilisés directement dans une planteuse mécanique.

Deux méthodes ont été utilisées :

- suppression de l'oeilletonnage des tubercules, pratiqué traditionnellement,
- augmentation de la densité de plantation (de 12000 à 40 000 pieds/ha).

Ces techniques ont échoué totalement : alors que sur les principales variétés cultivées à densité normale (10 000 pieds/ha), le nombre de tubercules par pied varie de 1,5 à 1,7, on n'obtient avec les fortes densités de peuplement qu'une moyenne de 2,3 et dans le meilleur des cas 2,5 tubercules par pied, ce qui est loin d'être suffisant.

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L'expérimentation de la planteuse a donc dû être menée avec des fractions de tubercule mère.

La Planteuse

L'outil de base a été une planteuse de pommes de terre mono rang, normalement employée pour la plantation de tubercules germés, donc conçue pour un travail assez délicat.

Sur notre demande, le constructeur a apporté un certain nombre de modifications afin d'obtenir finalement les caractéristiques suivantes :

- outil porté trois points
- hauteur de plantation : 0,5 m et soc de plantation réglable.
- voie des roues variables entre 1,0 et 1,2 m
- distances de plantation sur le billon variables de 0,6 m à 1,0 m, par écarts de 0,1 m.
- recouvrement du semenceau par disques réglables
- godets de descente de 12 x 18 cm et de 10 cm de hauteur.
- alimentation assurée par un seul ouvrier.

Le Fonctionnement de la planteuse a été observé durant la campagne agricole 1970 sur un terrain billonné de 6 600 m2, préparé selon la méthode décrite plus haut.

Des modifications complémentaires ont été apportées au cours des essais : reprofilage des ailes du soc de plantation - allongement de l'étançon du soc - augmentation du volume du bac d'alimentation.

Les premières estimations de temps de travaux permettent de fixer à une durée de 6 à 7 heures la plantation d'un hectare. Il est permis d'espèrer que le rendement pourra être diminué à 5 h/ha en :

- améliorant l'uniformité du billonnage (hauteur et alignement des billons) qui permettra un avancement plus régulier du tracteur.
- obtenant une meilleure organisation du chantier de plantation (approvisionnement plus rapide de la planteuse en bout de champ)

Les résultats de la plantation mécanique sont assez satisfaisants.

Cinq variétés dont les tubercules présentaient une taille et une forme favorables à la mécanisation de la récolte avaient été choisies pour ces essais.

Les semenceaux étaient constitués de fractions de tubercules d'un poids de 200 g environ.

La densité de peuplement désirée étant de 10 000 pieds/ha et les billons étant espacés de 1,25 m, l'écartement à obtenir sur le billon était donc de 0,8 m.

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En fait, l'écartement moyen obtenu après plantation a été de 0,75 m, soit une densité de 10 640 pieds/ha.

Les densités observées lors de la récolte, se sont révélées variables selon les variétés, comme le montre le tableau ci-dessous.

Tableau V

DENSITES DE PEUPLEMENT A LA PLANTATION ET A LA RECOLTE
(nombre de plants par ha).

Variété	Espèce	Date de plantation	Densité de peuplement ap. plantation	Densité de peuplement à la récolte
KRENGLE	D.cayenensis	15/4/70		8 000
OUAN	-	17/4/70		8 300
GNAN	-	17/4/70	10 640	9 200
BB D 20	D. alata	22/4/70	10 650	10 600
BODO	-	23/4/70	10 640	9 200

La principale cause de ces variations est la plantation pendant une période peu pluvieuse des diverses variétés à des dates différentes, necessitées par les arrêts pour les modifications à apporter à la planteuse en cours d'expérimentation.

Mais, ni les manipulations de tubercules, ni la plantation mécanique elle même n'ont eû d'action défavorable sur la levée des semenceaux, et sur la croissance des jeunes plants.

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ENTRETIEN DE LA CULTURE

La lutte contre les mauvaises herbes, dans une culture à cycle long (5 à 9 mois), telle que l'igname, nécessite évidemment de nombreuses journées de travail.

Il convient donc, dans un système de culture modernisé, de réduire ces interventions manuelles.

Nuisance des mauvaises herbes

L'igname est particulièrement sensible aux adventices pendant les 100 premiers jours qui suivent la plantation

Cette sensibilité est dûe à :

- la levée tardive des pousses (90 % des plants lèvent entre le 25è et le 40è jour après plantation).
- l'échelonnement de la levée, particulièrement lorsqu'on utilise des semenceaux provenant à la fois de têtes et de queues de tubercules mères.
- le développement relativement peu rapide des parties aériennes chez certaines variétés (D. cayenensis tardives).

Lorsqu'aucun désherbage n'est effectué, les dégâts occasionnés par les adventices peuvent anéantir complètement la récolte, comme le montrent les résultats des parcelles témoins des essais herbicides 1970 (voir plus loin).

Désherbage manuel

Pratiqué couramment en culture traditionnelle, il est possible dans ce cas, parce que la culture de l'igname est effectuée sur défriche de forêt, de savane ou de jachère de longue durée : deux à trois sarclages manuels suffisent alors à contrôler les mauvaises herbes.

Au contraire, dans un système de culture continue avec jachère de courte durée, quatre à cinq sarclages sont nécessaires et exigent 80 journées de travail à l'hectare.

Dans un système de culture motorisé, où la préparation mécanique du sol permet une extension des superficies, il est évident que les disponibilités en main d'oeuvre ne permettent pas de supprimer le "goulot d'étranglement" constitué par les sarclages.

Il faut donc s'orienter vers une autre solution : désherbage mécanique ou désherbage chimique.

Désherbage mécanique

Compte tenu du développement végétatif de l'igname, on peut tout au plus envisager les désherbages mécaniques sous la forme d'un léger rebuttage pendant le premier mois suivant la plantation, alors que les jeunes lianes ne se sont pas encore étendues sur le sol.

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Cette opération permettrait seulement de supprimer une vingtaine de journées de travail/ha, elle ne résoudrait pas pour autant le problème du désherbage en grande culture. Elle risquerait d'autre part de blesser les racines dont le développement est plus précoce que celui des pousses.

Désherbage chimique

Les résultats obtenus avec cette méthode, à la Station de Bouaké au cours des deux dernières années, sont très encourageants.

Parmi plusieurs produits testés, le Diuron associé au Paraquat, ou au 2.4.5. TP, appliqué entre plantation et levée, s'est montré particulièrement efficace contre les adventices et apparemment non phytotoxique pour l'igname, ainsi que le montrent les résultats ci-dessous

Tableau VI
ESSAIS DE COMPORTEMENT
(Années 1969 et 1970)

Produit	Année	Rendement en tonnes/ha
3,2 kg/ha Diuron + 1,6 kg/ha 2.4.5 TP	1969	20 T/ha
	1970	14 T/ha
Témoin non traité	1969	3 T/ha
	1970	0 T/ha

ESSAI DE CONTROLE D EFFICACITE (année 1970)

Produit	Rendement en tonnes/ha
1,6 kg/ha Diuron + 0,4kg Paraquat	10,95
2,0 " + "	11,20
2,4 " + "	12,15
Témoin sarclé (quatre sarclages)	15,35

Le coût d'un désherbage chimique au Diuron (2,4 kg/ha) associé au Paraquat (0,4 kg/ha) appliqué au pulvérisateur porté sur tracteur est de l'ordre de 10 à 12 000 CFA/ha (y compris les frais d'amortissement de l'appareil et les frais d'épandage), ce qui correspond à environ une tonne d'igname au prix actuellement pratiqué, de 10 à 12 CFA/kg.

Dans la mesure où ces résultats seront confirmés par l'expérimentation ultérieure en grandes parcelles, on peut espérer que le désherbage chimique permettra de solutionner le problème des sarclages en culture mécanisée de l'igname.

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RECOLTE

Comme pour la plantation, l'expérimentation a concerné deux problèmes :

- le choix de l'arracheuse et son adaptation
- le choix des variétés aptes à la récolte mécanique.

L'Arracheuse

Nous avons posé comme principe de base que l'appareil devait :

- être très robuste
- ne pas avoir une action trop brutale sur les tubercules d'igname très fragiles.
- laisser, après son passage, les tubercules intacts sur le sol, prêts au ramassage.

Notre choix s'est fixé sur une souleveuse de pommes de terre :

- portée sur l'attelage trois points d'un tracteur de 60 CV SAE.
- comportant une lame souleveuse, d'une largeur de 1,3 m.
- comportant un double tamis oscillant, entraîné par prise de force et équilibré par un volant à inertie.
- dont la hauteur libre utile entre lame et volant d'inertie était de 0,35 m.

Les premiers essais d'arrachage ont été effectués en fin 1970 sur la parcelle de 6 600 m2 plantée mécaniquement.

La texture hétérogène de cette parcelle sablo-limoneuse, graveleuse par endroits, associée à la sécheresse précoce, a fait que la machine a travaillé dans des conditions extrêmement difficiles (sol très compact) mais intéressantes pour révéler ses possibilités.

+ Ces premiers essais ont permis d'apporter les modifications suivantes :

- L'étançon supportant la lame souleveuse a dû être renforcé.
- La lame souleveuse d'origine épaisse de 0,4 cm a été remplacée par une lame de 1 cm.
- La largeur de travail a été diminuée de 1,3 m à 0,8 m.
- La hauteur libre utile entre lame et volant a été portée de 0,35 m à 0,50 m pour permettre un travail plus profond.
- L'inclinaison du soc a été accentuée afin d'améliorer la pénétration dans le sol.
- Le nombre de tringles des tamis a été réduit d'un tiers afin de permettre une séparation plus rapide de la terre et des tubercules.

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+ Ces premiers essais ont aussi montré la nécessité de :

- débarrasser le terrain des fanes d'igname avant le passage de la souleveuse pour éviter le bourrage.

Cette opération a été effectuée manuellement et exige trois journées de travail par hectare.

- détruire les cloisons antiérosives confectionnées entre les billons. Le passage du tracteur sur ces cloisons fait en effet varier la profondeur de travail et provoque le sectionnement de certains tubercules.

Ce travail effectué manuellement, demande également 3 journées d'ouvrier/ha.

+ Les multiples arrêts imposés par les modifications apportées à la souleveuse n'ont pas permis de déterminer avec précision les temps de travaux. Cependant, les quelques observations effectuées laissent à penser qu'un hectare d'ignames pourrait avec cet appareil, être arraché en 7 heures.

Les Variétés

Parmi les variétés de la collection de Bouaké (uniquement ivoiriennes), cinq, semblant aptes à la récolte mécanique, ont été retenues à l'issue de la campagne 1969.

Les critères de choix ont été :

- une productivité correcte :
- des tubercules de faible longueur
- des tubercules réguliers, ni fourchus, ni digités.

Les caractéristiques des tubercules, observés en 1969, étaient les suivantes :

Tableau VII
VARIETES D'IGNAME APTES A LA RECOLTE MECANIQUE

Espèce	Variété	Longueur maximum du tubercule	Poids moyen des tubercules
D. alata	OUAN	32 cm	1 500 g
"	BB Dt 20	31 cm	1 500 g
"	BODO	37 cm	900 g
D. cayenensis	KRENGLE	34 cm	500 g
"	GNAN	36 cm	1 000 g

Le tubercule idéal pour la récolte mécanique semble devoir être de forme sphérique ou ovoïde, d'un poids moyen de 1 500 g et d'une longueur maximum de 30 cm.

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La variété AKANDOU (D. cayenensis) qui répondrait le mieux à ces critères n'a malheureusement pu être testée en 1970 faute de semenceaux en quantité suffisante.

Les Résultats

Ils sont réunis dans le tableau ci-dessous :

Tableau VIII

RESULTATS DE L'ARRACHAGE MECANIQUE D'IGNAME

Variété	Rendement en T/ha	% tubercules intacts (en poids)	Longueur moyenne (moyenne de 100 observations)
OUAN	16,8	79,8	25,0 cm
BB Dt 20	17,5	60,5	24,0 cm
KRENGLE	9,5	57,5	26,3 cm
GNAN	6,9	45,2	26,2 cm
BODO	16,1	26,5	24,3 cm

Des sondages effectués au champ avant récolte, avaient fait apparaître que les trois variétés OUAN, BB Dt20 et KRENGLE avaient formé une proportion importante de tubercules inférieurs à 30 cm.

Ce résultat est bien confirmé à la récolte où ces trois variétés produisent le pourcentage le plus élevé de tubercules intacts.

Ce pourcentage peut certainement être encore augmenté

- en améliorant l'alignement des billons lors de la préparation du sol : on constate en effet que la sinuosité des billons entrave la marche de la souleveuse et provoque une casse des tubercules.
- en effectuant une plantation plus superficielle. La tête des tubercules se trouvait souvent à 15-20 cm sous la crête du billon, soit 5 à 10 cm trop bas. De ce fait, un certain nombre de tubercules ont été sectionnés.
- en récoltant en sol plus humide et plus meuble. En effet, en sol lourd et compact, la terre, sous la poussée du soc, se disloque en énormes mottes et les tubercules inclus dans ces mottes se rompent en même temps qu'elles.

X

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Ces premiers résultats - encore très incomplets - montrent cependant, à notre avis, que l'intégration de l'igname dans un système de culture modernisé ne présente pas d'obstacle technique insurmontable.

Au point de vue économique, les frais culturaux d'une telle culture mécanisée, incluse dans une rotation, devraient s'établir entre 60 000 et 80 000 CFA/ha, y compris semenceaux, engrais, désherbants et les interventions manuelles réduites à une vingtaine de jours/ha.

Ce chiffre est tout à fait compatible avec les rendements qu'on peut espérer obtenir et avec le prix moyen actuellement pratiqué sur le marché traditionnel.

Il reste à savoir si ce prix pourra être maintenu à ce niveau dans un circuit commercial organisé.

Cela dépendra évidemment des débouchés et surtout de la régularité de ces débouchés au cours de l'année. Pour ce faire, le problème posé par la conservation de l'igname devra être résolu.

A notre avis, il serait dommage de ne pas tenter de le résoudre, car l'igname est, dans cette zone de savane à deux saisons pluvieuses, aux précipitations particulièrement capricieuses, une culture sûre qui donne les rendements les plus stables quels que soient les aléas climatiques.

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THE JOINT INSTITUTE FOR
AGRICULTURAL RESEARCH/USAID
NIGERIA IRISH POTATO PROJECT

by

D. R. Suchomel

A Paper to be presented at
An Agricultural Research Seminar

- on -

ROOT AND TUBER CROPS

at

The Conference Centre
The University of Ibadan

22nd - 26th February, 1971

Mr. Dale Suchomel is the U.S.A.I.D. Agronomist attached to the Potato Project at Riyom, Benue Plateau State of Nigeria

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THE JOINT INSTITUTE FOR AGRICULTURAL RESEARCH/U.S.A.I.D. NIGERIA IRISH POTATO PROJECT

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(Institute for Agricultural Research, Ahmadu Bello University, Zaria)

INTRODUCTION

1. Introduction of potatoes to Nigeria

The Irish potato Solanum tuberosum was introduced in the Jos area of Nigeria by European miners during the 1920's. It was grown as a garden crop for private consumption. Records indicate that the first cultivation of potatoes as a commercial crop in the Jos area, began about thirty years ago. The Riyom Agricultural Station was engaged in multiplying and supplying seed potatoes to the local farmers during that time. Jos is located on a high Plateau at an altitude of about 3,500 - 4,500 feet.

2. Potato production on the Jos Plateau

It has been estimated that during the rainy season, about 1,200 farmers use about 800 acres (323.74 H.) for growing potatoes and that they produce 1,200 tons to 2,000 tons annually.* Potatoes are also grown successfully during the dry season under irrigation, however, acreage is limited due to the lack of water and irrigation facilities. There are no records regarding the acreage or production for the dry season, although it is estimated as small compared with the rainy season harvest.

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* Estimates supplied by the Jos Native Authority and Ministry of Agriculture and Natural Resources extension workers.

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3. Other potato growing areas

Potatoes are grown commercially around Zaria, (altitude about 2,000 feet) North Central State, and on the Biu Plateau, (altitude 2,200 feet) North Eastern State. They have also been grown on the less accessible Mambilla Plateau in the North Eastern State.

4. Varieties

The potatoes which are grown at present, are usually referred to as "local variety". In fact, they are an accumulated mixture of European and U.S.A. varieties which have been imported to Nigeria throughout the past 30 years. These include up-to-date, Trianta, Pimpernel, Arran Bannar, Arran Consul, and the recently introduced Kennebec, is now included in the pool.

5. Diseases and pests

The four diseases and one pest most common and destructive on Nigerian potatoes are listed as follows:

(i) Bacterial wilt - Pseudomonas solanacearum
(ii) Late blight - Phytophthora infestans
(iii) Alternaria blight - Alternaria solani
(iv) Common scab - Streptomyces scabies
(v) Nematode - Meliodogyne javanica

Due to a very severe attack of late blight in 1962, the potato growers requested the Nigerian Government to assist them with a project to investigate and experiment with new varieties to establish disease resistant lines. The present project began in 1964 for that purpose. Since then, bacterial wilt has been identified as the most important hazard to potato growing. It now appears certain that unless a solution to the problem of bacterial wilt is found, there is very little

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possibility of expanding the potato industry.

PROJECT AIMS

The aim originally was to establish disease resistant, well adapted, high yielding lines. Experience has proven that this is not easily done. A number of high yielding, good quality, advanced seedling lines and named varieties have been tested and screened in past years. Many seemed well adapted to local conditions and tolerant of diseases for up to eight generations, only to eventually break down completely from one or more of the local diseases. As a result, the project is concentrating on selection for resistance to the diseases. Selection for yield and quality shall not be disregarded but selection for disease resistance, especially to bacterial wilt, is the primary objective.

PROCEDURES

1. Source of Material

Most of the material tested to date, has been supplied by the United States Department of Agriculture, Beltsville, Maryland. Thirty advanced seedling lines were obtained from Scotland and about twenty named varieties from Europe. Presently there are fifteen varieties from Mexico along with some S. phureja material sent from Wisconsin University, in the screening process.

List of material tested:

About 20,000 first year seedling tubers from a range of crosses. (USDA)
265 advanced seedling lines (USDA) 20 from Scotland
20 named varieties (American & European)
15 varieties (Mexico)
S. phureja material (USDA/Wisconsin)

USDA/Beltsville, send between 4,000 to 6,000 first year seedling tubers for screening each year together with advanced lines as they become available.

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2. Screening

Usually all new material is planted at a small site, Ganawuri, located on the Jos Plateau. The area is a good screening site due to heavy infestation with potato diseases and nematodes. Any material which survives during the rainy season is retained for further screening the following rainy season. Between the two rainy seasons (i.e. during the dry season) the selected clones are multiplied at Ta Hoss site under irrigation. Some screening for resistance to bacterial wilt can be done at Ta Hoss during the multiplication stage since the site carries the disease. Of the material tested at the Ganawuri site only about 5% is retained. The site can only be used for large scale screening during the rainy season as the water supply is limited during the dry season.

Promising clones which appear from the screening and testing procedures are sent back to Beltsville for incorporation into the breeding programme.

3. SITES

During both the wet and dry seasons, the bulk of the screening and selection work is done on the Jos Plateau. Small observation trials are being conducted near Zaria and Kano with some success. The dry season presents a problem in regard to land area available or suitable for potato cultivation under irrigation.

RESULTS

1. Disease resistance

Presently there are 10 clonal selections that appear promising in regard to disease resistance. They have very high field resistance ratings to some or all of the local diseases.

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Continued resistance to bacterial wilt and late blight remains questionable. Since most of these are clone selections from single-hill segregates that have been screened under adverse conditions seed stock is limited.

2. Yields

The project has recorded yields of about 10 tons per acre from two clones. An overall average for most clones and varieties would be five to six tons per acre. The variety Kennebec (though highly susceptible to most diseases), continues to yield well for the local growers if planted early in the rainy season thus escaping the heavy late blight attack. It also does well during the dry season on irrigated land provided the site is free from bacterial wilt.

3. Spraying

Although little work has been done on spraying against late blight, it does appear that it may be a profitable practice for some farmers growing potatoes during the rainy season. From a small spraying trial conducted during the 1970 rainy season encouraging results were achieved. Using Dithane M-45 at the rate of 1½ lbs per acre, a plot of Kennebec was sprayed twice a week and occasionally three times if a heavy rain fell shortly after an application. The plot which was sprayed, produced a 40% yield increase compared to the unsprayed plot. More spraying trials are scheduled for this future rainy season.

FUTURE OUTLOOK

The present project is planned to develop as quickly as possible a subsistance type of potato which is highly resistant or tolerant to diseases and adaptable to local conditions. If

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desirable a later and different aim is to produce varieties for high input cash crop growers. Such varieties will need an essential resistance to bacterial wilt and other diseases and pests. They must also have high yields and respond well to local farming practices. In these circumstances some measures of disease and pest control may prove to be profitable.

Most of the work done in the past has been on disease resistance. There remains much to be done on cultural practices, irrigation, spacing, storage, fertilizers and use of fungicides and pesticides.

The Plant Pathology Section has begun small scale tests on the effects of dry bare fallow for the control of bacterial wilt.

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LIST OF DELEGATES

Attending a Seminar

on

RESEARCH ON ROOT AND TUBER CROPS IN WEST AFRICA

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to be held at

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(12)

RECENT RESEARCH ON SWEET POTATO (IPOMOEA BATATAS (L) LAM) AT THE UNIVERSITY OF THE WEST INDIES

P.H. HAYNES
Lecturer in Crop Production

Sweet potato research at the University of the West Indies subsequent to 1967 has been concerned with studies on tuber yield, the production of durable products which are convenient to use, the replacement of onerous tasks by mechanical operations and an understanding of the economics of regional root crop production. This research formed part of the Root Crop Programme[1] of the Faculty of Agriculture, the aim being to increase the production of sweet potato and yam.

This work, although carried out in different disciplines, was integrated to produce information thought capable of overcoming the following limiting factors:

(i) low and inconsistent yields;
(ii) uneven availability of tubers;
(iii) uncertain market demand;
(iv) high labour inputs for production;
(v) the absence of established production systems.

The organisation of the overall programme has previously been discussed (Haynes, 1970). For purposes of this paper the structure of the sweet potato research is given below:

I. AGRONOMY	II. PHYSIOL./BIOCHEM.	III. MECHANISATION
A. Yield increase	Mechanisms of yield	Reduction of labour in
Yield variability	Enzyme systems	
Fertilizer response	Process of tuberisation	Planting
Plant spacings		Harvesting
Pest control	IV. PROCESSING	V. ECONOMICS
Weed tolerance		
	Durability	Rational systems
B. Mechanisms of yield	Convenience	
Canopy structure		

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[1] Established by a grant from the Rockefeller Foundation

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Studies on Yield

Yield studies were carried out in two phases. The first of these was aimed at obtaining immediate increases in yield and was mainly concerned with agronomic studies on yield variability, fertilizer response, plant spacings, pest control and weed tolerance. The second phase of yield studies was directed towards understanding the mechanisms of yield. In this, agronomic and biochemical/physiological processes were considered.

I. A. Processes leading to immediate increases in yield

Yield variability

Average yields of sweet potato are about 2 tons/acre, best yields in commercial production about 6 tons/acre and record yields about 16 tons/acre. The discrepencies between average and best commercial led to the expectation that an understanding of these yield differences per plant could result in increase in yield through identification of limiting factors. It was also expected that the reduction of variability has important implications for field experimentation and the prediction of yield.

