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