Tuber yield for individual plants was measured from replicated samples in several fields. High levels of variability were noted within and between samples. Indications were that differences in soil, climate and type of planting material contributed in different proportions to yield variability, (Haynes and Wholey 1971). The influence of soil environmental conditions on sweet potato tuberisation has been established elsewhere (Togari, 1960). Some influence of the dynamic changes in the soil and its effect on tuberisation can be deduced from tuberisation data. This topic is worth further study.

Fertilizer response

Addition of fertilizer is one of the more obvious means of achieving increases in yield of most crops. Added to this, fertilizers are easy to apply and the return per unit of investment easy to calculate. For these reasons fertilizer studies are favoured in many crop research programmes. Attractive as this may appear, increase in yield does not always derive from fertilizer applications. This has been noted by Russell (1968) in the case of traditionally grown tropical food crops. Rice is a particularly good example of this lack of response. There is some evidence that suggests sweet potato behaves similarly. With this in mind nutrient studies on the sweet potato were started with three objectives:

(i) the evaluation of fertilizer response potential of locally available material;

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(ii) the recognition of characters associated with specific response types;
(iii) obtaining maximum response from the standard cultivars.

The evaluation of nitrogen response potential in local sweet potato varieties.

Selections on a visual basis were made from the breeding collection at U.W.I. Care was taken to include the highest yielding varieties together with those of diverse habit. These were planted in small plots half of each treated with nitrogen at 80 lbs/acre and half, unfertilized. The yields of the plots were determined 20 weeks after planting. A typical example of these results is shown in Table I.

Table I
Effect of nitrogen
on selected sweet potato varieties

Variety	Tuber in gms/plant		Change in tuber yield with N	
	-N	+N	gms/plant	%
C9/9	49.3	177.6	128.3	+260
A28/7	230.0	250.0	20.0	+8.7
049	221.2	198.4	-22.7	-10.3
AI 6/15	206.6	150.9	-55.7	-27.0
03/62	184.6	55.9	128.7	-67.7

It is suggested (Wholey and Haynes, 1969) that the response patterns showed by these varieties are a reflection of sweet potato response potential. These could be separated into the following types:

C9/9	positive
A28/7 and 049	none
AI 6/15 and 03/62	negative

Attempts to explain these response patterns in terms of foliage type have not been successful. Studies are being continued using material of greater contrast in branching habit than existed in the previously available material. Also the possibility of a relationship between

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nitrogen response and metabol sm of nitrogen in the plant should not be overlooked. This may provide a basis for explaining nitrogen response in this crop.

Recognition of characters associated with nitrogen response

In the nitrogen response screening trials such factors as nitrogen content of leaves and leaf thickness were measured. On selected varieties representative of the nitrogen response types detailed measurements of dry matter accumulation and of foliage habit were made. This has been useful in identifying the range of foliage types in the sweet potato.

Obtaining maximum response from standard cultivars

Standard fertilizer experiments were conducted to investigate the effect of addition of N, P and K fertilizers singly and in factorial cultivation on sweet potato (Haynes 1968a). The effects of level of nitrogen and time of application were also studied. In both instances the standard commercial cultivar 049 was used.

From the N, P, K study it was found that 049 gave no tuber yield response to nitrogen. There was a response to 100 lbs K in the wet season. There was some evidence indicating an enhanced response to K in the presence of 40 lbs of N, (Haynes 1968a). The petioles of leaves 1-9 and 10-15 proved to be useful indicators of potassium status and likely indicators of phosphorus (Haynes and Ahmad, unpublished).

A level of nitrogen and time of application study showed that time of application of N had no influence on yield response with 049.

The effects of row width and plant spacing on yield

Traditionally, row widths of 36 inches are used for sweet potato growing in Trinidad. When commercial production of this crop was being developed, 27-inch row widths were chosen since this spacing was appropriate to the available equipment (Haynes and Thomas, 1967). Opportunity was therefore taken to determine whether such spacing was justified.

Two cultivars with contrasting foliage size 049 and C-9 were grown on 36 and 27-inch rows and spaced 4, 8, 12 and 16 inches apart. It was found that maximum yields were obtained on 27-inch rows with either cultivar, and at 12 inches along the row for 049 and 8 inches for C-9 (Haynes 1968b).

Pest control

The major sweet potato pests in the West Indies are Euscepes batatae and Megastes grandalis. Surveys of the frequency and distribution of the

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former together with the extent of its damage to tubers have been made in Barbados and St. Vincent. Insecticides have been evaluated for their effectiveness as a means of control. Chlordane combined with Folidol Lebayeid gave good control (Parasram, 1968). Studies on Megastes have been confined to spray evaluation programmes and the epidemiology of the pest.

Weed control

Two lines of weed control investigation were followed. These included screening herbicides to determine crop and weed tolerance and studies on the effects of level and duration of weed competition.

For general control of sweet potato weeds, Amiben and Diphenamid at 1 and 2 lbs/acre respectively or Dacthal and Amiben each at 2½ lbs/acre were satisfactory. Eptam was shown to increase the effectiveness of Amiben/Diphenamid. The difficulties associated with incorporating this into the surface layers of ridged soil limit its usefulness in sweet potato growing in Trinidad.

It is generally accepted that weed control in the first 1/3 - ½ of crop life is most important (Nieto et al, 1968; Kasasian and Seeyave, 1969). Early work with the sweet potato showed that where it was kept weed free during the first 3 weeks yields were as good as keeping it weed free throughout its growing period, and that occasional weedings after the initial weed free period was better than more frequent weeding (Kasasian and Seeyave, 1969). Later work (Seeyave, 1969) showed the initial weed free period to be of greater benefit with crops grown for 14 weeks than with those grown for 20 weeks. With these latter weed control at 3, 6 and 11 weeks was recommended.

I. B. Studies on the mechanisms of yield

These studies were aimed at identifying the mechanisms associated with high yield. In the long-run it is hoped that this knowledge would be of assistance to the plant breeder in developing high yielding strains of sweet potato. Two lines of approach were followed. The canopy structure was investigated to see which canopy attribute was most closely related to yield (Wholey and Haynes, 1969). These studies on canopy are being supplemented by determinations of the photosynthetic efficiencies of leaves (Spence, 1971). The second line of study was concerned with the process of tuberisation and an evaluation of the enzyme systems in the plant.

Canopy structure

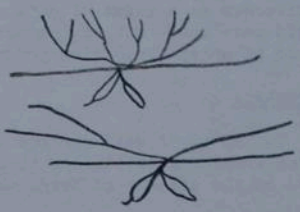
The existence of different foliage types was established (Wholey, 1968). These foliage types give rise to plants which may vary in response to spacing and fertilizer application. Foliage character is related to stem and internode length and further modified by branch number, different

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combinations of which produce the following types:-

(i) Bunching foliage
Low stem length
Low internode length
High branch number

(ii) Spreading foliage
High stem length
High internode length
Low branch number



The attributes of foliage which are most directly linked with yield are total leaf surface and the display of the leaf surface. Leaf surface can be measured directly but display is rather more difficult to define. In this study the number of branches per unit length of stem was used as an index of display. Display indices were determined for 4 high yielding cultivars selected from the U.W.I. breeding programme together with the standard commercial cultivar 049 and two of physiological interest C-9 and A138. The combined effects of the display index and leaf area on tuber yield (fresh weight) were determined by regression analysis. In only one variety (17/56/1) was there a significant relationship between leaf area and display on yield. Almost 70% of the variation in yield was accounted for by leaf area and display index. In other varieties these factors accounted for just over half (in 049) to 1% (in A138) of the yield variation. It would appear that for some varieties yield is foliage dependent.

II. The process of tuberisation in the sweet potato

In a recent review, Wilson (1970) discussed the morphology, anatomy, biochemistry and some aspects of the physiology of sweet potato tuberisation. Use was made of rooted leaves (Wilson, 1967) to study tuber morphology and indications were that tubers were formed on a specific root type. Wilson (1970) showed thick roots to be formed on terminal petiolar callus but roots of petiolar origin to be always thin. He was also able to suppress tuber development by growing sweet potato plants with root systems submerged in water culture even when these were aerated.

In studies on the anatomy of developing tubers, Wilson et al (1969) showed that the parenchymatous sheath formation separating the lignified cells in the stele, was a varietal characteristic. Such a tissue was formed in 049 but not in C9/9. Wilson and associates were also able to confirm the findings of Artschwager (1924) and Togari (1960) that anatomical differences between the other tuberous roots lie in the degree of lignification of the stele and activity of root meristems.

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On the biochemistry of tuberisation Wilson (1969) proposed an examination of the biochemical features common to lignification and cell proliferation and/or cell expansion, likely to be mutually antagonistic to meristematic activity and lignin formation. In this study, peroxidase activity was shown to be lowest in the developing tuber where lignification was minimised and highest in string (non tuberous root) roots and tuber stalk which contained considerable lignin. Wilson and Imbert (unpublished) have shown that exposure of roots to light increases peroxidase and IAA-oxidase activities and inhibits tuber initiation. It has also been shown that scopoletin is an effective stimulator of IAA oxidase at low concentrations (Imbert and Wilson, 1970). On the physiology of tuberisation, Wilson et al (1967) are examining the relationship between parameters of tuber development and tuber yield.

III. Mechanisation

Mechanical harvesting and planting have been the two main areas studied by the agricultural engineer. The aim in harvesting has been the development of a robust, easily fabricated and maintained tool, with the capability of lifting normal tubers from the soil with the minimum of damage. So far equipment has been developed in keeping with the concepts of intermediate technology. The machine in question, the tractor mounted side lifter, exposes the tubers on the surface of the soil but hand labour is used to gather the tubers. This reduces the drudgery of harvesting without complete replacement of hand labour (Campbell, 1969).

Work is also in progress on mechanical planting. It is usual in Trinidad to hand plant sweet potato using 12-15 inches vine cuttings. Attempts are being made to make use of a seedling transplanter. Recent trials are promising, but further modifications are required to overcome problems associated with planting on ridges.

IV. Processing sweet potato tubers

These studies are a good illustration of the value of integrated crop studies. The seasonality of supply of sweet potato tubers has already been mentioned. This is a result of the restriction of the growing season by drought and the short storage life of tubers. There is, therefore, need for a processed product which is durable and can be stored for long periods without loss of quality. In addition, the demand for sweet potato as a fresh vegetable is declining. This decline in demand, in the opinion of the writer, is partly associated with its lack of convenience as a food. Work on processing was initiated at the outset of the Root Crop Programme with the twin aims of increasing both durability and convenience of sweet potato products. To this end, a survey of the processing potential of sweet potato was made (Sammy, 1969). This included the preparation of sweet potato flour, precooked puree and canned slices. Work on the preparation of snack and protein fortified breakfast type products is projected.

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Sammy (1970) has shown varietal differences in the baking characteristics of sweet potato flour. 049 produced flour with superior baking characteristics to that from C9. Flour from 049 was used without difficulty as a substitute for wheat flour up to 15% in bread making and between 20% to 30% in pastries. An acceptable bread was made with 20% substitution. It was shown that peeling the tubers was of no advantage in flour preparation with 049. The colour of the product was improved by additions of sodium meta bisulphite. Levels of SO_2 beyond 100 p.p.m. had deleterious effects on baking properties. The addition of 1% glyceryl monopalmitate improved baking properties of the flour (Sammy, 1970). More recently, the flour from 17 cultivars from the plant breeding collection has been evaluated for baking quality.

V. Economics of regional sweet potato production

Attention has recently been drawn by Rankine (1970) to the importance of the sweet potato in the West Indies. He showed that in 1958, together with yam, there was a per capita production of some 90 kg (200 lbs) in the region. In the same paper, Rankine also cites as reasons for increased attention to root crops, the need for technical efficiencies within the Caribbean context and the use of agricultural diversification and import substitution within the framework of economic development.

Economic studies are therefore being made of the role and function of root crops in the development of the region. Attention is also being given to the means of rationalising sweet potato production in the different islands. In St. Vincent accurate and detailed costings for commercial production are being collected and in Saint Christopher work is in progress on the minimising of costs through changes in production patterns.

Preliminary indications are that within the region shortage of labour is a major limiting factor in the production of root crops. Small size of market and a lack of credit are also important factors.

Acknowledgments

While the author wishes to thank L.A. Wilson and D.W. Wholey for reading and commenting on the entire script, and the following for reading specific sections: L.G. Campbell - mechanisation, L.B. Rankine - economics and G.M. Sammy - processing, he accepts full responsibility for the interpretations contained in the text.

Dept. of Crop Science
February 15, 1971

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Pl. Br. in Madagascar - Arrauduaea

4 introduced Pringlei?

Where from?

anemophyllly? pollination?
entomophyllly

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THE PROGRAMME

For a seminar

on

ROOT AND TUBER CROPS

---

to be held at

The Conference Centre
The University of Ibadan

22nd - 26th February, 1971

CO-SPONSORS :

The Ford Foundation,

L'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières,

The International Institute of Tropical Agriculture.

Ibadan,
22nd February, 1971.

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MONDAY, FEBRUARY 22

Opening Session	Chairman : F.R. MOORMAN	
09.00 - 10.00	1.	Welcome address on behalf of the Ford Foundation, B.D.A. Beck.
	2.	Welcome address on behalf of l'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières. P. Silvestre.
	3.	Welcome address on behalf of the International Institute of Tropical Agriculture, R.A. Briggs.
10.00 - 10 15		Coffee
10.15 - 11.00		The history and the possible future of yam cultivation in West Africa, D.G. COURSEY.
11.00 - 12.30		Discussion
12.30 - 14.15		Luncheon
Afternoon Session	Chairman : P. SILVESTRE	
14.15 - 15.00		The history and possible future for the cultivation of cassava in West Africa, B.D.A. Beck.
15.00 - 15.30		Discussion
15.30 - 15.45		Coffee
15.45 - 16.30		The possible future use for root crops in West Africa, C. MICHE.
16.30 - 17.30		Discussion
19.00 - 21.00		Cocktail party in the Senior Staff Club.

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TUESDAY, FEBRUARY 23

Morning Session	Chairman : W.O. JONES	
09.00 - 09.45		The economic problems encountered in the intensive cultivati on of cassava by IRAT in Togo M. DELCASSO and P. SILVESTRE
09.45 - 10.30		Discussion
10.30 - 10.45		Coffee
10.45 - 11.30		The taxonomy of cassava M. ROGERS.
11.30 - 12.30		Discussion
12.30 - 14.15		Luncheon
Afternoon Session	Chairman : D.G. ROBERTSON	
14.15 - 15.00		The virus diseases of cassava. - C. GALVEZ.
15.00 - 15.30		Discussion
15.30 - 15.45		Coffee
15.45 - 16.30		The cassava improvement programme in Madagascar - M. ARRAUDEAU.
16.30 - 17.30		Discussion
18.30		"Happy Hour" at the Conference Centre

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WEDNESDAY, FEBRUARY 24

Morning Session	Chairman : D.G. COURSEY
09.00 - 09.45	The integration of yams in a modern system of agriculture - C. DUMONT.
09.45 - 10.30	The improvement of yam cultivation techniques in Nigeria - P. CHINWUBA.
10.30 - 10.45	Coffee
10.45 - 11.30	The botanical classification of yams - M. MIEGE.
11.30 - 12.30	Discussion
12.30 - 14.15	Luncheon
Afternoon Session	Chairman : C. DUMONT
14.15 - 15.00	Nematode diseases of yams G. MERNY.
15.00 - 15.45	Discussion of yam diseases
15.45 - 16.00	Coffee
16.00 - 16.45	Study on the control of the yam beetle. T. Ajibola Taylor.
18.30 - 20.00	A drinks party for delegates at the home of Dr. R.A. Briggs followed by a buffet dinner at the Senior Staff Club.

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THURSDAY, FEBRUARY 25

Morning Session Chairman : B. OKIGBO

09.30 - 10.30	The potato in the tropics - J. NIEDERHAUSER
10.30 - 10.45	Coffee
10.45 - 12.00	Discussion of the development of the potato crop.
12.30 - 14.15	Luncheon
14.15 - 17.00	Delegates visit IITA.
14.30	Meeting of the Drafting Committee in the Conference Centre Library.
18.00 - 19.00	"Happy Hour" at the Conference Centre.

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FRIDAY, FEBRUARY 26

Morning Session	Chairman : D.G. COURSEY
09.00 - 09.45	Presentation of the report of the drafting Committee
09.45 - 10.30	Discussion of the report
10.30 - 11.00	Coffee
11.00 - 12.00	Closing remarks
12.00 - 14.15	Luncheon
14.15	Delegates leave for the Airport Hotel, Ikeja.

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(10)

STUDIES ON THE CONTROL OF YAM BEETLES

by

T. Ajibola Taylor,
Department of Agricultural Biology,
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Ibadan, Nigeria

Ford Foundation/IITA Seminar on
"Research on Root and Tuber Crops in West Africa"

22nd - 26th February, 1971

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INTRODUCTION

Yams provide the staple food for millions of people in tropical and sub-tropical countries of the world, although large-scale production for food appears to be restricted to West Africa, South-East Asia and the Carribean (Coursey, 1967). Inspite of widely-held reservations about the future of yams as an economic crop because of its high comparative cost of production in relation to other sources of carbohydrates, there is hardly any doubt that it will, for a long time to come, hold its place and probably expand its export market because of its special appeal as a staple-food to many tropical peoples. In West Africa, most of the yam species cultivated for food, notably Dioscorea rotundata Poir., D. cayenensis Lam., and D. alata L. are attacked by some species Scarabaeoid beetles commonly known as yam beetles. Yam beetles are considered the most serious pest of yams and pest control in yams has been principally in connection with this attack. Yam beetle attack was first reported in the riverine areas of the Niger delta (Jemmet, 1910; Peacock, 1913) and within the next seven years, many areas of eastern Nigeria, mid-Western Nigeria and the low-lying areas of northern Nigeria were known to be infested. By the 1920s, severe and widespread depredations had been reported from all the principal yam-growing areas.

By the third decade of this century, the economic importance of yam beetles had become widely recognised in all the major yam-producing areas of West Africa from Sierra Leone to Angola and great

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concern was expressed about the losses sustained by farmers. Initial attempts at the control of yam beetle species were made by Golding (1928) and Lean (1928-29) and it was recognised that, for a successful, effective and economic control, a basic understanding of the bionomics of the species involved was essential. Preliminary observations were made and recorded by both workers, but ad-hoc control measures which became immediately necessary and which included the use of kerosene, naphthalene and other cultural control measures proved largely ineffective. Gregory (1952-60) resumed the studies of yam beetles and made valuable additions to our knowledge of the biology and control of the principal species (Gregory, 1963). Taylor (1964 a & b) published notes on the taxonomy of the main species and gave a comprehensive account of the bionomics and control of yam beetles in Nigeria. This paper intends to summarise our present state of knowledge of the yam beetles and their control.

YAM BEETLES AND THEIR BIOLOGY

With the further study of yam beetles, it became obvious that effective control can only be based on detail scientific information on the biology, ecology and migration of yam beetles. Basic work in these areas, a brief account of which is given here, has now provided a reliable basis for the effective control which has now been widely accepted and practised in the major areas of infestation.

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Four yam beetle species belonging to two genera of the sub-family Dynastinae, family Scarabaeidae, are principally associated with damage on yams in Nigeria. A fifth species, Heteronychus licas Klug., which is principally a pest of sugar-cane, has only been recorded once or twice on yams.

Two of the important species belong to the genus Heteroligus; they are Heteroligus meles Billb. (= H. claudius Klug.) and Heteroligus appius Burm. The two remaining species belong to the genus Prionoryctes and are P. canaliculus Arrow and P. rufopiceus Arrow. Both H. meles and H. appius are very widely distributed in West Africa, but H. meles appears to be the dominant and most destructive species. H. appius is small in size and occurs in very low numbers in yam-beetle infested areas in southern Nigeria; it has so far not been recorded in northern Nigeria. Both P. canaliculus and P. rufopiceus are found in the rain forest zone of southern Nigeria and appear to be commonest in the riverine areas and in the delta of the river Niger.

The distribution of nearly all the yam beetle species appears to be influenced principally by the occurrence and extent of suitable breeding areas in the flood plains or along the banks of the main rivers. The main areas of infestation are, therefore, to be found along the banks or within 30 miles radius of the main rivers or their all-season tributaries which also happen to be the principal areas of

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yam production. In northern Nigeria in particular, infestation appears to be restricted mainly to the Niger and Benue valleys. Fig. 1 shows the known distribution of the four main species of yam beetles in Nigeria.

Biology

Studies on the biology and ecology of yam beetles during the last few decades have produced the fundamental information on which the strategy for control has been based. The biology of the major species, H. meles, has been investigated by Golding (1928), Lean (1928, 1929), Gregory (1958-63) and Taylor (1964), and is summarised here.

H. meles is a univoltine species which breeds in the flood plains, low-lying areas and river banks in the period between November and March. The eggs which are deposited in November and December hatch out in 15-20 days and develop through three larval stages over a period of 138 to 178 days before pupating. During the second and third stages, the larvae may feed on roots of wild grasses, bananas and other crops or on yams if planted within the breeding areas. The mature third instar larva constructs an earthen cell inside which it pupates for about 17-20 days. At the end of this period, the adult emerges but usually remains in the earthen cell until the beginning of the rains when they embark on their first migratory flight to the yam-growing areas.

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Flight Activity

Two distinct flights occur during the life-history of H. moles and probably other yam beetle species; the first, a post-teneral flight shortly after emergence and soon after the beginning of the rains. This flight has been referred to by Taylor (1964b) as the 'feeding migration'. During this flight, adult males and females with undeveloped gonads engage in nocturnal flights which take them from the breeding areas along the rivers to the feeding areas in the yam-growing zones and are attracted to yams which have already germinated. The flight continues throughout the period late March to June and may be repetitive as shown in a simple greenhouse experiment with H. moles (Experiment I, Fig.2) and from field data in which marked adults were recaptured on many occasions. The peaks of flight activity during this period also appears to be distinctly related to the rainfall regime and major flights were observed to occur on nights immediately following rainy days. The beetles remain in the yam-growing areas feeding on the yam setts or developing tubers during the period June to October. In October, they engage in a second pre-reproductive flight which is referred to as the 'breeding migration' from the yam-growing zones to the breeding areas in the flood plains and river banks. During this period, the gonads are fully developed and oviposition starts soon afterwards. This cycle is represented in Figure 3.

It is believed that most of the other species of yam beetles have a similar pattern of breeding and behaviour. In H. appius,

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Taylor (1964b)has suggested a probable difference because adult females caught during the early part of the year in March and April were found to contain ripe ova and oviposited readily in yam heaps. He therefore referred to this as a 'feeding-breeding migration' and drew attention to the fact that this could lead to their breeding and feeding on yams. Jerath (1967),in further studies, has shown that H. appius would also breed during the dry season in the low-lying areas but that its pre-reproductive flight appears prolonged and indistinct and flying adult females were still laying eggs until late March. This confirms that this species may be more dangerous because of the ability to feed and breed on yams which this flight behaviour confers.

DAMAGE

Yam beetles are principally pests of yams although Chevalier (1937) and Annet (1940) reported them as attacking bananas and Raphia palms in French Guinea, and Vayssiere and Galland (1950) also recorded the larvae as attacking in the swampy valley of River Noun in the Cameroon. The first instar larva feeds mainly on organic detritus in the soil, but second and third instar larvae are known to feed mainly on grass roots in the breeding areas. The major damage, however, is done by the adults during the periods immediately following their first migration and immediately prior to the reproductive flight. During these periods, the adults attack either

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the yam setts (in late-planted yams) or the developing tubers. The main periods of feeding are April to June and September to October. The effect is that, if the setts are attacked, they are extensively damaged causing complete inhibition of germination, delay in germination or retardation of subsequent growth. When the developing tubers are attacked, they cause substantial losses in yield, quality and market value of the crop. With early planting, the first type of attack may be avoided but the second type of attack is bound to occur unless adequate control measures are taken. Very late planting (later than March or April) which sometimes result in low rates of attack has been shown to be undesirable agronomically because of low yields (Waterworth 1961).

Yam beetle damage may be estimated in terms of actual reduction in yields or in terms of the percentage of harvested yams attacked. The first is obtained by comparing the yields from insecticide-treated plots with control; this may be further broken down into the second by determining the relative proportions of attacked yams in both treatment and control plots. The lowering of the market value is a third parameter but this is difficult to quantify. It is estimated that yam beetle damage in parts of Nigeria varies from about 5 per cent to 70 per cent, but in the main areas of infestation in yam-growing areas along the river basins, percentage attack is almost always higher than 20 per cent (Taylor, 1964b). Increases in yield

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of the order of 20 - 77 per cent have been recorded on late-planted yams (Gregory 1957-59). There is no doubt that yam beetles are economic pests in the main yam-growing areas and the control investigations fully justified.

CONTROL

Considerable progress has been made in the control of yam beetles since the early days of Golding (1928) and Lean (1928, 1929) when naphthalene and kerosene and some cultural and physical methods were first used. Also, although number of biological agents, mainly Tachinid and Sarcophagid flies, have been recorded as parasites of the immature and adult stages of yam beetles, none of these appear to exercise a significant biological role either in the breeding or feeding areas. The advent of the modern organic insecticides, particularly the soil insecticides in the chlorinated hydrocarbon group, in the last two decades in Nigeria has led to more satisfactory control of beetles. Our knowledge of the biology and behaviour of beetles has guided us to attack the species at the crucial stage when it flies into the feeding areas rather than in an extensive and diffuse breeding area, the extent of which cannot be determined accurately.

Beginning from about 1950, many proprietary insecticides, either as dust formulations or emulsifiable concentrates, have been applied for the control of yam beetles. These include BHC, Aldrin,

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Chlordane, Dieldrin and Endrin applied as dusts to setts or as sprays to yam heaps. These early trials showed that the 2½ per cent dust formulation of Aldrin applied to setts at planting was most satisfactory in reducing beetle damage and increasing yields in late-planted yams (February-April). Significant increases in yields and reduction in beetle attack were obtained from Aldrin-treated plots when compared with Lindane, Dieldrin or Chlordane-treated plots. Waterworth (1961) also reported that Aldrin was more effective than Lindane and gave 7 per cent damaged tubers whereas Lindane and control gave 31 per cent and 40 per cent respectively. But a high proportion of plantings in the yam-growing areas are early plantings and with early planting, sett-treatment was found to be unsatisfactory for beetle control.

In 1962 and 1963, series of trials were conducted at Agenebode in mid-western Nigeria and Bori-Ogoni in eastern Nigeria to investigate the influence of methods of application of Aldrin dust on yam beetle control on early and late-planted yams (November and March). Aldrin 2½ per cent dust was applied at the rate of approximately 1 lb active ingredient to the planting holes. The rate of application to the setts was less accurate because of losses during the sett treatment by hand whereas hole application was fairly accurate because divided portions were fairly uniformly applied to the holes using a perforated tin. The results of some of the experiments are given in Tables 1 and 2.

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Table 1 Effect of Aldrin 2½% dust on beetle damage and yield of yams at Agenebode 1963

Insecticide Treatment	Percentage* yams attacked	Yield in* lb/acre
Early Yams		
Aldrin 2½% dust (sett application)	28.2 b	9,428 b
Aldrin 2½% dust (planting hole application)	7.1 c	10,430 a
Control	42.6 a	5,714 c
Late Yams		
Aldrin 2½% dust (sett application)	8.4 b	7,819 a
Aldrin 2½% dust (planting hole application)	6.3 b	8,224 a
Control	38.4 a	4,316 b

* Means followed by the same letter do not differ significantly at the 5% level according to Duncan's multiple range test.

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Table 2. Effect of Aldrin dust on beetle damage and yield of yams at Bori-Ogoni 1963.

Insecticide Treatment	Percentage* yams attacked	Yield in* lb/acre
Early Yams		
Aldrin 2½% dust (sett application)	29.4 b	8,014 b
Aldrin 2½% dust (planting hole application)	15.6 c	9,840 a
Control	51.2 a	4,624 c
Late Yams		
Aldrin 2½% dust (sett application)	10.7 b	6,966 a
Aldrin 2½% dust (planting hole application)	9.2 b	7,447 a
Control	43.5 a	4,028 b

* Means followed by the same letter do not differ significantly at the 5% level according to Duncan's multiple range test.

Tables 1 and 2 indicate that the application of Aldrin to planting holes, if properly carried out, gave considerable improvement on beetle control and significantly increased yields on early-planted yams. In late-planted yams, no significant differences were observed in the damage index and yields in the two methods of applications. It is probable that a great degree of control will be obtained with an increase of the rate of application to planting holes to about 1½ - 2 lb of active ingredient per acre. It appears that the key factor

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here is the presence of active and lethal quantities of the insecticide in sufficient concentration around the yam setts or developing tubers during the period of infestation by the beetles in the first flight.

Jerath (1967),in subsequent experiments, compared the use of dust formulations of (1 lb a.i. per acre) Aldrin and Lindane and Telodrin (0.5 lb a.i. per acre) for post-planting beetle control. The insecticides were applied at monthly intervals from March - July on early-planted yams by digging the insecticides into the soil in a ring around the growing plant. He concluded that plots treated with Aldrin in March gave the most satisfactory beetle control and significantly higher yields than other treatments and control. This will be a possible alternative method of Aldrin application for yam beetle control. It has the advantage of economy because insecticides will only be applied to yam setts that have germinated but it must be timed properly in relation to beetle flight the date of commencement of which may change according to the rainfall regime.

Reservations have been expressed about the possible occurrence of residues in tubers harvested from plots treated with insecticides for beetle control. Taylor (1968) has shown by gas-chromatographic analysis of residues of Aldrin, and its epoxide Dieldrin, that the levels of residues in the pulp were in the range 0.01 - 0.13 ppm and far below the tolerance levels of these insecticides. In the peel, the range was 0.09 - 1.98 ppm, but it was felt that the washing of

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the yams which is normal procedure after harvesting would considerably reduce the residues in the peel.

SUMMARY

An account is given of the biology and control of yam beetles in Nigeria. The basic strategy for control has been based on the understanding of the biology and behaviour of yam beetle species in relation to their breeding and feeding areas. The application of Aldrin 2½% dust either to setts or planting hole at the rate of 1 lb a.i. per acre has been shown to be the most effective in beetle control on early-planted yam, and planting hole application on early-planted yams or application in March prior to beetle flight have been fairly satisfactory. Residues are within tolerance levels in part of the tuber destined for human consumption. Further work with other types of insecticides and methods of application, particularly on early-planted yams would be of great value.

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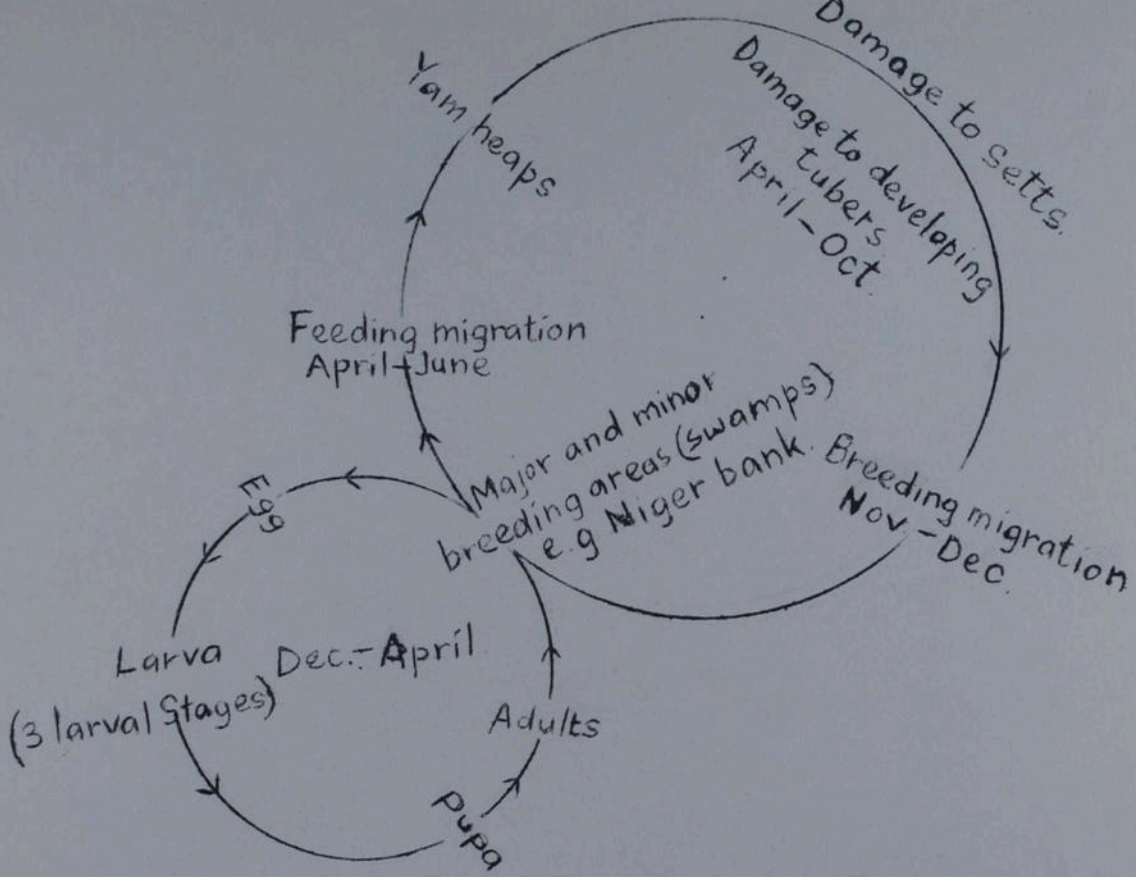
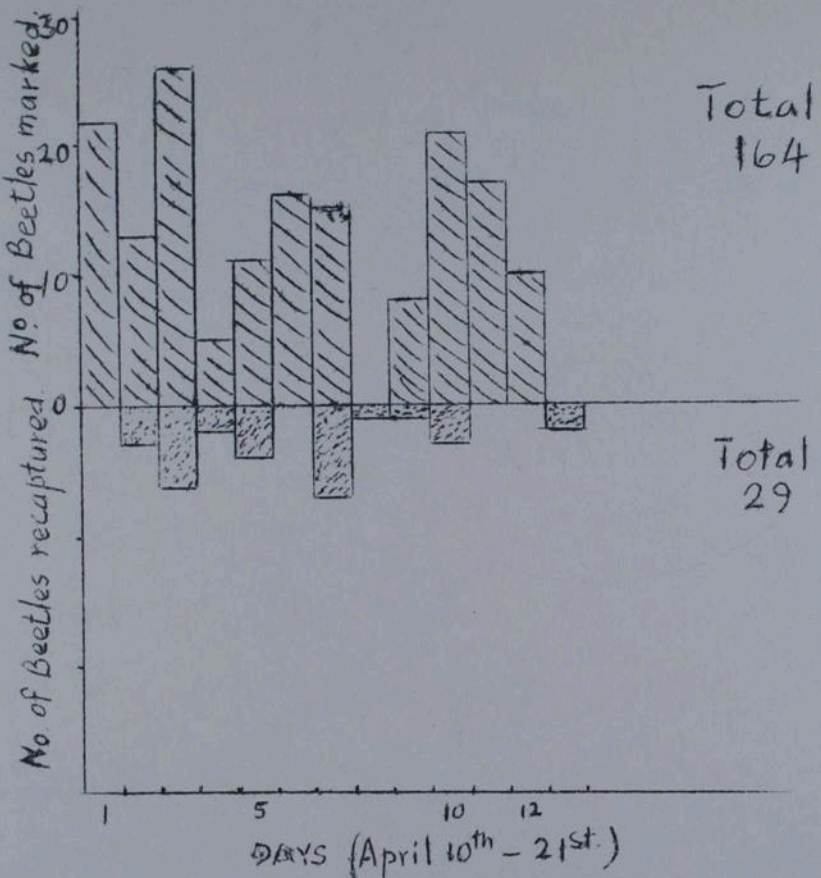
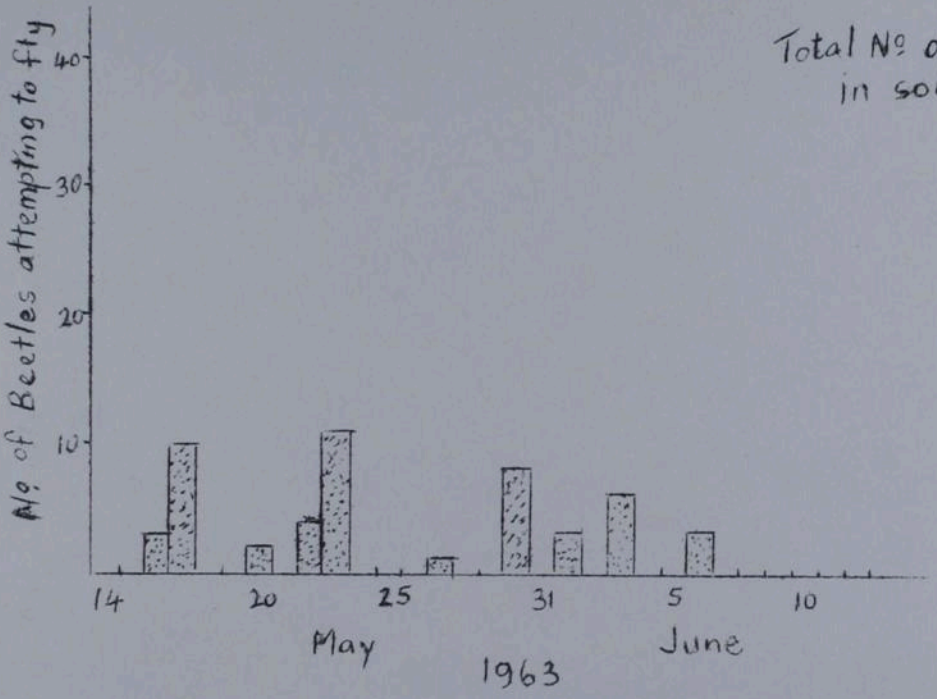


FIG. 2. Life cycle of the Yam Beetle H. meles.

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THE PLANT PARASITIC NEMATODES ASSOCIATED WITH SOME TUBER CROPS OF WEST AFRICA

by

G. Merny

A Paper to be presented at
An Agricultural Research Seminar

- on -

ROOT AND TUBER CROPS

at

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THE PLANT PARASITIC NEMATODES ASSOCIATED WITH SOME TUBER CROPS OF WEST AFRICA

The first part of this communication will deal with the parasites of yam and the second of cassava and sweet potato.

As it is the case for almost all the tropical crops, very few attention has been paid to nematodes parasitizing yam until recently. In general, the presence of nematodes does not give rise to specific symptoms. They only cause a reduction in the growth of the plant, and subsequently in the yield, reduction which could be attributed to other factors, such as soil or climatic conditions. In other cases, such as yam, crop losses were caused by other organisms, like fungi or bacteria, which entered the plant tissues after they had been invaded by nematodes.

During the last twenty years, more attention has been paid to nematodes attacking the tropical crops and a rather high number of parasites were found to be associated with yam. However, it is often difficult to decide whether a namatode is, or not, a true parasite of the plant in the vicinity of which it has been found. Some of the species are endoparasites and live inside the roots or tuber tissues during at least part of their life-cycle. When one of these species has been found inside the tissues of a certain plant it is justified to consider this species as a parasite of the plant. But, when ectoparasites are involved, which are found only in the soil and never in plants, it is difficult to know whether they are really parasites of the plant. This is particularly true in a case

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like yam, which is often cultivated simultaneously with other crops such as tomato, eggplant, okro, maize and so on.

Three kinds of parasitic nematodes have been found in the roots or tubers of yam :

Root-knot nematode (Meloidogyne)

Root-lesion nematode (Pratylenchus)

Yam-nematode (Scutellonema)

In the tropics, the root-knot nematodes, consisting of several species belonging to the genus Meloidogyne are, undoubtedly, among the most dangerous parasites for many crops, especially vegetables. They all are sedentary endoparasites. The second stage larvae move freely in the soil. When they have entered a root they remain in the plant sittues and undergo three subsequent moults. After the last moult, they have developed into fully differenciated males or females. The role of the males in the parasitism is unknown. The females remain embedded in the root and feed on the tissues surrounding their heads. They form a gelatinous matrix in which they deposit a great number of eggs.

The presence of the females inside the roots, causes the latter to undergo a certain number of changes resulting in the formation of galls which can reach a considerable size and the physiology of the plant may be strongly disturbed.

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The parasitism of root-knot nematodes towards yam, has been known for a long time, the first record having been made by Queva in 1895, on Dioscorea illustrata in a French botanical garden.

Since, these parasites have been recorded on several species of yam in Florida, Nigeria and Ivory Coast. In addition, they have been found in Guatemala, on wild species of Dioscorea grown as medicinal plants.

The exact importance of losses caused by root knot nematodes is not known but, in some cases, the tubers are heavily injured. Young (1923) gives an illustration of an emaciated and warty tuber, a feature which has been found again in West Africa .

The life-cycle of root lesion nematodes is different. They are migratory endoparasites. All their larval or adult stages can be found either in the soil or in the roots. All stages can move freely into a root or out of it.

Several species of Pratylenchus are well known to cause losses in many crops. In 1931, Steiner mentions, under the name : Tylenchus pratensis, a parasite of yam in Nigeria. At this time, the taxonomy of plant parasitic nematodes was incertain but it seems likely that the nematode found by Steiner was actually, a Pratylenchus. Nowadays

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is known about its specific identity, nor on that of other Pratylenchus referred to in Japan, Jamaica and Puerto-Rico under the name Anguillulena pratensis. The parasite attacking yam in Nigeria and Ivory Coast belongs to the species P. brachyurus.

Attacked tubers display a splitting of the skin which gives them a corky appearance and a dark brown rot extending irregularly into the flesh, a feature which is found again in the case of an attack by other migratory parasites such as Scutellonema. It is likely that the attack by Pratylenchus is associated with fungi and bacteria, which produce the observed lesions such as dry rot.

Last, but not least, the yam nematode, Scutellonema bradys, is, like the root lesion nematode, a migratory endoparasite. It has been referred to, in earlier literature, under other names : Rotylenchus blaberus, Scutellonema blaberum, S. dioscoreae. They all have been recently synonimized with S. bradys which is the only recognized name for this nem

Although this species is the main parasitic nematode attacking yam, some other species of the same genus seem to be more or less associated with this crop.

S. clathricaudatum is often found, in Ivory Coast, in the vicinity of yam roots where it seems to act as an ectoparasite. Caveness, in Nigeria, has observed that the main three cultivated species of yam

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(D. alata, D. cayenensis and D. rotundata) seem to favour the development of high populations of this species.

S. cavenessi and S. validum, the former in association with S. bradys, are often found, in Nigeria, bear the roots of yam.

S. aberrans, has been observed on one occasion, by Smit in the roots of yam and must be considered, therefore, as a parasite of this plant.

But all of them are only parasites of secondary importance, the main parasite of yam, as far as nematodes are concerned, remaining S. bradys.

This species has been observed in many plants of the American Continent (U.S., Puerto-Rico, Jamaica and Brazil). In West Africa, it has only been reported in Nigeria and Ivory Coast, but it would certainly be observed in other countries if it were systematically looked for.

S. bradys seems to be able to attack a high number of cultivated species of Dioscorea. In Ivory Coast, Smit has observed it on twelve varieties of D. alata, eight of D. cayenensis, one of D. esculenta and one of D. dumetorum, to population level being markedly lower on the latter. It has been found elsewhere on D. rotundata and D. bulbifera.

The symptoms observed on the tubers ressemble those caused by the root-lesion nematode. When bacteria enter the root following the nematode, they give rise to a "wet-rot" but the most common syndrome is the "dry-rot" which appears when the nematode is followed by fungi, belonging mainly to the genus Fusarium.

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Baudin (1955), in Ivory Coast, has noted that the symptoms are more easy to see from the outside in the species D. esculenta, the teguments of this species being thin. The tubers shrink and can be markedly reduced in size.

By peeling off the outer layers of the tuber, at the beginning of the attack, little areas can be seen, displaying a yellow or, a little later, a brown discolouration, turning black in the latest stage. Later, the tissues, on the whole surface, are blackening to a depth of about 1 cm and yellow or brown patches with yellow rims begin to form in the deeper tissues.

Nematodes can be extracted in great number from the diseased tissues. Several generations can develop during the life of the tuber and populations can reach levels as high as several hundred thousands in a single tuber. Smit has noted that the populations were higher and composed of younger stages in the distal and youngest part of the tuber. So, they seem to follow the development of the tuber tissues.

Hence, the parasite, besides its action in the field, reducing the crop, goes on reducing the weight and commercial value of the tuber during storage.

The losses caused in the field have been evaluated by Smit. He estimated the average weight of healthy and diseased tubers in a field of about $2\frac{1}{2}$ acres. The difference between both categories of tubers was about 20 to 30%. This is a rather high difference which will be increased later on by the losses in tubers during storage.

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The same author has observed that all the stages of the parasites were able to enter the plant tissues and to develop inside. He states that, in the field, the nematodes are liberated from a seed tuber, move in the soil and attack young, newly-growing roots and tubers.

Although the primary source of infection may be provided by nematodes present in the soil, it is likely that the main infecting material comes from seed tubers.

At the first sight, it is evident that the control of this parasite will be difficult.

Soil fumigations with D.D. or D.B.C.P. would be too expensive and, furthermore, they would not destroy the nematodes introduced in the soil with the seed tuber.

The use of resistant varieties would provide a good control but, unfortunately, almost all the varieties of cultivated species are highly susceptible and the work of the plant-breeder would be difficult for cultivated yams rarely flower.

The problem must be considered from two points of view :

1. The elimination of nematodes present in the planting material.
2. The elimination of those present in the soil.

As far as the first point is concerned, it is possible, as in many other cases, to kill the nematodes in the plant tissues by hot water treatments.

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Smit states that dipping the tubers in water at 50°C during 30 to 40 minutes should prove suitable for this purpose. The disadvantage of this method is to necessitate an important equipment and, furthermore, it should be applied with care for it tends to break the dormancy of the tuber and disturb its physiology.

The first measure to be applied is to choose the tubers to be used as planting material carefully and to eliminate those obviously diseased.

To clean the soil, fumigations being too expensive, the best means is to adopt a crop rotation which does not allow the survival of the parasite between two subsequent yam crops. According to Caveness, two years fallow is sufficient to eliminate Scutellonema from the Soil.

Smit has inoculated S.bradys to several cultivated plants and has noted that tropical gramineae (millet, sorgho, maize) as well as cotton were not invaded by the parasite. In a crop rotation experiment, in Ivory Coast, planting maize, peanut and then cotton after yam had considerably lowered the level of the populations.

Nematodes parasitizing cassava are almost the same as thos found on yam : several species of root-knot nematodes have been recorded, as well as two species of root-lesion nematodes : P. brachyurus and P. coffeae and Scutellonema bradys which has been reported in Gogo by LUC and de GUIRAN.

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The second of this authors has made a study of the nematodes problem in a region of the South of Togo where cassava had been grown for many years on the same soil and where the yield had considerably lowered. The losses could have been attributed to populations of plant parasitic nematodes having reached a high level.

Two parasites have been almost constantly found associated with cassava in this region :

Pratylenchus brachyurus which has been extracted from the roots and can be therefore, considered as a parasite of cassava.

Helicotylenchus sp. which is only found in soil. Its parasitism towards cassava has not been ascertained.

The importance of populations extracted from soil or roots is variable but it may, in some cases, be very high : 3 500 Helicotylenchus per liter of soil or 40 000 Pratylenchus in 100g of roots.

In view of evaluating the eventual losses caused by the parasites, De GUIRAN has made a trial in which 10 control plots were coupled with 10 plots treated with D.B.C.P. The results of this trial are shown in table 1 :

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Table 1

	Treated	Control	field increase	P.
aerial parts	17,9	16,5	8,5%	0,10-0,05
tubers	16,4	15,3	7,2%	0,20-0,10
aerial parts + tubers	34,3	31,8	7,9%	0,05

The pathogenicity of nematodes seems probable. In this case, the yield increase following soil fumigation is weak because this trial was situated on exhausted soils which have acted as a limiting factor. It seems likely that, in better soils, the increase of yield would have been more important.

De GUIRAN has tested the susceptibility of 42 cassava varieties by inoculating cuttings planted in pots with 2.500 Pratylenchus for each cutting.

Three months after inoculation, the population levels in the roots differed markedly from one variety to the other. The highest level was reached with the variety "Touye" (14.000 individuals per 100g of roots) and the lowest with the variety "B25 x 50" (63 per 100g).

In a comparable study cover and fallow crops were tested and showed considerable differences in their susceptibility (table 2).

Control measures could include the use of resistant varieties. However, the first measure to be taken should be to incorporate non-host plants for P. brachyurus

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in the crop-rotation. By all means, maize, which is a particularly good hose plant for the parasite should be avoided. In the case of the region studied by de GUIRAN crop rotations in view of improving the soil should include Stylosanthes gracilis.

There is only little to say about the parasites of sweet potato. They include species already observed on yam and cassava: Pratylenchus brachyurus and different Meloidogyne species. One remark should be made : apart from these nematodes, sweet potato may be parasitized by other species which are dangerous for bananas : Helicotylenchus multicinctus and Radopholus similis. This remark is also true for tuber plants in general : Pratylenchus brachyurus is not only dangerous for yam and cassava but also for numerous plants like maize and pineapple. Another parasite of pineapple : Rotylenchulus reniformis has also been found on cassava and sweet potato. Therefore, tuber crops should be employed with caution in crop rotations.

Table 2

Tested plants	Number of P. brachyurus per 100g. of roots
Calopogonium mucunoides	50.700
Cynodon plectostachyus	23.380
Desmodium asperum	10.787
Centrosema pubescens	6.920
Crotalaria mucronata	3.855
Flemingia congesta	3.357
Cratalaria usaramoensis	2.905
Dijitaria decumbens	2.535
Stylosanthes gracilis	.257

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SEMINAIRE SUR LES PLANTES A RACINES ET A TUBERCULES

(IBADAN 22 - 26 Février 1971)

Le manioc dans la région maritime du Togo

Expérimentations effectuées par l'IRAT

P. SILVESTRE

G. DELCASSO

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RESUME

La culture du manioc occupe au Togo des surfaces importantes notamment dans la région maritime.

Cette région à climat équatorial guinéen est particulièrement peuplée. La forte pression démographique conduit à une utilisation des terres allant jusqu'à une dégradation avancée. Maïs et manioc sont traditionnellement cultivés en association mais la rusticité du manioc et ses aptitudes à pousser en terres dégradées lui ont valu un intérêt croissant.

Le manioc est essentiellement destiné à l'alimentation humaine mais une part accrue de la production est traitée à la féculerie de Ganavé (1/5 de la production doit être traité en 1975).

Une opération d'intensification de la production du manioc et du maïs a été entreprise à partir de 1966. L'accent a été mis sur une meilleure utilisation de la féculerie et son agrandissement.

L'IRAT a mené depuis 1966 une expérimentation portant sur les variétés et les techniques de culture. L'amélioration des conditions de fertilité a été abordée, notamment dans les zones les plus dégradées. La recherche des dates de bouturage et de récolte dans le cadre d'un cycle de production optimal doit permettre de préciser les conditions d'une amélioration qualitative (teneur en fécule) et quantitative (rendement en racines) des livraisons à l'usine. L'association culturale maïs-manioc a été également étudiée dans l'optique d'une rotation plus rapide des cultures sur les mêmes surfaces.

LA PRODUCTION DU MANIOC AU TOGO

La culture du manioc couvre au Togo une superficie de l'ordre de 100.000 ha, dont 60.000 dans la seule région maritime.

Le rendement moyen de la production est de 8 tonnes de racines à l'hectare en culture traditionnelle. Cependant, on constate des écarts importants liés à la richesse naturelle des sols et au mode de culture. La plus grande partie de la production est réservée à l'alimentation humaine et consommée localement sous forme de manioc frais ou de Gari.

Dans la région maritime une féculerie fonctionne depuis 1953 ; elle permet le traitement industriel d'une petite partie de la production. Les surplus sont traités artisanalement et commercialisés vers les pays voisins sous forme de Gari. Dans cette région la production de manioc est beaucoup plus importante que dans le reste du pays.

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LA REGION MARITIME

Données générales

Elle couvre une superficie d'environ 610.000 ha.

Le climat est de type équatorial guinéen caractérisé par deux saisons des pluies et deux saisons sèches. La grande saison des pluies va de fin Mars à la mi-Juillet, la petite de la mi-Septembre à la mi-Novembre. Les précipitations moyennes annuelles sont de l'ordre de 900mm sur la côte et de 1100mm au Nord de la région maritime. La température moyenne annuelle est de 27° à Lomé et à Tabligbo, ces deux villes encadrant l'aire de production du manioc. La durée du jour varie peu au cours de l'année. L'insolation dépasse 2.000 heures par an, sauf dans la zone littorale où la nébulosité est importante en saison sèche.

La population de cette région (600.000 habitants) représente le tiers de celle du pays. La densité y est voisine de 100 habitants au km2.

Les sols d'origine sédimentaire sont essentiellement constitués par de la "terre de barre". La texture est d'autant plus sableuse que l'état de dégradation est poussé.

Dans la région d'approvisionnement de la féculerie de Ganavé on peut distinguer :

- une zone de terres de barre usées centrée sur Anfoin, où les jachères ont pratiquement disparu (culture répétée du manioc depuis 40 ans) ;

- une zone de fertilité moyenne, concentrique à la première, dite zone intermédiaire, déjà passablement cultivée ;

- une zone de bonne fertilité, périphérique, cultivée depuis peu.

Compte tenu de la dégradation des terres et d'un faible niveau des techniques culturales, notamment pour le maïs et le manioc, la région maritime présente un caractère de surpeuplement relatif.

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CARACTERISTIQUES DE LA CULTURE DU MANIOC

Les surfaces exploitées en manioc couvrent dans la région maritime environ 60.000 ha dont la moitié est récoltée annuellement, produisant 250.000 tonnes de racines.

Les bouturages se font durant la grande saison des pluies (de la fin Mars à la mi-Juillet) et la petite saison des pluies (de la mi-Septembre à la fin Octobre), sur une période de 5 mois. Environ 70 % des surfaces bouturées le sont d'Avril à Juillet.

Dans le Nord de la région maritime le bouturage se fait le plus souvent sur jachère non dessouchée. Dans le Sud il n'y a plus de brousse arbustive, les jachères sont de courte durée et les terrains dessouchés ; le bouturage se fait en ligne.

1 - Les systèmes de production du manioc présentent trois aspects :

. la culture de case, bien fumée, soignée, réservée à la consommation domestique ;

. la culture traditionnelle en général associée au maïs. Le maïs est d'abord semé en ligne à 80 cm et le manioc est bouturé dans les interlignes 10 à 15 jours après la levée. Après récolte du maïs, le manioc reste en culture pure. Les densités respectives de manioc et de maïs sont de l'ordre de 15.000 et 30.000 pieds à l'ha ;

. la culture en champs collectifs où le manioc est cultivé seul. Il s'agit de blocs de culture organisés par les Sociétés de Développement. Certains travaux lourds y sont parfois mécanisés. La densité est de 15.000 pieds/ha environ.

Les rotations

En culture associée la culture se poursuit pendant un nombre variable d'années jusqu'à épuisement du sol. Une jachère vient ensuite. L'hétérogénéité des sols ainsi exploités se traduit par une grande variabilité des rendements d'une parcelle à l'autre.

A cause du système de culture sans restitution d'éléments organiques et minéraux et du fait que dans certaines zones une importante densité de population oblige le paysan à raccourcir la durée du temps de jachère le sol est amené à un tel état d'épuisement qu'il n'y a plus de culture possible pendant de nombreuses années.

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2 - Les variétés

Les maniocs cultivés dans la région maritime sont des maniocs doux utilisés indifféremment pour l'alimentation humaine ou l'approvisionnement de la féculerie. Ils sont bien adaptés aux conditions locales : leur résistance à la mosaïque est généralement bonne. Cependant les rendements en racines restent assez faibles, dépassant difficilement 25 - 30 tonnes dans les meilleures conditions, en parcelles expérimentales.

KATAOLI occupe 75 à 80 % des surfaces. Cette variété à pétiole rouge est assez tardive et productive. Sa teneur en fécule est bonne (24 - 25 %).

GOULA occupe 15 % des surfaces. Cette variété est à pétiole vert, à rameaux et à feuille peu colorée. Plus précoce que Kataoli, elle est de productivité équivalente et sa teneur en fécule est légèrement supérieure (jusqu'à 28 %).

DAZANE-FETO occupe 4 - 5 % des surfaces. C'est une variété précoce et plus productive mais sa teneur en fécule est faible (15 - 20 % dans les meilleures conditions).

UTILISATION DE LA PRODUCTION

Consommation locale

Le manioc est consommé localement soit en frais, soit surtout sous forme d'une semoule appelée "gari". Cette semoule fortement granulée se conserve plusieurs mois. On peut obtenir en moyenne 1 kg de gari à partir de 5 kg de manioc titrant 22 % de fécule.

Le prix mensuel moyen de détail du kg de gari enregistré au marché de Lomé par le Service de la Statistique en 1967 fait apparaître des écarts relativement importants d'un mois à l'autre. Les prix passent de 26 Frs le kg au mois d'Avril à 18 francs au mois de Décembre, ce qui valorise le kg de manioc respectivement à 3,80 et 2,20 Frs, à environ 22 % de fécule si on estime à 7 Frs par kg de gari le prix du travail.

Ces changements sont liés à l'approvisionnement plus ou moins important en maïs sur le marché : les cours du gari baissent en période de récolte du maïs et remontent en période de soudure.

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D'après une enquête de la SEDES les besoins totaux de la population de la région maritime s'élèveraient à 220.000 tonnes de racines par an, dont 190.000 tonnes transformées en gari et 30.000 tonnes consommées en frais. Ce chiffre est à majorer de 11 % pour 1975 et de 13 % pour 1980 compte tenu des besoins prévisibles.

Exportation en gari

Le gari du Togo jouit d'une bonne réputation de qualité dans les pays voisins.

Le Dahomey a importé environ 1.000 tonnes entre Juin 1963 et Juin 1964, bien qu'il n'y ait pas dans ce pays de déficit de production.

Le Ghana importe annuellement environ 5.000 tonnes, destinées principalement à la capitale Accra, dont la population croissante devrait accentuer la demande en gari dans les années à venir.

Transformation industrielle

Une usine de transformation du manioc en fécule, située à l'Est de Lomé, dans la circonscription d'Anecho, fonctionne depuis 1953.

Sa capacité de transformation de racines de manioc en fécule est passée de 20.000 tonnes en 1953 à 30.000 tonnes en 1958, pour être portée à 45.000 tonnes en 1969, année qui a vu également la mise en route d'une chaîne de fabrication de tapioca.

APPROVISIONNEMENT DE L'USINE

Compte tenu de l'irrégularité pluviométrique de la région et d'une certaine indiscipline des producteurs dans leurs livraisons, l'usine n'a pas toujours traité le tonnage pour lequel elle avait été conçue.

Pour essayer de résoudre ce problème de l'approvisionnement les Sociétés Régionales d'Aménagement et de Développement ont institué des contrats de culture assortis d'une aide à la production sous forme de prêts octroyés par la Caisse Nationale de Crédit Agricole du Togo.

L'usine travaille généralement de Mars à Décembre, cessant généralement toute activité en Janvier-Février, mais les arrêts sont fréquents en début de campagne (plus de 50 % des arrêts

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totaux depuis 1953). Les livraisons ont été de l'ordre de 20.000 tonnes par an depuis la création de l'usine, avec toutefois une grande irrégularité (30.000 tonnes en 1965 et 2.000 tonnes en 1966).

Les plus gros apports se situent en Juillet-Août et Octobre-Novembre, périodes correspondant aux maxima de grande et petite saison des pluies. Les maniocs livrés à la féculerie ont entre 11 et 21 mois de végétation, suivant les dates de bouturage et de récolte.

Incidence de la pluviométrie

Les surfaces bouturées sont environ de 21.000 ha en grande saison des pluies (70 % de la surface bouturée annuellement) et 9.000 ha en petite saison des pluies (30 %).

Les pluies de grande saison sont en général assurées, celles de petite saison sont aléatoires.

Ainsi une année où les pluies sont insuffisantes se traduit par une baisse sensible des surfaces bouturées en manioc, mais aussi des surfaces semées en maïs. On constate l'année suivante :

- . une diminution de la production de manioc ;
- . une augmentation du prix du maïs ;
- . une hausse du prix du gari, suscitée par une plus forte demande ;

et, par contre-coup, une diminution des livraisons de manioc à la féculerie.

Par contre, une année de fortes précipitations se traduit l'année suivante par un plein approvisionnement.

La pluviométrie modifie également les conditions d'arrachage :

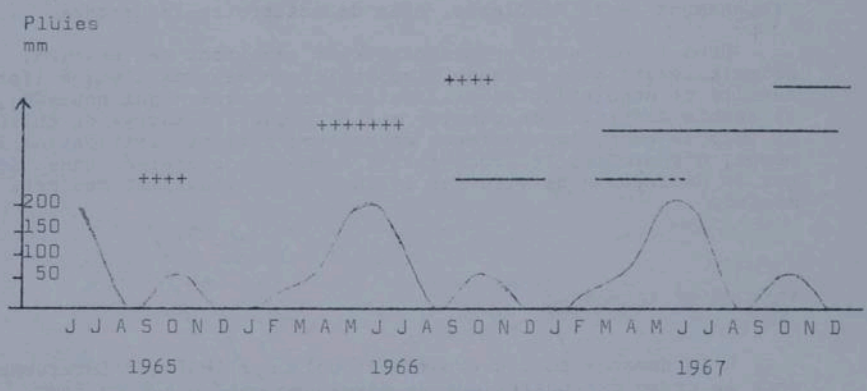
- . en saison pluvieuse les maniocs sont plus faciles à arracher et leur poids est élevé,
- . en saison sèche il est plus pénible d'extraire les racines mais elles n'ont pas atteint leur poids maximum.

En 1969 la direction de l'usine a diversifié ses prix d'achat aux producteurs en fonction de la densité des racines. Cette formule a déjà permis d'améliorer la régularité et la qualité des livraisons.

×
× ×

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En 1967 l'approvisionnement a été réalisé par des maniocs bouturés en 1965 et 1966, comme le montre le schéma suivant :



Les maniocs sont récoltés entre le 11ème et le 21ème mois de végétation, principalement durant la grande saison des pluies.

× × ×

Les besoins en manioc dans la région maritime croissent assez rapidement. On peut récapituler les besoins en 1968 et ceux de 1975 comme suit :

U T I L I S A T I O N S	1970	1975
	t.	t.
Consommation locale (en frais + gari)	220.000	240.000
Transformation industrielle (féculerie..)	20.000	60.000
Exportation vers les pays limitrophes	6.000	10.000
TOTAL	246.000	310.000

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Compte tenu des prévisions à court terme on voit qu'il sera nécessaire de produire en moyenne 60.000 tonnes de racines supplémentaires par an en 1975 dont 40.000 t dans la zone d'approvisionnement de la féculerie, afin de satisfaire la demande.

Dans l'optique d'un accroissement important des besoins, principalement dans la zone d'approvisionnement de l'usine (forte densité de population et utilisation des terres assez poussée), il semble difficile de compter sur de nouvelles terres de culture. Il importe donc, les surfaces en culture restant pratiquement les mêmes, d'accroître la productivité annuelle du manioc, sans négliger la production de maïs qui influe sur la stabilité des prix du manioc.

TRAVAUX DE RECHERCHE

A la demande du Gouvernement togolais l'IRAT est intervenu dans le cadre des opérations de développement au Sud du Togo.

G. COURS-DARNE, spécialiste du manioc à Madagascar, effectua une mission vers le milieu de 1966 ; il formula des recommandations relatives à l'amélioration des conditions agronomiques de production du manioc dans les zones intéressées par cette culture. Un programme d'étude et d'essais destinés à apporter des solutions aux problèmes les plus urgents fut en outre proposé.

L'objectif essentiel de ce programme est l'intensification de la production, c'est-à-dire l'accroissement des récoltes par unités de surface et de temps.

Cette intensification est recherchée :

. par la réduction du cycle cultural du manioc de manière à permettre la réalisation d'autres cultures, notamment le maïs ;

. par la fertilisation ;

. par l'association pendant une certaine durée du manioc et du maïs.

Les actions entreprises comprennent :

1 - l'étude du développement, croissance des racines et évolution de la teneur en fécule, des principales variétés cultivées, dans différentes situations, avec différentes dates de bouturage et à différents niveaux de fertilité.

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Cette étude a été réalisée par prélèvement de 10 plants à périodicité régulière (15 jours) entre les 8ème et 24ème mois de végétation dans les conditions suivantes :

GANAVE bouturage Juin 1966

variété Kataoli
2 types de sol très épuisé
et fertilité moyenne
sans engrais

bouturage Octobre 1966

variété Kataoli
sol de fertilité moyenne
sans engrais.

AGBESSI bouturage Octobre 1968 et Mai 1969

variétés : Kataoli, Goula, Dazane-Feto
sol dégradé
avec et sans engrais

AFAGNAGAN bouturage Octobre 1968

variétés : Kataoli, Goulé
sol non dégradé.

L'essai d'Agbessi faisant intervenir trois variétés et deux niveaux de fertilisation est le plus instructif.

2 - des essais statistiques permettant de contrôler les résultats de l'étude précédente.

On a réalisé à Agbessi un essai pour chaque date de bouturage retenue (Octobre 1968 et Mai 1969) comportant 3 variétés x 3 niveaux de fertilisation x 3 dates de récolte (10 - 15 - 20 mois de végétation).

3 - des essais d'association maïs-manioc permettant d'apprécier l'influence dépressive du maïs sur le manioc et réciproquement.

4 - l'implantation et l'observation d'une collection comprenant 10 variétés du Dahomey, 1 du Ghana, 2 de Nigéria, 1 du Gabon et 10 de Madagascar.

5 - divers essais de fertilisation.

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a - Rythme de croissance des tubercules

Les courbes établies font apparaître une forte incidence de l'alimentation hydrique sur la croissance des tubercules.

. A partir du 8ème mois de végétation, date du début des observations, l'allure générale de la croissance est plus rapide pour les maniocs ayant eu une bonne alimentation hydrique au début de leur développement. C'est généralement le cas pour les maniocs bouturés en grande saison des pluies au mois de Mai.

A Agbessi, on constate avec la variété Kotooli la progression suivante :

Pluies cumulées			Rendement		
Mois	Bouturage		Mois	Bouturage	
	Mai	Octobre		Mai	Octobre
	mm.	mm.		t	t
6	675	335	8	4	0
10	765	860	12	4,5	5,7
14	1.467	1.010	16	10,5	6
16	1.500	1.055	18	14,5	9

Les observations faites à Ganavé, montrent une supériorité des bouturages en petite saison des pluies, s'expliquant de même en raison du caractère anormal de la pluviométrie en 1967 et 1968.

. L'alimentation hydrique a, en outre, une influence instantanée sur la croissance des tubercules.

. En période de fortes pluies la croissance est accélérée.

. En période sèche la croissance diminue jusqu'à s'annuler.

b - Evolution de la teneur en fécule

La teneur en fécule est très influencée par l'alimentation hydrique instantanée et ses fluctuations en fonction de ce facteur sont très importantes.

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Pour toutes les variétés et quelle que soit l'époque de bouturage on observe :

. des maxima en Août-Septembre et en Janvier-Février correspondant respectivement aux petite et grande saison sèche ;

. des minima en Octobre-Novembre et Mai-Juin correspondant respectivement aux petite et grande saison des pluies.

Les valeurs observées pour la variété Kataoli sont :

bouturage en Mai 1969

Maximum		Minimum	
Février 70	25,2 %	Mai 1970	18,5 %
Sept. 1970	25 %	Oct. 70	24,2 %

bouturage en Octobre 1968

Août 1969	21,9 %	Nov. 69	19,4 %
Février 70	22,3 %	Mai 1970	17,5 %

La régularité des fluctuations est très nette. Quant aux valeurs absolues atteintes, il semble que les minima soient d'autant plus bas que les précipitations sont plus abondantes mais il conviendrait de procéder à une interprétation plus poussée pour les expliquer. Celle-ci devrait prendre en considération non seulement la pluviométrie mais également l'évapotranspiration et l'état physiologique de la plante (état de forte ou de faible croissance végétative).

c - Evolution de la production de fécule à l'hectare

La production de fécule à l'hectare a été appréciée en faisant le produit du poids des racines par leur teneur en fécule.

On a noté que la croissance des racines tend à s'annuler pendant les périodes sèches tandis que ces périodes correspondent à un fort enrichissement en fécule de celles-ci.

La production de fécule a l'hectare a une allure générale croissante qui recouvre des périodes de forte croissance et dans certains cas des périodes de diminution temporaire.

Les périodes de diminution temporaire n'ont été observées qu'avec des bouturages réalisés en petite saison des pluies. Dans ce cas la diminution la plus marquée se situe à partir de Février ; elle se poursuit jusqu'en Mars ou Avril.

Elle correspond à un arrêt de la croissance des tubercules et à une diminution de la teneur en fécule.

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Il semble donc que pendant la période de Février à Mars, qui correspond aux toutes premières pluies de la grande saison, l'activité végétative de la plante mobilise des réserves amylacées de telle sorte que la quantité totale de fécule de la plante diminue de même, évidemment, que la teneur en fécule des racines.

Après cette période la teneur en fécule continue à décroître jusqu'au mois de Mai mais cette fois sous l'influence des fortes pluies et de l'effet de dilution qu'elles entraînent car la quantité totale de fécule devient croissante. Le poids des tubercules croît fortement sous le double effet de l'absorption d'eau et de la formation de fécule.

Dans le cas de bouturage en grande saison des pluies on n'a pas observé de diminution de la fécule totale, la diminution de la teneur en fécule dans les racines ne paraît être due alors qu'à l'effet de dilution.

Dans tous les cas les périodes de saison des pluies qui, à leur début, entraînent de faibles teneurs en fécule dans les racines sont peu recommandables pour procéder aux récoltes. La période qui se situe du 1er Avril au 15 Juin est la plus défavorable.

d - Variétés

Les éléments donnés ci-dessus se réfèrent à la variété Kataoli la plus largement cultivée dans le pays.

Les variétés introduites en collection se sont révélées en général inférieures aux variétés locales tant au point de vue rendement que teneur en fécule.

D'une manière générale la mosaïque ne paraît pas être un facteur limitant important.

Il est à noter que les clônes sélectionnés à Madagascar qui, dans leur pays d'origine, ont des teneurs en fécule comprises entre 25 et 30 %, voient au Togo leur teneur en fécule descendre à des taux extrêmement faibles qui les rendent inutilisables.

Les trois variétés locales ont été bien étudiées du point de vue de leur développement comparé à celui de Kataoli.

On observe notamment que la variété Goula présente des courbes de rendement et de teneur en fécule assez voisines de celles de Kataoli pour un bouturage en grande saison des pluies.

Pour un bouturage en petite saison des pluies la variété Goula s'avère plus précocement productive que Kataoli.

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La variété Dazane-Feto se caractérise par une forte productivité, une précocité analogue à celle de Goula mais de très faibles teneurs en fécule qui ne dépassent jamais 20 % et se situent généralement autour de 15 %.

Les essais statistiques montrent des différences nettes entre ces trois variétés.

Bouturage en petite saison des pluies :

Variétés	Juillet 10 mois		Décembre 15 mois		Mai 20 mois	
	Rendement	% fécule	Rendement	% fécule	Rendement	% fécule
Katsoli	2.380	21,7	5.010	21,7	8.825	19,6
Goula	6.120	24,6	8.012	25,2	11.739	18,7
Dazane-Feto	10.310	16,1	16.252	18	21.722	> 15

Bouturage en grande saison des pluies :

Variétés	Mai 10 mois		Octobre 15 mois	
	Rendement	% fécule	Rendement	% fécule
Katsoli	2.520	21,7	7.647	25
Goula	3.600	22,4	8.391	24,7
Dazane-Feto	13.124	15	23.479	15,3

e - Fertilisation

Les divers essais réalisés sur terre de barre montrent que celles-ci sont généralement carencées en azote (faible teneur en matière organique), en phosphore et en potasse.

Des essais factoriels de fumures appliquées sur maïs ont montré sur le manioc, venant immédiatement après :

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. des réponses linéaires à l'azote mais relativement peu importantes : 2 t/ha de racines pour 80 kg de N ;

. une réponse quadratique à la potasse avec un maximum pour 60 kg de K_2O qui accroît le rendement de 3,5 t/ha ;

. un effet du fumier : 3,5 t/ha de manioc pour 25 t/ha de fumier.

L'étude du développement des racines et de la fécule conduite à Agbessi sur trois variétés et à deux niveaux de fertilisation (0 et 40-40-60) montre que les courbes de croissance des tubercules avec engrais sont toujours situées au-dessous des courbes sans engrais ; vers les 8ème à 10ème mois de végétation l'excédent de rendement procuré par l'engrais est de l'ordre de 1 t/ha, vers les 20ème à 21ème mois de végétation il n'est que d'environ 2 t/ha pour Goula et Kataoli mais il atteint 3,5 t/ha pour Dazane-Feto.

Les essais statistiques réalisés à trois niveaux de fertilisation montrent :

1 - la meilleure utilisation de l'engrais avec les boutorages de grande saison des pluies :

moyenne des trois variétés récoltées à 15 mois

bouturages	Octobre	Mai
0	8.030	9.528
40-40-60	9.520	14.364
80-80-120	11.720	15.625

2 - la meilleure réponse à l'engrais de Dazane-Feto :

bouturage Mai	Récolte à 10 mois		Récolte à 15 mois	
	Kataoli	Dazane-Feto	Kataoli	Dazane-Feto
0	2.170	9.463	6.140	16.740
40-40-60	2.356	13.607	8.180	25.920
80-80-120	3.030	16.204	8.620	27.780

Il n'a pas été possible de mettre en évidence de façon nette une action des engrais sur la teneur en fécule.

f - Association culturale maïs-manioc

Des essais ont été réalisés au Togo et au Dahomey afin de dégager les effets réciproques du manioc et du maïs cultivés en association selon que le manioc est bouturé plus ou moins tardivement dans les champs de maïs.

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Lorsque le manioc est bouturé au moment du semis du maïs le rendement de ce dernier est diminué de façon significative d'environ 15 %, il passe de 35 à environ 30 quintaux.

Lorsque le manioc est bouturé 40 jours après le semis du maïs (première date suivante essayée) - ou plus tardivement encore - on n'observe plus du tout d'effet dépressif du manioc sur le maïs.

L'influence du maïs sur le manioc est plus difficile à analyser. Dans les essais relatés ici le manioc bouturé à diverses dates comprises entre le 1er Avril et le 29 Juillet dans le maïs était comparé à un manioc bouturé seul aux mêmes dates. Ainsi observe-t-on non seulement l'effet du maïs sur le manioc mais également l'influence des dates de bouturage sur le rendement du manioc. Il se dégage ainsi une date optimale de bouturage du manioc au cours de la grande saison des pluies qui se situe dans la première décade du mois de Mai. Pour cette date la perte de rendement due au maïs est de l'ordre de 30 %. Elle correspond à peu près au moment où le bouturage du manioc dans le maïs n'a plus d'influence sur ce dernier.

A mesure que l'on retarde le bouturage du manioc l'influence dépressive du maïs décroît mais la productivité du manioc bouturé seul décroît plus encore.

On peut ainsi réaliser une culture de maïs qui procure 35 q/ha et une culture de manioc sur laquelle on perd 6 t/ha environ par rapport à une culture faite sans maïs mais qui produit 6 à 7 t/ha de plus que celle que l'on aurait pu faire après récolte du maïs.

CONCLUSIONS

Il est encore trop tôt pour formuler des recommandations précises.

On a pu cependant montrer :

1 - que la variété Goula qui n'intervient que sur 15 % des surfaces cultivées est souvent un peu supérieure à la variété la plus largement cultivée Kataoli tant au point de vue du rendement que de la teneur en fécule et que cette supériorité est très nette pour les bouturages de petite saison des pluies ;

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2 - que la variété Dazene-Feto est très productive et précoce, donc intéressante pour les paysans mais qu'elle l'est peu pour l'usinier en raison de sa faible teneur en fécule.

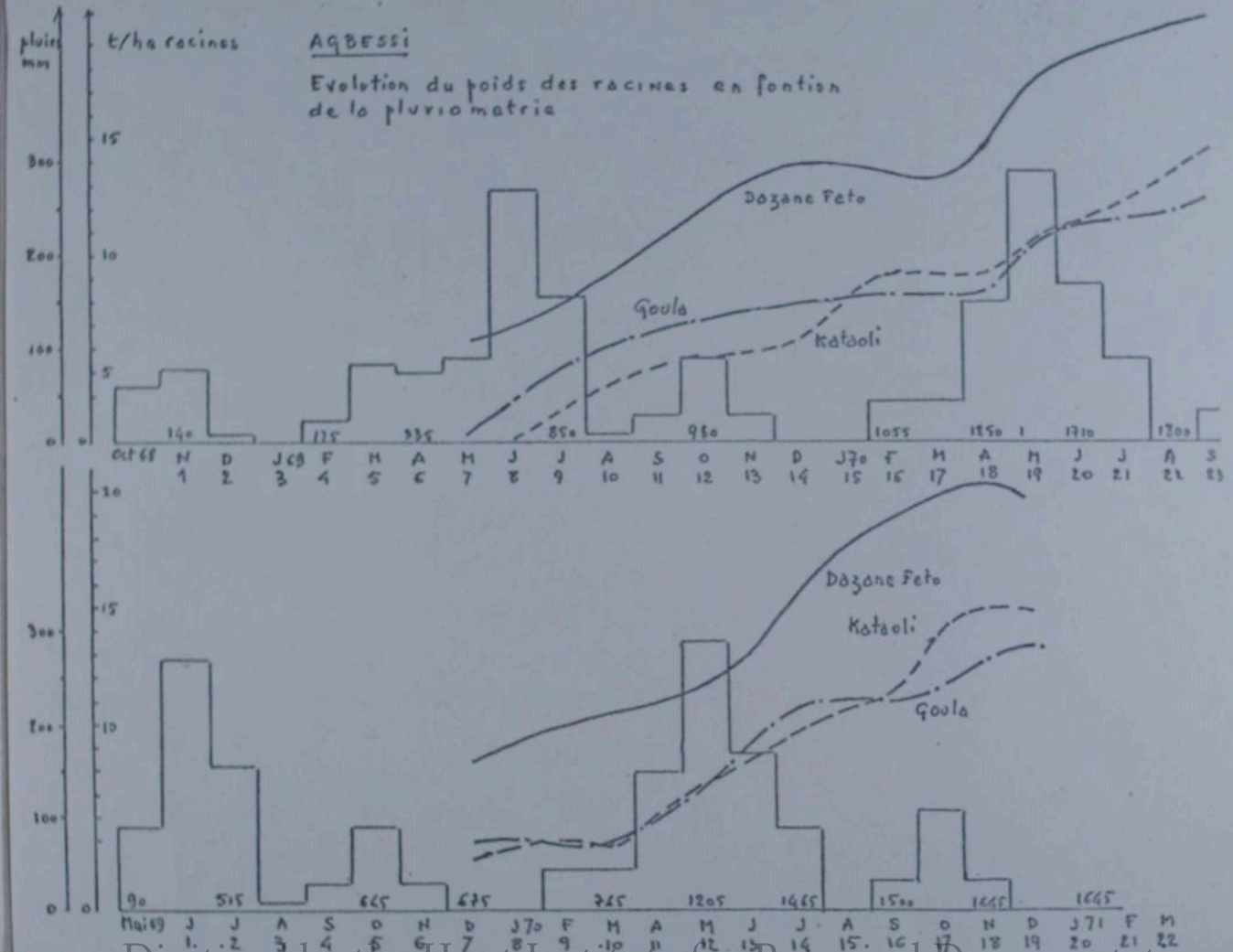
Dans l'état actuel cependant cette variété est la seule qui permette de rentabiliser la fumure minérale de sorte que l'on peut se demander si elle n'est pas intéressante pour tout le monde dans la mesure où sa culture avec engrais pourrait s'opposer à l'appauvrissement minéral des sols ;

3 - que les meilleures périodes de récolte se situaient en saison sèche au moment où le poids des tubercules atteint un palier et où les teneurs en fécule sont les plus élevées.

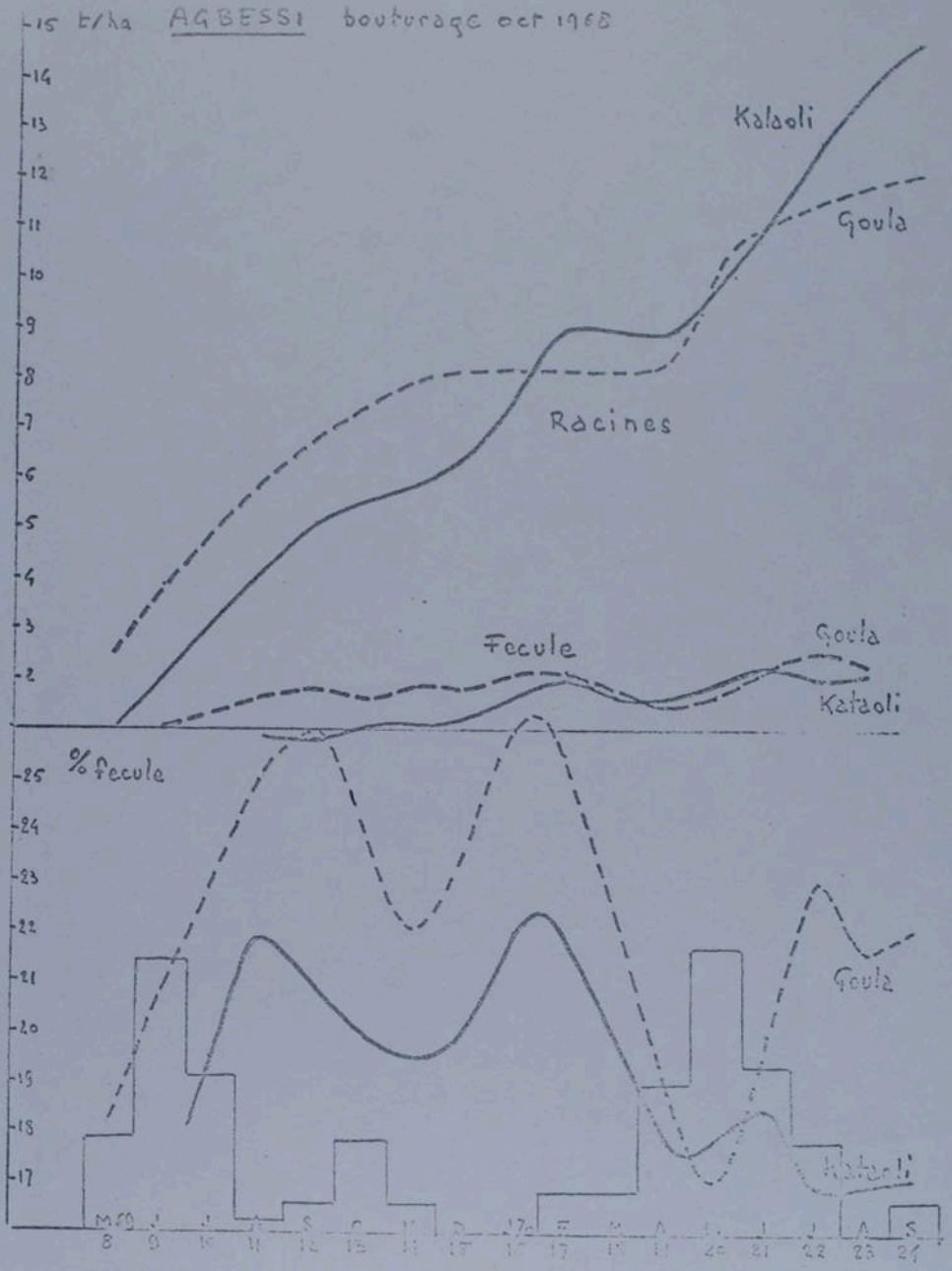
Une telle pratique permettrait, en outre, d'intensifier le système de production en autorisant la mise en place d'une nouvelle culture (maïs ou manioc) sans perte de temps, dès l'arrivée des pluies suivantes ;

4 - que l'association culturale maïs-manioc n'est pas à rejeter mais qu'elle contribue elle aussi à l'intensification du système de production.

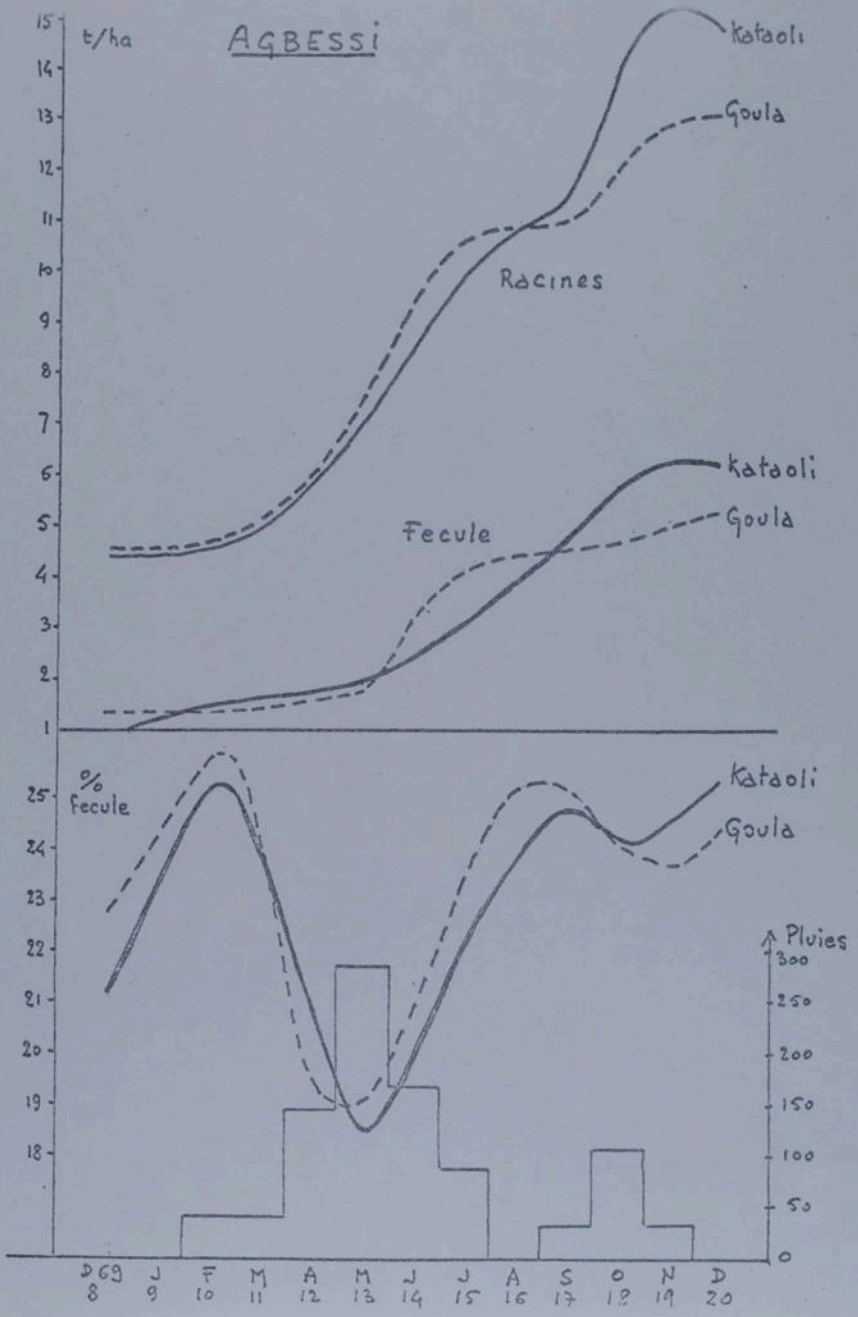
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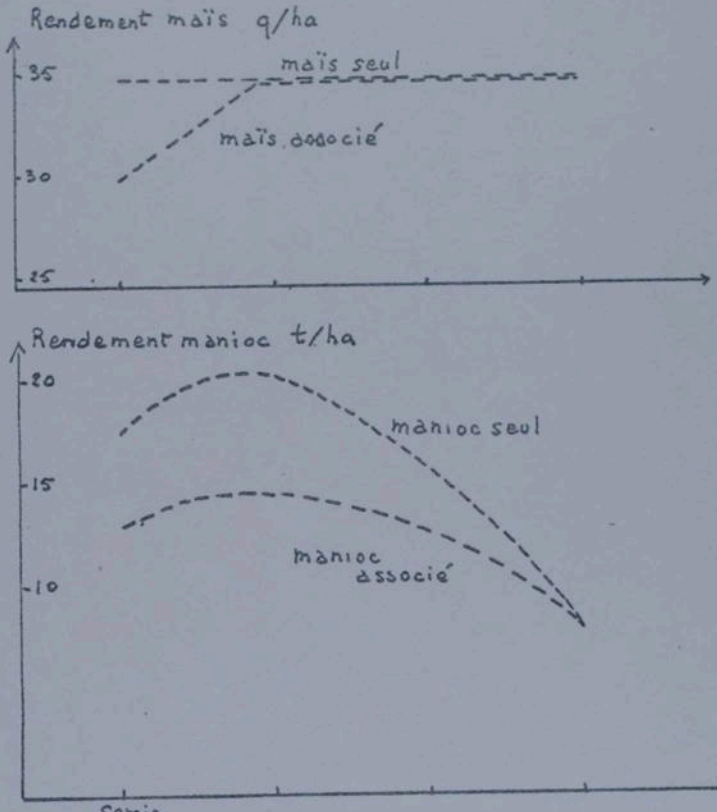
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ZOOTI

maïs var. Nidoulio semis 0,8 x 0,3 m
manioc var kataoli bouturage 0,8 x 0,8 m



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A "GREEN REVOLUTION" FOR TROPICAL AFRICA IN THE 1970S, AND THE ROLE OF THE AGRICULTURAL RESEARCHER

by

Haldore Hanson

A Paper to be presented at
An Agricultural Research Seminar
- on -

ROOT AND TUBER CROPS

at

The Conference Centre
The University of Ibadan
22nd-26th February, 1971

Mr. Haldore Hanson is the West Africa Representative of the Ford Foundation, 47 Marina, P.O.B. 2368, Lagos, Nigeria.

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The International Institute of Tropical Agriculture

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My remarks will suggest a place in African history for the present agricultural seminars.

I suggest that the agricultural scientists in this room, and their colleagues, can be a key factor in launching a Green Revolution in tropical Africa during the 1970s.

I suggest that this green revolution will concentrate on food crops.

I suggest that this green revolution will make it possible for nations of tropical Africa to feed themselves during the remainder of the 20th Century, despite a great increase of population.

I suggest that unless this green revolution begins soon, there will develop gradually, during the next thirty years, political unrest, accompanied by more military governments, more civil wars, more conflicts between African nations, and disruption of economic growth.

In short, I suggest that agricultural scientists hold a special responsibility to decide whether Black Africa can move forward economically.

To prove that power is in your hands, I propose to describe first the Green Revolution now taking place in Asia.

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Second, I offer my own explanation why the Green Revolution has not yet started in tropical Africa.

Third, I list the basic foodcrops of tropical Africa, which will require urgent increases, both in quantity and quality.

Fourth, I estimate the population growth in tropical Africa, which will raise food requirements.

Finally, I shall speak of the role of research in launching a green revolution for tropical Africa, and where your role lies.

What is the Green Revolution in Tropical Asia?

You have read much about a Green Revolution in Asia. Revolution is a journalist phrase. But it has a scientific foundation.

The "Green Revolution" in Asia refers to a sudden end of the old equilibrium in traditional agriculture, and the beginning of a chain reaction of continuous changes in food production methods.

The old equilibrium was based on poor soil fertility, poor moisture control, poor insect and disease control, poor weed control, and tough varieties, which had a low genetic yield potential, but which had aquired the ability, during centuries of natural selection, to tolerate this hostile environment. Everything in traditional agriculture was in balance, and unchanging.

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The "Green Revolution" which began after World War II and gained major momentum during the 1960s, involves a rapid interrelated change of all the factors of production. It employs new varieties of high genetic yield potential, accompanied by control of fertility, control of moisture, control of insects, disease, and weeds, which results in the achievement of much higher yields per hectare under commercial conditions. Yields have often doubled. These higher yields enable the cultivator to pay for the new inputs.

If this Green Revolution were not already happening in Asia, it would be very difficult to predict similar, rapid changes in Africa. Ten years ago, few people in Asia believed such rapid changes were possible.

I will repeat here only a few key statistics from Asia. Between 1964 and 1968, Asian farmers cultivating 15 million hectares (40 million acres) planted new varieties of wheat, rice, and maize. On the average, those who grew the new foodcrops with the recommended practices, doubled their yield per hectare. These new tropical food varieties include dwarf wheats from Mexico; dwarf rice from the Philippines; hybrid and synthetic maize from Mexico, India and Thailand.

The same new varieties of rice and maize which helped launch the Green Revolution in Asia have been available in tropical Africa since 1965. But so far there is no Revolution in Tropical Africa.

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We must logically ask why. I will suggest some answers.

Why no Green Revolution yet in Africa?

Tropical Africa has already had one green revolution. That was the development of export crops under the colonial administrations during the twenty years before 1960.

The green revolution for export crops was based upon the tree crops, oil palm, rubber, cocoa, and coffee, and industrial crops like groundnuts and cotton. For each of these crops, new technology was developed by the colonial administrators.

Basic foodcrops were little affected.

Why no revolution for food crops?

If we compare Asia and sub-Sahara Africa, we find that the food supply in Africa is more adequate; and that the methods of growing foodcrops are not the same in Africa. These differences may teach us something about the constraints to a green revolution for the future.

Let me comment on some of the differences between Asia and Africa.

1. Africans are not yet hungry. Asia's green revolution arose from hunger. Countries like India had experienced decades of food

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shortage, and the great Asian drought of 1966-67 was a major factor in the Green Revolution. Moreover, the food shortage in Asia was in carbohydrates, or the starchy foods, for which new technology was available.

Africans by and large are not hungry, and African Governments do not feel a food crisis. The carbohydrate situation in Africa is satisfactory for the present population. There are seasons of the year with more food than others. There are problems of transporting surplus food to deficit areas. But, in general, tropical Africa is growing enough starchy foods to feed its population.

The real food deficit of tropical Africa is in proteins. Protein deficit is greatest in the rain forest, or Guinean zone, stretching along the coast of West Africa, and deep into the Congo River basin.

In 1970, the lack of urgency in African food production is a factor which discourages a green revolution. However, as we shall discuss in a moment, the growing population will change this outlook.

2. The African farming system for food crops is very complex. As all of you know, subsistence food producers in tropical Africa generally use shifting cultivation and mixed cropping. These are complex systems to improve.

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The typical subsistence farming family clears the forest or bush from about three acres, but leaves the major trees and woody stumps standing, so that the tree roots will help hold the soil against torrential tropical rains. Within this half-cleared land, the family grows food crops for three to five years. Then weeds gradually multiply, and fertility declines. So the family lets the land grow back into bush, a form of fallow, for five, ten, or even fifteen years, and the fertility is restored, and the arable weed population is destroyed by shading and competition. The family moves its food crops to another area.

Mixed cropping is another feature of this farming system. The farmer, for example, mixes cassava, maize, and vegetables all in the same field at the same time. This assures complete ground cover, and thus helps to hold the soil against the heavy rains. The cropping mixture acts as a form of crop insurance. Some crops are more drought resistant, some can tolerate excessive moisture, some resist diseases and insects better. There is almost never a total crop failures.

This African farming system was a very wise choice, learned over centuries, to maintain soil fertility without fertilizer; to control weeds without herbicides; to prevent soil erosion.

The great liabilities of the system are, first, that it gives low yields per acre; second, that it requires a very great amount of labor for clearing the bush; and third, it is wasteful of land during the long fallow periods.

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New technology for a green revolution in Africa must start, therefore, with this question: How can the farmer improve his farming system, to grow maximum crops, to safeguard his soil fertility, and to prevent erosion?

This question cannot be answered from Asia. It must be developed by researchers in Africa.

3. Lack of Irrigation in Africa. Irrigation has hardly begun in tropical Africa. This region has few broad, flat, riverine plains or deltas suitable for irrigation. Africa has no Himalaya Mountain Range, 1,000 miles long, where perpetual melting snows feed a vast underground lake, from which Indian and Pakistani farmers lift irrigation water with tubewells or Persian wheels.

There are African streams to be harnessed, but fewer than in Asia. Underground water in Africa has not generally been mapped, and may be expected to be more limited than in Asia. Heavy rainfall in the African wet seasons can be impounded with bunds or stored in tanks, as in Asia, but there is no African tradition for these practices.

Irrigation was an important element of the Green Revolution in Asia. A farmer with irrigation will, on the average, produce three times the yield per acre, compared to a farmer without irrigation, even if the two farmers live side by side, employing the same climate and soils.

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In Africa, since World War II, some governments have built irrigation schemes based upon stream diversion, and the World Bank is now offering loans in this field.

Nevertheless, Africa begins the 1970s with no extensive irrigation systems in place, and a green revolution for African foodcrops must be based upon rain-fed crops, not irrigation.

4. Animal power and tractor power for cultivation. In Asia, most foodcrops are produced by farmers with animal power. They may use one buffalo or one camel, or a pair of bullocks or a pair of donkeys. Whatever the power, it is Asian experience that a farmer with animal power can prepare a better seedbed, and thus produce a bigger crop. Also, the farmer with animal power will, on the average, cultivate five hectares, or 12 acres per season, compared to the man with a hoe, who will cultivate one hectare. The ratio is 5-to-1 in favor of the man with animal power. When tractors are used, the ratio is of course much greater.

In tropical Africa, draught animals are little used. To some extent this is due to the tsetse fly. But even in areas where there are no tsetse flies, animal power is rare, and tractors are even rarer.

The wisdom of trying to introduce animal power or mechanization in Africa is a very complex social question. There is general belief that animal power and tractors will displace farm labor, and thus drive more rural population to the African cities, where unemployment is already rising. .....

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Nevertheless, some kind of supplemental power is needed in African agriculture, at least for peak labor periods, which means land preparation and harvesting.

The lack of mechanization is one of the restraints to a green revolution in Africa.

5. Marketing. Finally, there are marketing factors, which are prerequisites for a green revolution. Roads are needed to move the crop. There must be wholesale buyers for the crop. There must be storage. There must be credit. There must be processing industries, like rice mills, and the mills must be large enough, and efficient enough, to keep the price of milling down. Some countries have found it desirable to guarantee prices to the farmer for a few years, in order to persuade the subsistence farmer to grow more food than his family requires, and sell the surplus for cash.

In almost all these marketing arrangements, Asia has gone a long way during the 1960s toward solving the problems for larger food-crops. And tropical Africa is still at the beginning of these developments.

So we must include marketing arrangements as another constraint for a green revolution in tropical Africa.

Let me now repeat the five factors of food production which I have observed are different between Asia and Africa, and which represent constraints to a green revolution in Africa.

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They are:

1. Africa is not generally hungry, at its present level of population, and feels no food crisis.

2. The farming system for foodcrops in Africa is very complex, involving shifting cultivation and mixed cropping, for which improved technology is needed.

3. Lack of irrigation.

4. Lack of animal power or mechanization, at least for periods of peak labor requirement.

5. Inadequate marketing arrangements.

There are many other obstacles to a green revolution, but this list will serve our discussion.

You may properly ask: Why is anyone optimistic about an agricultural revolution in the 1970s? I would suggest first that the above problems existed in Asia, in varying degrees, only ten years ago, and Asia has made substantial progress in finding solutions during one decade.

But more important, it was the introduction of new technology in Asia that launched the Green Revolution. Developments of science have enabled the farmer to achieve higher yields, to make a bigger profit, and thus to pay for new inputs.

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African problems are not the same as those in Asia, and African solutions must be found in Africa.

This then brings us back to the subject of this seminar, which is the role of the agricultural scientist in launching a green revolution.

Let us therefore ask: What are the foodcrops with which a revolution in Africa will be concerned?

Foodcrops of Tropical Africa

A green revolution in tropical Africa will be concerned initially with the foodcrops which people eat today.

If you turn to the FAO Production Yearbook you will find that people in tropical Africa now grow and consume the following each year:

1.	Tuber crops, like cassava, yams and sweet potatoes	50 million metric tons
2.	Coarse grains like maize, sorghum, and millets	25 million metric tons
3.	Rice of all types	4 million metric tons
4.	Grain legumes	2 million metric tons

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These are the basic foodstuffs eaten in tropical Africa. One should add tropical vegetables, on which suitable statistics are not available. Also tropical pasture grasses, on which livestock are grown throughout the savannah zone of Africa. I suggest these six cropping groups are the keys to a green revolution in Africa.

Let me restate the list of cropping groups:

1. Tubers (cassava, yams, sweet potatoes)
2. Coarse grains (maize, sorghum, millet)
3. Rice
4. Grain legumes
5. Tropical vegetables
6. Tropical grasses suitable for animal production

It is logical that these six cropping groups are the areas of interest of the International Institute of Tropical Agriculture in Ibadan. The French Government research institutions have given much of their research effort in recent years to these six cropping groups. And the six cropping groups are the focus of these seminars.

It is not we who have chosen the crops. It is the people of Africa who have chosen them, by their eating habits.

Research on these crops will not be the exclusive jurisdiction of the biological scientist. Agricultural change is also a concern of the social scientist--especially the economist, and the scholar

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who studies community organization and community behavior. Social scientists have a place in these seminars.

Thus I have identified why we selected the program for these seminars.

Before we can move now to the strategy for research, however, we must speak about the size of population we are going to feed.

The Population of Tropical Africa, 1970, 1980, and Beyond

Thirty-two independent countries of tropical Black Africa have populations of 215 millions in mid-1970. This calculation excludes Angola, Mozambique, and Rhodesia, all of which lie within the tropical zone. If we consider their populations, tropical Africa contains 235 million people today.

This population is growing at an average growth rate of 2.5 percent a year. If people continue to multiply at the current rate, the population will rise as follows:

1970..... 235 millions
1980..... 325 millions
1990..... 450 millions
2000..... 600 millions

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Long before the population reaches 600 million people, some areas of tropical Africa will face a food crisis comparable to India in the 1960s.

Most African governments today believe there is no population problem and no food problem. Nevertheless, it must be the premise of agricultural scientists that Africa will very soon face a food problem, and work must start now on the new technology for food production, and on the marketing and other services needed to handle much larger food crops.

Role of Agricultural Research in a Green Revolution in Tropical Africa

Against this growing population, we are now able to present the role of the agricultural researcher in a green revolution.

In Asia the revolution of the 1960s began with new, high-yielding varieties of the principal food crops.

In Africa, we need new technology for the farming system, and within that system, we need new, higher-yielding varieties of maize, sorghum, millet, rice, cassava, and legumes, with improved agronomic practices which permit the full expression of the yield potential of the new varieties. This may mean a shift away from the traditional system.

In Asia, the development of new varieties began with a study of a world collection of each crop, especially a search for better genetic

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materials from the place of origin for each crop. For maize, this meant a search of Central and South America. For rice, it meant a search in Asia. For sorghum and millets, the search was in tropical Africa and India. For cassava, the original home is believed to be Brazil and other countries of Latin America. For yams, the home is said to be India, and tropical Africa. Cowpeas are thought to be indigenous to tropical Africa, but many other legume species, as, for example, the pigeon pea, originated in India.

The development of the new varieties was followed by the improvement of agronomic practices, for example, increasing plant density and the use of fertilizers and insecticides.

In Africa, a reasonably good world collection already exists for rice and maize. For other crops, even the world collection is still to be assembled and screened in tropical Africa.

Some of the agronomic technology generated in Asia is transferable to Africa, but most of this work requires adaptation to African conditions.

This vast research strategy for Black Africa will not be achieved by any one institution, or any one group of scientists. The 1970s will produce cooperative exchanges among all agricultural researchers in Black Africa. Even countries which do not presently have any agricultural research capacity will need to establish at least field stations, where they can verify under local conditions the research conducted by other countries.

This cooperative research in Africa will encounter a language problem not found in Asia. Tropical Africa contains 13 independent

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countries whose official language is English, and 18 countries whose official language is French. One country uses Spanish as its official language.

Those in these seminars know how much the researcher needs a free flow of scientific information between French-speaking and English-speaking research centres in Africa.

There will be continuing discussion on the form of an agricultural translation service which can move scientific results easily across the English-French language barrier.

Improved seeds, fortunately, speak no language. And it is important that the new genetic materials also should move freely across national boundaries, and be tested in all countries of Black Africa.

Conclusion

I come to my conclusion. These seminars are co-sponsored by three organizations: by IITA in Ibadan, by IRAT in Paris, by the Ford Foundation office in West Africa. These seminars, we expect, will give us an overview of the current state of foodcrop research in West Africa, and the current state of world technology in the crops most grown in tropical Africa.

Out of this review may evolve a strategy of research cooperation which could make possible the beginnings in the 1970s of a green revolution for tropical Africa.

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These seminars should enable approximately 300 scientists to get to know their counterparts in West Africa, and thus contribute to scientific exchanges, without which the green revolution cannot reach full momentum.

Let us hope our discussions contribute to one of the historic developments of tropical Africa in the 1970s.

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Basic demographic and economic data on 32 Independent Countries in Tropical Africa

Independent country	Capital	Independence year	Population mid-70 (millions)	Birth rate per 1000 population	Death rate per 1000 population	Current rate of population growth	GNP (US $ millions)	Percapita GNP (US $)
Western Africa English-speaking								
Gambia	BATHURST	1965	0.4	39	21	1.9	360	90
Ghana	ACCRA	1957	9.0	37	20	2.9	1800	200
Liberia	MONROVIA	1847	1.2	44	24	1.9	230	190
Nigeria	LAGOS	1960	55.1	50	25	2.6	4400	80
Sierra Leone	FREETOWN	1960	2.6	44	22	2.3	320	140
Sub-total			68.3	-	-	-	7100	-
Western Africa French-speaking (plus 1 span.-speaking)								
Cameroon	YAOUNDE	1960	5.8	50	26	2.2	750	130
Central Africa Rep.	BANGUI	1960	1.5	48	25	2.2	180	120
Chad	FT. LAMY	1960	3.7	45	23	2.4	260	70
Congo (Brazzaville)	BRAZZA.	1960	0.9	41	24	2.2	170	190
Congo (Kinshasa)	KINSHASA	1960	17.4	43	20	2.2	1570	90
Dahomey	PORTO NOVO	1960	2.7	54	26	2.6	220	80
Equatorial Guinea	SANTA ISABEL	1969	0.3	-	-	1.3	70	240
Gabon	LIBREVILLE	1960	0.5	35	25	0.9	200	410
Guinea	CONAKRY	1958	3.9	49	26	2.3	350	90
Ivory Coast	ABIDJAN	1960	4.3	50	25	2.4	1000	230
Mali	BAMAKO	1960	5.1	50	25	2.4	400	80
Mauritania	NOUAKCHOTT	1960	1.2	45	25	2.2	160	130
Niger	NUAMEY	1960	3.8	52	25	2.9	270	70
Senegal	DAKAR	1960	3.9	46	22	2.4	750	190
Togo	LOME	1960	1.9	50	24	2.6	190	100
Upper Volta	OUAGADOUGOU	1960	5.4	49	28	2.1	270	50
Sub-total	-	-	62.3	-	-	-	6800	-
Total, Western Africa			130.6				13900	

Source: 1970 World Population DATA SHEET
Population Reference Bureau, Washington, D.C.

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Basic demographic and economic data on 32 Independent Countries in Tropical Africa.

Independent country	Capital	Independence year	Population mid-1970 (millions)	Birth rate per 1000 population	Death rate per 1000 population	Current rate of population growth	GNP (US $ millions)	Percapita GNP (US $)
Eastern Africa English-speaking								
Botswana	GABORONE	1966	0.6	-	-	2.2	50	90
Ethiopia	ADDIS ABABA	1000	25.0	-	-	2.1	1500	60
Kenya	NAIROBI	1963	10.9	50	20	3.1	1200	120
Malawi	BLANTYRE	1964	4.4	-	-	2.5	260	60
Somali Republic	MOGADISCIO	1960	2.8	-	-	2.4	140	50
Tanzania	DAR ES SALAM	1961	13.2	47	22	2.6	1100	80
Uganda	KAMPALA	1962	8.6	43	18	2.6	900	100
Zambia	LUSAKA	1964	4.3	51	20	3.0	800	180
Sub-total			69.8				6000	
Eastern Africa French-speaking								
Burundi	BUJUMBURA	1962	3.6	46	26	2.3	200	50
Malagasy	TANANARIVE	1960	6.9	46	22	2.7	700	100
Rwanda	KIGALI	1962	3.6	52	22	2.9	200	60
Sub-total	-	-	14.1	-	-	-	1100	-
Total, Eastern Africa		-	83.9	-	-	-	7100	
Total, 32 Independent countries of Tropical Africa		-	214.5	-	-	-	21000	-

Source: 1970 World Population DATA SHEET
Population Reference Bureau, Washington, D.C.

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CASSAVA PRODUCTION IN WEST AFRICA

by

Brian Beck

A Paper to be Presented at
An Agricultural Research Seminar

- on -

ROOT AND TUBER CROPS

at

The Conference Centre
The University of Ibadan

22nd-26th February, 1971

Mr. Brian Beck is the Agricultural Research Specialist of the Ford Foundation, 47 Marina, P.O.B. 2368, Lagos, Nigeria.

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The first reliable record of cassava cultivation in West Africa was made in 1668 by Dapper, who noted the cultivation of this crop at Forcados and San Tome.

There is little doubt that the cassava seen by Dapper was grown around the slave barracoons. Sir Richard Hawkins records that the slave ships he captured during the seventeen hundreds used cassava flour to make cakes to feed the slaves, and it appears that during this period, the South American techniques for the production of cassava flour was well known to the slave traders. It would also appear that the slave traders used Amerindian techniques for the production of farina. In this technique, cassava tubers were peeled and grated and the product was put into a wicker sleeve, made in South America, on the end of which was hung a heavy weight. The flexibility of the sleeve under tension brought about the rapid expression of the juice of the tuber and almost complete removal of the cyanogenetic glucoside content of the tuber.

It is interesting to speculate how the slave traders brought cassava to West Africa. Almost certainly it was not brought as seed, for cassava seed are extremely difficult to germinate. It is most doubtfull if cuttings could have survived the traditional two stages of the"triangular trade".

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First from the West Indies to England with sugar. Thence, after protracted delays in Bristol or Liverpool, to the West African Coast with trade goods. The establishment of cassava on the West Coast of Africa almost certainly required that a slave ship should beat against the Trade Winds in a direct passage from South America to the Coast. We know this could be done and H. M. Royal Navy has the rather ridiculous claim that it was possible in under four weeks. If the Navy took four weeks, the slavars certainly could do the passage in three and it is reasonable to suppose that this is what happened. Long stem cuttings were brought by the slavers and cassava farms established around the barracoons.

This then leads to two hypotheses which I find very interesting and upon which I would value the comments of the meeting. If we look at the traditional diet of the forest dwellers, before the advent of the European, we are forced to one of two conclusions, either they were damned hungry, or there was an extensive trade in cereal grain from the Savanah areas. The latter is most unlikely in part because in the south there is no tradition of eating sorghum, millet or red rice and also because strangers were invariably waylaid and sold as slaves. Therefore we are forced to the opinion that the slave traders, who, were after, all essentially practical men, had explored the food resources of

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the Coast, found them wanting for the intense local demand of the barracoons, and had used food crops with which their servants were familiar and could prepare.

I will not enter into a discussion this morning on the effect this had on West African Maize Production which is a parallel case, but for cassava this was a most unfortunate occurrence. The number of types introduced by the slavers were very limited, their sexual fertility was low and although seedlings were produced by cross fertilization, they had little chance of establishment in a rotation system where minimum care was given to the crop. Most seedlings were smothered by weeds despite the fact that the African farmer will do all that he can to preserve a food plant. The amount of variation between cultivars on the West Coast is therefore very low. For example, after fifteen years of selection within 1,200 varieties of cassava in Nigeria, we have found only one which exeeds the average value of the yield plus twice the standard deviation of the range of variation. There has been a considerable amount of movement along the Coast of cassava varieties. This movement involved only the sweet varieties which could be eaten after cooking (roasting or boiling) and without processing. As I will say later, the great expansion of cassava production did not take place in

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West Africa until the knowledge of the fermentation process of the preparation of cassava was known.

I will digress a moment. We talk a lot of rubbish about "bitter and sweet cassava". These were terms developed by Dutch Chemists in Indonesia to fit a set of circumstances they observed in the laboratory without reference to the cultivation of the crop.

Certainly there are cassava varieties with a higher genetic potential for the development of cyanide than others. Certainly the level of cyanide can be affected by the level of nitrogen application, the degree of water logging of the soil, the age of the tubers at harvest, possibly by the phase of the moon, but certainly it is used as a vegetable throughout West Africa using tubers consumed after ten months from planting, without fear of poisoning from cyanide. I would therefore ask you to consider the papers that follow mine in this light. The amount of cyanide toxicity established in a variety, grown in a given environment is defined and clear cut. You must always be prepared for a difference in cyanide levels in material grown in your own environment and when it is grown elsewhere.

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There is also a great deal of nonsense talked about cassava yields. Very few of the experiments carried out in West Africa have determined the amount of starch produced per acre. Mr. Godfrey-Sam-Aggrey has a small instrument with him which he has used to measure the starch content of cassava tubers. I would value your opinions on the general usefulness of this device, obviously it has to be used under controled lighting conditions. But, if it is capable of giving repeatable results, it would be a great advance over the earlier techniques of the measurement of starch or sucrose, by polarimetric methods.

With the decline of slave trade, the original methods of preparing cassava was lost, partially because the local population had no tradition of wicker weaving and could not produce the sleeves for the extraction of the flour, and partially because cassava was regarded as a slave food and people were slow to adopt it.

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The subsequent development of cassava production in West Africa is largely the result of a fortunate accident. The methods of making cassava flour were reimported by the repatriated slaves who modified the efficient Amerindian process for the extraction of the juice, by placing the grated mass of peeled cassava roots into jute bags and squeezing out the liquor with the use of heavy stones and logs. This process was inefficient, as it took a considerable amount of time to express the juice. Collard has shown that during this prolonged period of pressure, a two-stage fermentation process takes place. The first stage of the fermentation is caused by Corynebacterium Manihot which produces organic acids by breaking down starch. The cyanogenetic glucoside is unstable at pH value below 7. The increase of acidity is sufficient to release gaseous hydrogen cyanide from the glucoside. A second stage of fermentation caused by Geotricum candida in the acidified mass results in the

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production of aldehydes and esters which give the cassava flour its characteristic flavour.

The flour is generally known by its Yoruba name of Gari. Gari making was known in Sierra Leone in the early nineteenth century and brought to Nigeria by the Missionary group which accompanied the Reverend Samuel Crowder to Nigeria. As in other West African territories, it is possible to collerate the expansion of cassava production with the spread of the knowledge of gari making. Gari is easy to store for periods up to six weeks and is cheap to transport.

In Nigeria, by 1920, cassava had become an integral part of the rotation system of the farmers of Southern Nigeria. It was traditionally planted as the last crop in the rotation before the bush fallow and was harvested as and when it was needed by the family. After establishment, it received very little care and maintenance and had to compete with the weed flora which had become established during during the early stages of the rotation. Yields are therefore low in this system and this has lead to the unthinking impression that cassava is not a productive crop. In point of fact, cassava well produces more calories per acre than any other lowerland crop other than sugar cane.

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In the early nineteen-twenties, the disease "cassava mosaic" was recorded in Ghana and Nigeria. The mosaic disease is transmitted by the whitefly Bemissia tabaci and within 10 years the entire crop in Southern Nigeria was infected with the disease. Mosaic is still spreading slowly northwards from the Coast. It is established that the disease can cause up to 80 per cent lost in yield. There is no known source of resistance to this disease within the species M. esculenta.

It has always been considered that the causal organism of cassava mosaic was a virus. There is now evidence which, I hope Dr. Galvez will present, that a similar leaf mosaic condition of cassava in Brazil is associated with a microplasma and not with a virus.

However, what ever it may be that causes cassava mosaic, Golding and latter Chant and Robertson have shown that transmission can be effected by the whitefly Bemissia and, in common with other whitefly transmitted viruses, it has not be possible to obtain transmission by mechanical means.

Both Storey in East Africa and Beck in West Africa have shown that it is possible to obtain resistance to cassava mosaic virus in hybrids between Manihot esculenta and Manihot glaziovii. Storey was able to incorporate this

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resistance into high yielding lines and obtained, on large scale plots, yields of over 40 tons per acre. Much of Storey's material has now been lost. Resistant lines are now available from the Federal Department of Agricultural Research at Moor Plantation. These varieties incorporate some of the genes for resistance from Storey's material, others from local races of M. glaziovii, which was introduced to West Africa as a possible rubber plant some forty years ago. It is interesting to note that many lines of M. glaziovii in Nigeria show leaf symptoms which closely resemble the leaf symptoms of mosaic in cassava.

Mosaic tolerant hybrids are also available in Nigeria. These yield between ten and fifteen tons per acre, and their parentage includes lines from the Caribbean. They show leaf symptoms of mosaic, but consistently produce yields 2.5 to 4 times the Nigerian national average.

No discussion of the future of cassava in West Africa could be complete without a mention of the potential of the crop as a stock feed. The early work of Oyenuga

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showed clearly that cassava tubers could form an important part of pig rations. The discovery by C.I.A.T. of cassava varieties with up to 7 per cent protein in the roots, together with the use of species such as M. saxicola and M. melanobasis as parents in breeding programmes will make the use of cassava more and more attractive to the West African animal producer (note: these high protein levels will have little immediate impact on human diet; for all that is left behind after the traditional methods of production is starch. To take advantage of these high protein varieties for human food, entirely new processing methods will be necessary, and the history of new methods of preparing traditional foods is not very encouraging.)

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In recent years there has been a developing interest by European countries in using dried cassava chips for stock feed. These export markets are quite large and have resulted in considerable changes in the traditional patterns of cassava cultivation.

The present position of cassava products in the traditional West African diet is for low-cost, high-calory material. This has been in part brought about by the traditional place of cassava at the end of a bush-fallow rotation. The plants were harvested as and when required and there was never a glut of cassava on the market. Cassava always used to form one of the most stable price indices in Nigerian markets.

Around the large towns which have developed in the last forty years, farmers have commenced to grow cassava as a cash crop. In periods of civil unrest this new system has not been able to maintain a stable price structure. It is also possible that the stability of cassava prices will be adversely affected from the point of view of the consumer by the development of large-scale production for animal feed.

In the medium to high rainfall areas of West Africa I would suggest that cassava will play a vital role in human nutrition and an increasing role in animal nutrition for the next century. I would put it to you that cassava will maintain this position despite the changes in diet I outlined in my preliminary address this morning. I would put it to the research institutions that there is an urgent need for concentrated research on this crop. Yields of up to 30T/acre are quite within the scope of development of actual research programmes in the next ten years. If you achieve this, gentlemen, you will find you will have to live with cassava for a very long time.

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Comsey on Yams
Reverse procedure -
Could not some wild forms
be "feral" derivatives
And, what are the boundaries
of the West African region
Could East Africa have
been earlier than W. Africa?
The high ploidy level
would indicate these cult. species.
derivative species are

The total ecological system of
approaching problems is of
extreme importance.

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S E M I N A I R E S U R
LES PLANTES A RACINES OU A TUBERCULES
Ibadan, 22-26 février 1971

LES USAGES POSSIBLES DES PLANTES A RACINES OU A TUBERCULES

par

C. MICHE

Chef du Service de Technologie de l'IRAT

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(1)

THE HISTORY AND THE POSSIBLE FUTURE OF YAM CULTIVATION IN WEST AFRICA

by
D. G. COURSEY

A Paper to be Presented at

An Agricultural Research Seminar

- on -

ROOT AND TUBER CROPS IN WEST AFRICA

at

The Conference Centre
The University of Ibadan

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INTRODUCTION

Of all the food crops of the tropics, few are as closely associated with a particular group of peoples, or particular cultural area, as are the yams with the West African peoples. Yams are, of course, grown and used in many other parts of the tropics, but nowhere else - except perhaps among the Melanesian peoples of New Guinea - are they so central a feature of day-to-day life. In much of West Africa, they are still today the preferred staple food among most of the inhabitants of the forest zone and of the southern parts of the savannah, while they were, of course, relatively more important in early days, before the introduction of American food crops such as maize (Zea mays L.), cassava (Manihot esculenta Cranz) and "new" cocoyam (Xanthosoma). It is, perhaps, no coincidence that the great medieval empire-states of the forest zone of West Africa - Ashanti, Ife, Igbo Ukwu and Benin - arose in areas where yam may have played a part in the evolution of these cultures. Although the paramount position of the yams has been affected to some extent by the introduction of first the Asiatic Colocasia or "old" cocoyam (probably about 1,000 years ago) ; next, of the American crops just mentioned ; and, most recently, within living memory, of Asiatic rice, they are still crops of major importance. African cultural patterns tend to be strongly oriented towards the staple carbohydrate food item in the food/agriculture complex (Uchendu, 1970) and through much of West Africa the yam is still a prominent factor in the

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cultural life as well as the material subsistence of the population. Prior to the widespread impact of western European ideologies and education during the present century, rituals associated with the yam harvest and other events in the yam farming calendar were major cultural junctures in the year among most West African ethnic groups (Coursey and Coursey, in preparation) and the yam harvest was regarded as the equivalent of the New Year.

In this paper, the word "yam" is, of course, used in its exact sense as referring to useful members of the genus Dioscorea. The name is often mis-applied to sweet potatoes, aroids, and other tropical root crops, but all such uses are incorrect. It is of interest to note that this is one of the comparatively few words of African origin to be absorbed into European languages: it is derived from the Mande 'niam' or Temne 'enyame'. The genus Dioscorea is the type, and by far the largest, genus of the Dioscoreaceae, and contains some six hundred species of pan-tropic distribution. The Dioscoreaceae are monocotyledons, formerly classed with the Liliales (Burkill, 1960; Coursey, 1967), although recent studies on certain African species (Lawton and Lawton, 1967) have demonstrated the existence of non-emergent second cotyledon in the embryo and young seedling. The most recent botanical revision (Ayensu, 1966; and under publication) establishes the order Discoreales, within which are the lower orders of classification given in Table I.

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It would not be appropriate here to discuss in great detail all the past work on the edible yams, as adequate recent monographic treatments covering most aspects exist (Waitt, 1963; Coursey, 1967; Coursey and Martin, 1970) although we shall in this paper refer to a few very recent developments. Summarising, the yams which are important as crop plants originated in areas of tropical rain forest to savannah where there were sharply demarcated rainy and dry seasons and it is mainly in such regions that they are economic plants today. During the rainy season the plant grows as a 'vine', which twines, often for many metres, through trees or underground: in cultivation, the vines are usually trained on stakes, strings or wires. The vines bear racemes of inconspicuous flowers, the male and female flowers always being separate, and usually occurring on separate plants; the female flowers being followed by dehiscent capsules containing the seeds, which are winged for dispersal by wind. At the end of the rainy season, the vine dies down, and the plant persists through the dry season in the form of dormant tubers. It is these tubers, which are the natural food storage organs of the plant which are economically useful as human food.

The tuber may be an annually renewed organ, as is the case in all the edible forms, or may be perennial, becoming larger and progressively more lignified from year to year, as in many other species, while a few of the more primitive

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members of the genus are rhizomatous, rather than tuberous. The tuber has generally been regarded as being organographically a stem tuber: recent studies on certain West African species (Lawton and Lawton, 1969) have indicated that at least in these species the tuber arises from the hypocotyl. The whole question of tuber genesis in the Dioscorea is one which needs considerable further attention.

Yams are propagated vegetatively in normal agricultural practice, by means of "setts" - small tubers or pieces of tuber. Centuries if not millenia of this process of vegetative propagation have reduced the sexual fertility of many of the cultivars, so that they flower comparatively seldom, and even less frequently set fertile seed.

THE ORIGINS OF YAM CULTIVATION

The yams appear to be amongst the oldest of man's foods. Wild yams are extensively used to this day by the few pre-agricultural peoples still surviving in various parts of the tropical world - such as the Australian aborigenes (Maiden, 1889) - and in at least some cases even the most primitive peoples have developed some concept of protecting the wild plants, (Burkill, 1953) which may represent the first step towards agriculture. This concept of protecting a wild food plant appears to be present in the West African idea of the New Yam Festival, which may be a social survival from very early,

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pre-agricultural, times. There is thus every reason to suppose that the use of yams as food goes back to the earliest days of man's history. In West Africa, Davies (1967; 1968) has related paleolithic artifacts, provisionally dated as far back as 50,000 years B.P., to the gathering of wild yams, although it would not, of course, be reasonable to suggest that agriculture is so old. There are archaeological records of horticultural civilizations, dated around 9,000 B.P., in the area of South-East Asia where the cultivation of D. alata is believed to have originated (Gorman, 1967), and also successions of artifacts which can be associated with root-crop utilization dating back very much further (Harrisson, 1963) in other parts of the same area.

True yam-based agriculture appears to have developed quite independently, but almost simultaneously, in West Africa and in South-East Asia, (Alexander and Coursey, 1969) around 5,000 years B.P., possibly as a result of cultural interactions between pre-agricultural peoples who exploited wild yams for food (possibly with some degree of protection of the plants) and early Neolithic grain-using agriculturalists who, at that time, were moving southward from the Sahara in Africa, and into the Malay Peninsula in Asia. Different, although similar, species of yam were brought into cultivation in these two areas.

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The process of domestication of a vegetatively propagated crop such as the yam should not be thought of as a sudden cultural change, comparable to the 'Neolithic Revolution' which occured in south-western Asia with the beginnings of grain-crop agriculture in that area (Harris, 1967; 1969). Rather it should be seen as a gradual change, taking place over centuries or millenia, during which the intensity of the symbiotic relationship between man and the crop plant gradually increased, until eventually a true agricultural complex emerged. The principal species of yam which have been domesticated in different parts of the world are given in Table 2.

The Asiatic yams, especially D. alata and D. esculenta became disseminated in cultivation throughout South-East Asia, the Indian sub-continent, the Indonesian archipelago and the Pacific Oceans in fairly early times, probably more than 2,000 years ago, and certainly long before European contact with the areas. At least the former species reached Madagascar, and probably the East African littoral, about 1,500 B.P. or earlier, as a result of Malaysian contacts with Madagascar. Nevertheless, it is quite unreasonable, in spite of the views which have been expressed by many Africanists such as Murdock (1959) to suppose that they reached West Africa, or had any influence on the development

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of West African yam cultivation at that time (Coursey and Alexander 1968; Posnansky, 1969). It appears that D. alata was introduced to West Africa by the Portuguese in the 16th century: illustrations of this species, from the island of São Thomé were published about 1,600 A.D. The other Asiatic species, D. esculenta, has been grown in West Africa only very recently; in fact, it appears to be a deliberate introduction of the Colonial era (Miège, 1948) and is still grown only to a limited extent.

In West Africa, yam cultivation was originally a purely indigenous development (Coursey, 1966; 1967) and the main species grown, the typical West African "White Yam" D. rotundata, is not known elsewhere in the world, except as a comparatively recent introduction. Not only does the cultivation of yams antedate European contact (Clark, 1962), but one of the earliest Portuguese navigators who visited the Coast during the 1490 s writes of an extensive river trade in yams between Bonny, in the Niger Delta and the yam-growing areas "hundreds of leagues" inland (Pacheco Pereira, 1505). The great amount of ritual, ceremony and superstition which surrounds almost every aspect of yam cultivation and utilization also indicates the great antiquity of their use (Coursey, 1968; Coursey and Coursey, in preparation) in West Africa.

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The Yellow Yam D. cayenensis, which is also of some importance as an economic plant, occurs in the wild state throughout the West African forest zone (where the dry season is short) and was doubtless used, together with other wild species, by the earliest human inhabitants of the area. The exact process by which D. rotundata was developed is not known: it is a true cultigen, unknown in the wild state except as an escape. Its true taxonomic status has also been the subject of much confusion. The species was taxonomically defined from type material derived from cultivated plants in Jamaica in the eighteenth century, by Poiret, who believed it to be indigenous: D. Cayenensis was similarly described by Lamark from cultivated material in French Guyana (the specific name is from the town of Cayenne) at about the same time, and was also then believed to be a native American species. The two are certainly very closely related, and indeed several authors (Chevalier, 1936; Miège, 1968) regard D. rotundata as merely a subspecies of D. cayenensis. There are, however, biochemical differences in the polyphenolics present (Bate-Smith, 1968) and substantial differences in the vascular anatomy (Ayensu, 1970) which justify the separation, although the colour of the tuber is not alone sufficient to distinguish between the two species reliably.

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The most plausible explanation of the origin and status of D. rotundata is that it is of hybrid origin, D. cayenensis being one of the parents, as was originally suggested by Burkill (1939). The other genetic contribution to its ancestry must have been a savannah species, possibly D. abyssinica Hochst. or D. praehensilis Benth., which gave the hybrid the capability of adaptation to dryer climatic conditions (more critically, a shorter growing season). Such hybrid forms may often have arisen spontaneously at the fringes of the forest and savannah, but were not favoured by the natural ecology, and did not survive in the wild. After the advent of Mesolithic man, who had some concept of protecting his food plant resources, and, even more, of Neolithic man, with his systematic cultivation of plants, new ecological niches were formed, which favoured the survival of the ancestral forms of D. rotundata. These were recognised by man as superior food plants to the wild Dioscorea and other roots which he had been using hitherto, and were gradually selected and ennobled into the profusion of clonal cultivars that exist today. Different cultivars arose from different initial chance hybridizations, and from subsequent further hybridizations and so the proportions of genetic material derived from the two (or more) ancestral species can vary between cultivars: somatic mutation is likely also to have played a part. In situations such as this, where cultivars have emerged over centuries of vegetative

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propagation, it is highly questionable as to whether strict Linnean concepts of taxonomy are applicable: the approaches adopted by Simmons (1966) for the bananas, or the statistical taxonomy used by Rogers (1967) for cassava may well be more appropriate. A great plurality of cultivated forms of the species is now known and these are now predominant types of yam grown in most of West Africa. It is interesting to note that in several distinct West African languages, the name given to yams of this species signifies "proper yam" or some similar concept. In some parts of West Africa, D. dumetorum is fairly widely used, though some forms are highly poisonous.

A few indigenous American species of yam, notably D. trifida L.f., were used and domesticated by Amerindian cultivators before Hispanic contact with the New World, but they never attained the status of major crop plants, probably because of the availability of the more easily cultivated and less seasonal cassava. Subsequent to European contacts with tropical America and the Caribbean, the more important species of yam from both Asia and Africa were introduced, and today these are far more extensively grown in this area than are any of the indigenous American Dioscorea species. Forms of D. alata are the most popular in the eastern Caribbean, but in Jamaica and Puerto Rico, and much of the mainland the African species are preferred.

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THE PRESENT STATUS OF THE YAMS

It has been estimated that the current production of tropical root crops is of the order of 140×10^6 tons/annum. This represents 200 Teracalories of energy, or the staple food of around 4×10^8 people: almost one third of the total population of the tropical world (Coursey and Haynes, 1970). About half of this total is derived from cassava, and around 12 per cent from yams. Although these estimates are necessarily very approximate, they indicate that yams already make a sizeable contribution to the feeding of the tropical world, and indeed a much larger one than is commonly realized. The main area of yam production is West Africa, but the Caribbean, parts of South-East Asia, New Guinea and the Pacific are also major yam producers.

Production of yams in West Africa is largely confined to the West African "Yam Zone" (Coursey, 1965, 1966). This area, once described by Miège (1954) as "la civilisation de l'igname", extends from the central Ivory Coast to the Cameroon mountains, spanning both the forest and the more southern (i.e. more humid) parts of the savannah. Within it, about two thirds of the yams in the world are grown: indeed, Nigeria alone produces almost half the world's yam crop. The distribution of production is indicated at Figure 2 (Morgan and Pugh, 1969). Within this area of major yam production, yam was formerly the main staple

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food. During recent decades, yam has been displaced to a substantial degree by the hardier, more accommodating, more easily grown, but less nutritious cassava, but even today it may be calculated from production and demographic statistics that the average inhabitant of the "Yam Zone" consumes between half and one kilogramme of yam daily, representing between a quarter and a half the total calorific intake.

Virtually the whole of this production is derived, both in West Africa and in other yam-growing parts of the world, from the activities of peasant farmers. The cultivars they grow have not been developed by any systematic process of selection; particular cultivars are often grown for traditional reasons; cultural practices are simple; fertilizers are rarely used. Under these conditions, yields are often low, often only 5 to 10 tons/hectare, or even less. It should, nevertheless, be emphasized that the West African peasant is often possessed of a great fund of valuable knowledge and experience of his crops: although this is not expressed in scientific terms, it should not be neglected by the agricultural scientist. His cultivars, although not produced by conscious application of scientific method, have been evolved over thousands of years to optimal adaptation to prevailing ecological conditions. Under better conditions, such as prevail at experimental stations, far higher yields -

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have been obtained, using the same virtually unimproved cultivars. The figures in Table 4 (selected from Coursey, 1967, except where otherwise indicated), show the very high yields that have been attained with even the existing yam cultivars. Even when the high moisture content of the yam tuber is taken into consideration, the yams are thus found to be biologically exceedingly efficient producers of human food. Using the approach of de Vries et al. (1967), and converting these yield figures to calorie production (which enables foods of different moisture contents to be compared effectively), they are equivalent to 62 to 266 Cals/ ha/day x 10^3, if a nine-month growing season is assumed. The better of these figures compare favourably with optimal caloric production figures for the tropical grains (115 to 200).

Root crops often tend to be looked at unfavourably by Western-trained scientists whose views on matters relating to food and agriculture may be influenced by the folk-ethnocentricism of their own cultures (Uchendu 1970). For this reason, even when their potential for high food calorie production under certain tropical ecosystems is admitted, they are often regarded as inadequate sources of protein in the diet, when compared to grain staples. This is regrettably true of cassava, but yams (and aroid crops such as the cocoyams, Colocasia and Xanthosoma spp.) contain substantial amounts of crude protein, when the results are expressed on a dry-

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weight basis, the few figures available in the literature ranging from 4% to 7%, and occasionally higher. The writer has encountered forms of D. alata in New Guinea which have been reported as containing 12% protein (as crude N) on a dry-weight basis. If the Utilizable Protein value is considered (Payne, 1969), yam may be only marginally inferior to maize and rice - the major tropical grain staples. Yam-based diets, therefore, should need relatively little supplementation with high-grade protein, compared, say, with cassava or plantain-based diets, except for those sub-populations, such as young children or pregnant or lactating women, who have higher than normal protein requirements. The quantity of yam normally consumed in West Africa in diets based on this staple is sufficient to supply almost a third of the basic protein requirement for an adult male: it may well be that the incidence of malnutrition, especially in urban populations, reported in recent years has been associated with the partial displacement of yam by cassava in the diet. Regrettably, little is known, however, about the amino-acid composition of yam proteins: the results given by Busson (1963; 1965) suggest that the sulphur-containing amino acids and tryptophan are the principal deficiencies in its composition. There is, in any case, likely to be appreciable variation between species and cultivars, which has not to date been investigated, although this could be a fruitful field for research.

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Yams are also nutritionally useful in that they supply substantial amounts of minerals and vitamin C to the diet. It has been shown (Coursey and Aidoo, 1966) that the quantities of yam normally eaten in West African diets can supply the entire requirement of vitamin C. Smaller but still useful amounts of some of the B vitamins and mineral elements are also present.

THE FUTURE PROSPECTS OF THE YAMS

The high capacity for food production possessed by the yams, which has just been illustrated, has been achieved with material which has admittedly undergone selection over the thousands of years that yams have been used by man, but little or no selection on a rational scientific basis. Hardly any systematic selection and multiplication of improved varieties has been done to date, and essentially no breeding. Attempts at breeding made in Nigeria some years ago (Waitt, 1959-61) were not highly successful.

The point has been made elsewhere (de Vries et al. 1967 ; Coursey and Haynes, 1970) that many of the grain crops, and other temperate crops such as the potato, have already been so improved by plant breeders that the theoretically attainable limit of production is now being fairly closely approached. The tropical root crops, including yams, which are virtually untouched by plant breeders, should be capable of being improved very substantially even with a limited amount of effort. During the last few decades, in

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England, potato yields per hectare have been almost doubled. (Duckham, 1968): it should be possible for something similar to be accomplished in West Africa with yams.

Such an improvement can only be achieved by a concentrated effort devoted simultaneously to:
(a) selection and multiplication of the best existing cultivars
(b) breeding
(c) dissemination, through extension services, of the products of these two lines of research.

Among the first problems which must be overcome in any attempt to improve the yams is the lack of satisfactory records and "living museums" of species and cultivars. The major edible species, D. rotundata, D. cayenensis, D. alata, and D. esculenta exist in a profusion of cultivars, many of very localized occurrence, known only by vernacular names. The majority of these cultivars represent distinct clones, between which there is great variability in nutritional quality, yield potential, adaptation to different climatic regions, and many other factors.

Attempts have been made to build up and classify living plant collections of D. alata cultivars in Malaysia (Burkill, 1917-19) and more recently in the West Indies (Gooding, 1960), while more general collections have been

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made in Nigeria (Waitt, 1959-61) and the Ivory Coast (J. Miche, private communication). Recently, collecting work has been re-started in Trinidad, as part of an integrated approach to root-crop problems (Haynes, 1970), and by the USDA in Puerto Rico. (F. W. Martin, private communication).

The collection and enumeration of existing cultivars at a suitable, stable "living museum" is an essential preliminary to effective work on the improvement of yams as crop plants. In view of the high degree of variability, it is desirable that such a collection should be made on a world-wide basis.

Attempts to improve yams by breeding have been hampered by the infrequent flowering and poor seed setting of many of those cultivars which, from an agricultural point of view, are the most desirable: by the dioecious nature of the yam plant, many of the better cultivars being made: by the flowering of male and female plants of different times: by the incomplete opening and poor pollen release in male flowers in some forms: and by the fact that most cultivated forms are high polyploids (Waitt, 1959-61); F. W. Martin, private communication). Essentially no effective work has been undertaken so far. It may be noted, however, that very recently seeds of good cultivars of D. rotundata have been successfully germinated in Ghana (E. V. Doku, private communication), and the plants produced

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have, themselves, flowered. Flowering in cultivated yams may be stimulated simply by allowing the plants to grow unchecked for several years, and so reach full sexual maturity, which they do not under ordinary field conditions where plants are regenerated annually from small tuber fragments. Auxin treatments may also prove to be useful.

Wild yams, many of which are occasionally used as collected food, have, of course, retained their sexual fertility. These species are prospective seed parents for plant breeding work in conjunction with cultivated forms as pollen parents. In this context, it should be mentioned that, although the greatest natural variation of the genus Dioscorea occurs in the New World, only a single American species (D. trifida) has been brought into cultivation to any significant extent. This species sets seed freely (Henry, 1967), and appears to be a promising starting material for plant breeding work. Whether successful hybridization between American and Old World species, which are genetically far apart, can be achieved has not yet been established. However, in connection with work on drug-containing Dioscorea, successful hybridization between D. deltoidea Wall. and D. sylvatica Eckl., which are also genetically disparate, has been achieved (Wilson, 1966).

In any programme of selection and breeding, aims must be clearly defined. Improved yield constitutes an obvious aim. However, yams of some known cultivars are already of

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such excellence in this respect that some secondary aims may be of greater practical significance, at least as far as breeding is concerned. Particular attention to the following aspects could be fuitful:-

1. tuber size and form, to allow the application of mechanical harvesting techniques;

2. industrial processing characteristics;

3. maximum response to fertilizer treatment (many existing forms show little positive response (Ferguson and Haynes, 1970).

4. enhanced nutritional value: this should concern not only protein content, but amino acid spectra of the protein;

5. good storage life in the fresh state: this is associated with a low level of metabolic activity during dormancy;

6. adaption to various ecological conditions.

The yams present many serious problems to the plant breeder, as has been mentioned above. However, many somewhat similar difficulties have successfully been overcome in other crops, notably the banana (Simmonds, 1966).

A factor which has so far been a deterrent to systematic work on yams has been the conventional method of propagation by tuber cuttings. The very limited number of planting setts which can be obtained from one tuber means that a multiplication rate of only two- or three; or at best five- or six-fold per year, can be obtained. Much more rapid

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techniques are now available: vine cuttings provide means whereby a particular strain can be multiplied twenty-or thirty-fold, or perhaps even more, per year. This technique has been developed mainly in connection with the drug Dioscorea, but is equally applicable to the edible yams (D. G. Coursey, unpublished work). Potentially even more efficacious are meristem culture techniques, which have been applied successfully to several crop plants (Nickell and Torrey, 1969); some experiments have already been made with D. bulbifera (J.R.S. Lawton, private communication) and D. sansibarensis (Rao, 1969). Some further development work on these techniques is needed before they can be extensively applied as every-day propagation methods, but it is not anticipated that major difficulties will arise.

The yams which have been most highly ennobled during the long history of their cultivation are those, such as D. alata and D. rotundata which produce a single large tuber, or, at most, a few: these appear to have been favoured by peasant cultivators who use manual cultivation techniques. When grown under more favourable conditions than normal, these species usually respond merely by producing abnormally large tubers (Haynes and Coursey, 1969) which can be extremely difficult to harvest, rather than additional tubers. From the viewpoint of the development of mechanized agriculture, on the other hand, plants producing larger numbers of individually smaller tubers would be at an advantage

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(Haynes, 1967): D. esculenta and D. trifida would probably be highly promising species for study in this context. Apart from the comparatively few Dioscorea species which are currently of economic importance as food crops, many others find occasional use, as famine foods, or as seasonal relishes collected from the wild. It is known that many Discorea species are remarkably plastic in cultivation, of which fact advantage may be taken. For example, D. dumetorum is highly toxic in the wild state, owing to the high content of dihydrodioscorine in the tubers, but after only a few seasons of cultivation, and annual propagation from tuber fragments, the toxicity is greatly reduced: the reverse process occurs when cultivated plants revert to the foral stage. (D. G. Coursey, unpublished work). Similar considerations are said to apply to the Asiatic D. pentaphylla (Burkill, 1924). It may well be partially chance that led to the selection by primitive man of the ancestors of the few cultivated yam species that we use today out of the 600 species that are known. Many of the remainder might also be ennobled to yield useful crop plants, if subjected to the appropriate ecological pressures, in cultivation, after systematic selection from the wild, quite apart from their possible value for hybridization work.

We live at a time in human history when serious attention is, at least, being given to the deleterious effects that human activities can have on the environment. So, in

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considering the future prospects of a crop plant or of an agricultural complex we need to evaluate not only its potential capacity for helping to feed the 'exploding' world population, but also for maintaining an economically useful level of production, without inflicting severe damage on its ecological matrix. Traditionally, the practices of 'shifting cultivation' that are the norm in most of the yam-growing parts of West Africa, and indeed of most of the tropical world, have been subjected to much criticism by agricultural scientists as being highly destructive of the environment. However, it is now fairly well accepted (Gourou, 1966) that shifting cultivation, with bush fallowing, can be a highly satisfactory method of protecting the comparatively fragile tropical soils if, though only if, the period of bush fallowing is sufficient for the recovery of soil fertility and structure between one cropping phase and the next.

In recent studies of traditional cultivation practices in tropical America - under climatic conditions not vastly different from those of West Africa - Harris (1969) has shown that the conuco farming systems, based on vegetatively propagated root crops, are inherently more stable ecologically than are the milpa systems of the same area, which are based on a complex of seed crops, principally maize, legumes and cucurbits, and give substantially less opportunity for soil erosion to take place. There may be a lesson here for those

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concerned with the future development of food-crop production in West Africa.

It is necessary for developments towards complex mechanized agricultural systems to be made with due caution, especially when dealing with a crop, such as the yam, which is not yet well understood from the view point of agricultural science, and which is so different from most of the crops for which mechanized systems have been developed. In this context we should not only heed the warnings of the "dust bowls" of central USA and such ill-fated tropical agricultural operations as the Tanganyika Groundnut Scheme, but also bear in mind the basic energetic relationships of mechanized agriculture. This factor is beginning to give rise to some concern: when manual and mechanized agricultural farming operations are compared, from the point of view of energy inputs per calorie of food produced (Black, 1971), it is seen that, although mechanization reduces - by a factor of ten to a hundred times - the amount of human effort needed to produce a given quantity of food, it does so only at the cost of expending fossil fuel resources of up to five times the calorific value of the food produced.

To close, then, it must be emphasized that the future development of yam farming in West Africa can make a useful contribution to the economy and to the quality of human

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sustenance and life in the region. But it can do so only with a proper appreciation of the place of the crop in both material and human ecologies. For this, while looking to the future, and making the massive infusion of modern scientific and technological method into the improvement of the yams as crop plants and into the practice of their cultivation that is needed, we must at the same time draw on the past. The interrelationship of man and yam in West Africa has been built up slowly and gradually over many thousands of years: the introduction of scientific methods should make an upward turn in the graph of progress in this relationship: it should perhaps be a point of inflexion, but it should not be a discontinuity.

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Table 1

Structure of the Order Dioscoreales

Order	Family	Genus
Dioscoreales	Dioscoreaceae	Avetra
		Dioscorea
		Rajania
		Stenomeris
		Tamus
	Trichopodiaceae	Trichopus
	Roxburghiaceae	Croomia
		Stemona
		Stichoneuron

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Table 2
Cultivated Yam Species

	Africa	Asia	America
Major spp.	D. rotundata Poir[a][b]	D. alata L.[a]	D. trifida L.f.
	D. cayenensis Lam.[b]	D. esculenta (Lour.) Burk.	
minor spp.	D. bulbifera L.[c]	D. bulbifera L.[c]	D. convolvulacea Cham. et Schlecht.
	D. preussii Pax.	D. hispida Dennst.	
	D. praehensilis Benth.	D. pentaphylla L.	Rajania cordata L.
	D. sansibarensis Pax.	D. nummularia Lam.	
	D. dumetorum (Knuth) Pax.[e]	D. opposita Thunb.[d]	
		D. japonica Thunb.[d]	

Notes:

(a) Both these species are true cultigens, and are unknown in the wild state.

(b) Many authors, especially those of Francophone West Africa, regard D. rotundata as only a subspecies of D. cayenensis (Miège, 1968).

(c) D. bulbifera is the only species common to both Africa and Asia in the wild state. The African form is, however, quite distinct, and is sometimes regarded as a separate species D. Latifolia Benth.

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Notes on Table 2 (continued)

(d) These two species, often known by the invalid name *D. batatas* Decne, are temperate species, native to China and Japan.

(e) Sometimes incorrectly referred to, in older literature, as a subspecies of the Asiatic *D. hispida*.

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Table 3

Selected High Yield Records for Yams

Species	Country	Yield (tons/ha.)
D. alata	Malaysia	42.5
"	Trinidad	46.8
"	ST. Vincent	58.2
"	Fiji	25.4 (de Vries et al. 1967)
D. esculenta	Malaysia	24.6
"	Trinidad	32.2
"	West Irian	70.0 (anon, 1963)
D. rotundata	Ghana	20.8*
"	Nigeria	16.2*
D. cayenensis	Trinidad	31.5

* These figures appear to suggest that the yield potential of D. rotundata is lower than that of other species: it is considered more likely, however, to reflect the limited amount of work undertaken on this species.

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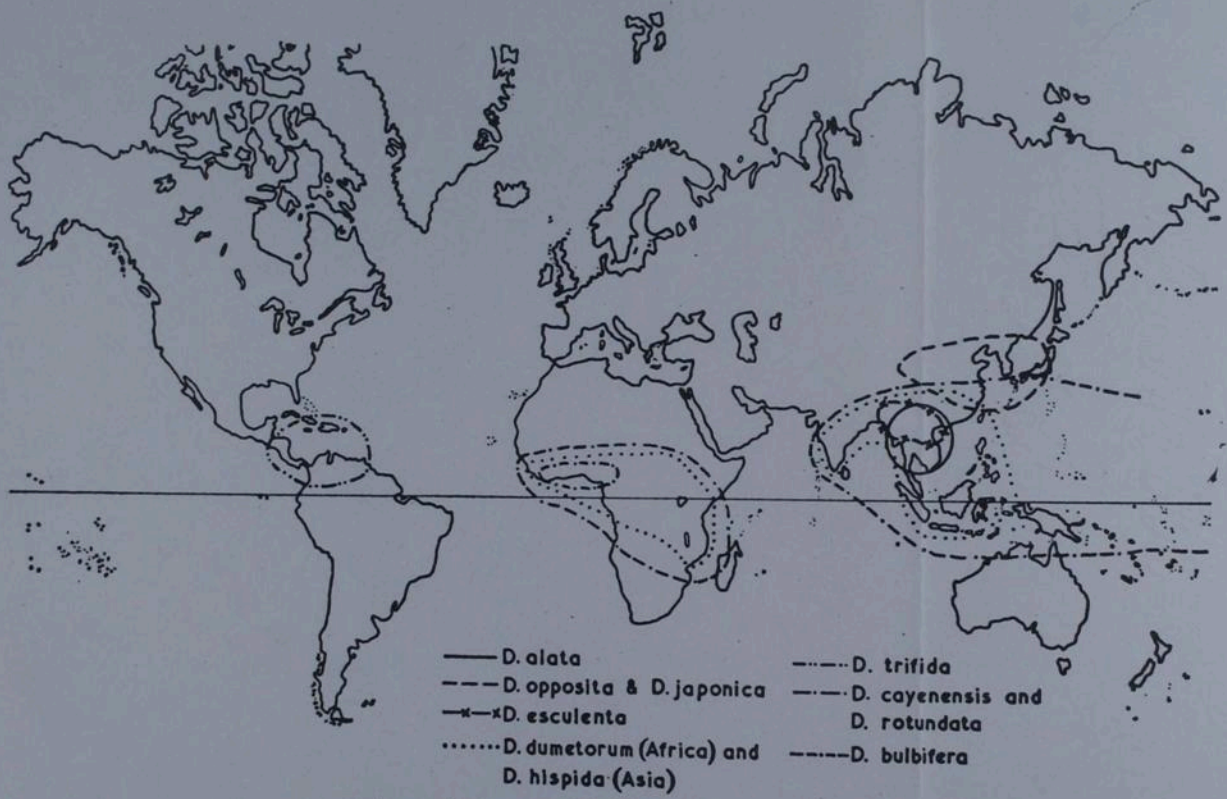
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YAM DISTRIBUTION IN WEST AFRICA



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Approximate natural habitats of the principal food yams.

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THE REPORT OF THE DRAFTING COMMITTEE

Chairman: D.G. Coursey

Members: F.R. Moorman
P. Silvestre
W.O. Jones
D.G. Robertson
J.C. Dumont
B.N. Okigbo

A Paper to be presented at
an Agricultural Research Seminar
-on-
ROOT AND TUBER CROPS
-at-
The Conference Centre
The University of Ibadan
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The International Institute of Tropical Agriculture

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MONDAY, FEBRUARY 22

Morning Session

Chairman: F. W. Moormann

Paper: The history and possible future of yam cultivation in West Africa, D. G. Coursey.

Summary of Discussions.

THE FUTURE OF YAMS

Various opinions were expressed on the future of yam cultivation in West Africa. Some delegates believe that yam cultivation will diminish for various reasons, as there are high labour requirements, difficulties with mechanization and problems of storage and marketing. Cereal crops may well become a preferred food, replacing yams to a large extent. Other delegates, whereas admitting that the yam cultivation has its drawbacks, believe that yam has a definite future in West Africa as a quality food, preferred to higher yielding cassava. It is pointed out that many of the drawbacks of yams can, at least partially, be solved by selecting the right cultivars from the very rich variability of available material. Moreover, yams are bound to remain or to even become important as a quality food in areas with an ecology which is unfavourable for cereals, particularly for upland rice.

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THE FERTILIZATION OF YAMS

Many cultivars do respond to nitrogen, but in most cases reported, application of nitrogen leads to larger cells in the tubers and, consequently to poorer storage qualities. Of importance is time of application of nitrogen. Response to phosphorus was reported from East Africa, where massive initial doses of phosphorus gave a positive effect. Little is known on the inter relationships between habitat varieties and fertilizer practices; studies in this field are needed, but it may be expected that "classical" NPK trials will not give much useful information, if other milieu and cultural parameters are not taken into account.

THE STORAGE OF YAMS

Storage of yams is recognised to be an acute problem, and one that hampers large scale marketing of yams. The farmer's method of storage in barns in a cool damp, shaded place appears superior but is not adaptable to large scale operations.

Use of inhibitors against sprouting has had a mixed success, and need certainly more study. Dormancy characteristics of different varieties vary greatly.

Mechanical damage, as well was nematode damage usually lead to secondary infections and consequently to losses during storage. Irradiation did not appear promising for improved storage.

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THE REPRODUCTION OF YAMS

In traditional plantings, the ratio between planting material and harvested crop is frequently unfavourable (e.g. 1:10). There are, however, indications of varietal differences in this respect, and also some varieties may be reproduced from small sections or peelings of the tuber. More research is required in this field.

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MONDAY, FEBRUARY 22

Afternoon Session

Chairman : P. Silvestre

First Paper : The History and future prospects of the cultivation of cassava in West Africa
B. BECK.

Second Paper : The possible uses of tuber crops in West Africa, C. MICHE.

The following problems were raised after the first paper :

THE POTENTIALITIES OF CASSAVA

- Present yields are much higher than those shown in agricultural statistics because cassava is essentially a crop grown at the end of the rotation, and not always harvested if the other food crops have been successful.

- It would however be necessary to consider the life cycle of the plant, in view of the results obtained. Cassava is largely a two year crop, but the time factor is becoming increasingly important in an intensive system where the efficiency of land use must be increased.

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THE FUTURE OF CASSAVA

It was admitted that, in spite of the competition with cereals in the diet, as the level of the standard of living increases cassava will remain as a crop both prosperous and viable and will continue to play a considerable role,

because its yield potential is high, and it has a high calorific value and is cheap. But, it should be considered a cash crop if we want to have a stable system of rotation.

It is also necessary that a system of marketing is adopted. For this we should recommend to the economist to study the marketing system of food produced for the consumer. Although it is often considered to be a crop which is consumed by the producer, cassava is already widely marketed in some regions.

FARMING SYSTEMS

A delegate stressed that we should take into account the man power in-put in the input/output ratio. The family is likely to encounter a labour constraint at harvest time.

But another delegate noted that we should not only envisage family labour. To avoid the transportation of products such as cassava which do not have a good keeping quality,

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we should try to process such crops on the spot and allow this processing to act as a nucleus for the establishment of large-scale profitable markets for export crops.

SPECIAL RESEARCH PROBLEMS

It was stressed that in the distinction between sweet and bitter cassava there are other factors and besides hydrogen cyanide to be considered.

In the process of fermentation microrganisms other than Coryne bacterium and Geotrichum play their part.

We should study simple apparatus and methods for determining starch content.

x
x x

The second paper gave rise to the following remarks:

Priority must be given to the supply of local markets rather than foreign markets in roots and tubers.

Pre-cooked foods are at present prepared traditionally. This can be improved - it has already been improved in certain areas by local craftsmen. It is therefore

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- unnecessary to envisage for the time being the construction of large factories for making pre-cooked foods like gari although such factories exist already in some countries.

- We must not forget that as towns grow, the city-dwellers will turn away from long and laborious food preparation processes.

- The value of the finished product will condition the success processing operations:- dehydration, packaging of the processed commodity, will make it more expensive, so that in the long run it will not differ so much from the traditional product.

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TUESDAY, FEBRUARY 23

Morning session

Chairman : W O. Jones

Paper 1 : The Economic problems encountered in the in the intensive cultivation of cassava by IRAT in Togo.
M. Delcasso & P. Silvestre

Paper 2 : The taxonomy of cassava
D. Rogers

Summary of Discussions

The discussion period consisted essentially of exchanges of informal information among members of the seminar and of amplification of their ~~rewards~~ Remarks by the speakers.

There were discussions of the suitability of Manihot glaziovii in cross-breeding for resistance to mosaic. Apparently the species is free of mosaic over many parts of West Africa, perhaps because selection has led to a virus free form. But it is known from observation elsewhere that M. glaziovii may be susceptible to the virus.

Varieties likely to be more suitable in breeding for mosaic resistance include about 15 species closely related to M. esculenta.

There is little or no prospect that virus in cassava can be controlled by chemical means because the vectors are too widespread.

The classification system presented in the second paper is based on

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about 50 characteristics, taking principal account of vegetative form, and the shape and structure of flowers and fruit. The classification is based on American specimens, but would probably be little altered if African and Asian specimens were added. There are likely, however, to be differences in the cultivars in the three areas. The method of classification has been applied to cultivars employing characteristics of their morphology.

It was reported that in some parts of West Africa wild (possibly feral) varieties of Manihot are eaten in time of shortage.

Collections of the many species of Manihot are few and quite incomplete.

Relatively simple techniques have been worked out for the rapid germination of cassava seed.

In consideration of the optimum date of planting cassava, optimum date of harvest and time from planting to harvest must be taken into account. It is a rather complex relationship. The optimum time for each operation may also be affected by the timing of other farming operations and by non-economic factors.

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TUESDAY, FEBRUARY 23

Afternoon Session

Chairman : D.G. Robertson

Paper 1 : The Virus Diseases of Cassava
G. Galvez

Paper 2 : The Cassava Improvement Programme in Madagascar -
M. Arraudeau (presented by P. Silvestre).

Summary of Discussions

It was noted that the virus diseases affecting the crop in Africa were of major economic importance, whereas those described from South America did not constitute important disease problems.

Heat treatment was stated to be a method of inactivation of cassava mosaic virus, but it was pointed out that this was not a practical method of control, which could only be effected by the use of resistant varieties.

A number of delegates drew attention to the variation in symptoms caused by cassava mosaic virus infection (suggested as being possibly caused by different strains) and the fact that plants became symptomless in certain ecological zones and under certain environmental conditions. Natural heat inactivation and movement of the virus in

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the conducting tissues of the plant were suggested as possible explanations of this phenomenon.

It was noted that the methods of scoring for virus disease resistance in Madagascar and Nigeria were similar and differed from that used in the early breeding programme in East Africa. One delegate pointed out that the degree of contamination (as used in East Africa) should be regarded as an important factor in assessing resistance in breeding material, but it was observed that in Nigeria resistance usually took the form of mild symptoms, sometimes becoming latent, and not in the percentage of plants infected.

It was agreed that breeding for resistance to cassava mosaic virus was one of the major priorities in the improvement of the crop in Africa.

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WEDNESDAY, FEBRUARY 24

Morning Session

Chairman : D. G. Coursey

Paper 1 : The Integration of yams in modern system of Agriculture
C. Dumont

Paper 2 : The Improvement of yam cultivation techniques in Nigeria
P. Chinwuba

Paper 3 : The botanical classification of yams

Summary of Discussions

Mechanization of Yam Cultivation

One delegate pointed out that the basic requirements of mechanization - a compact, medium sized and regularly shaped tuber - was also a desideratum for storage.

Much discussion took place on the subject of mechanization, several delegates felt that this should have the highest priority for further research, and considered that it was only through the economics of mechanization that the yam would continue as a crop of any importance. Others, however, considered that smaller scale producer using predominantly manual cultivation techniques would continue to be important for a long time, and that their problems also needed consideration. A warning was sounded by certain delegates of the social problems that could arise from over-rapid introduction of mechanization causing gross rural unemployment.

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Research Priorities

Much concern was expressed over the awarding of priorities in research. There was a general consensus of opinion that thorough economic studies of the present status and future prospects of the yam crop (and, indeed, of other crops) was needed, but it was equally recognized by most that there existed in West Africa a strong cultural attachment to the yam, which would probably ensure continued interest in production, even when economic reasons ~~preserves~~ worked against the crop.

Research work in the past had paid little attention to the crop, and many farmers were becoming discouraged as a result. However, with the strong interest that is now being shown by some research workers, it would be expected that this position would change in the future.

Several delegates felt that work on mechanization should receive the highest priority : others considered that work directed to helping the peasant farmers was of greater importance. It is therefore desirable that research efforts should be directed both ways. The suggestion was made that individual countries especially the larger ones could establish committees of workers on yams (and on cassava and on other individual crops) to decide national priorities. Effective interchange of ideas between countries through regular personal contacts (such as at the present meeting) was also most desirable.

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The botanical classification of yams

A number of delegates agreed that the chemotaxonomic approach adopted in the paper given was a useful one, and that the work could well be extended in scope to establish taxonomic differences at cultivar as well as species level. There was nevertheless a strong feeling that this should be regarded only as an extension of more conventional taxonomy based on morphological features, and that within chemotaxonomy the study of secondary plant constituents, each as polyphenolics, was likely to be more rewarding than the study of such universal plant constituents as proteins and starches.

The serious need for the proper classification of West African yam cultivars, especially of the complex *D. cayenensis*/*D. rotundata* group was generally appreciated, and it was generally agreed that computer analysis would be needed to examine the high degree of variability that exists.

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WEDNESDAY, FEBRUARY 24

Afternoon session

Chairman : C. Dumont

Paper 1 : The Nematodes of yam
G. Merny

Paper 2 : The control of yam beetles
T. A. Taylor

Summary of Discussions

The following questions were raised with regard to the nematodes of yam.

The role of fallows

A considerable fall in the nematode population is apparent during the fallow period.

The cultivation of a fallow or cover crop which is not a host plant of the parasite is in any case preferable to a fallow whose composition or exact behaviour towards the parasite is in fact unknown.

Plants having a toxic effect on nematodes

There are many of these but they have not been studied on a large scale in the tropics. The difficulty lies in introducing them into relay system. Finally, we must not forget that infection by yam setts is greater than that contracted from the soil.

Dissemination of nematodes

Water can be a means of dissemination but agricultural implements are an equally important factor.

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Mixed or intercropping

If two host crops of the same nematode species are considered, relay cropping will be more harmful than intercropping.

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After the paper on the control of yam beetles, the respective roles of the larvae and the adult beetles were considered with regard to damage caused.

It was emphasised that the role of the wild species of yams as host plants was little known, as also the potential differences in sensitivity between the cultivars.

Finally it was confirmed that there is a diapause between the two migratory adult flights. During this period it is difficult to control them and that is why it is better to try to destroy them at the moment when they migrate.

It was also confirmed that some insecticide applied to the soil at the time of treatment is translocated into the tuber tissues.

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THURSDAY, FEBRUARY 25

Morning Session

Chairman : B. N. Okigbo

Paper 1 : Joint Institute for Agricultural Research/USAID Nigeria Irish Potato Project - D. Suchomel

Paper 2 : The Potato in the Tropics
J. Niederhauser

Paper 3 : Recent Research on Sweet Potato (Ipomoea batatas (L) Lam) at the University of West Indies -
P. N. Haynes

Summary of Discussions

Some concern was expressed about the danger of introducing the golden nematode from Europe to the Tropics or the second of the two compatibility groups of Phytophthora infestans from Mexico into the other areas of the Tropics by large scale importation of planting materials. It was suggested that caution should be exercised in the introduction of planting materials from these areas. In this respect it was emphasized that it would be necessary to interchange only clean materials, to minimise the amount of material involved and serious steps should be taken to produce and multiply seed in and for each locality where potato production and research is being conducted.

In response to a question by a participant, it was indicated that one of the advantages of growing of potatoes in the Tropics is the possibility of multiple cropping. This was stressed by the example that, on the Jos Plateau, of Nigeria

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potato varieties that took up to 120 days to mature in temperate countries took only from 65 to 85 days on the Plateau.

A lot of interest was shown in the sweet potato as a potential root crop in Africa : it was noted that mechanization is possible with this crop, especially in the West Indies, where labour was the most important limiting factor in the production of the crop.

A participant pointed out the ommision of edible aroids among the tropical root crops considered in the seminar since they constitute important staple food in certain parts of West Africa.

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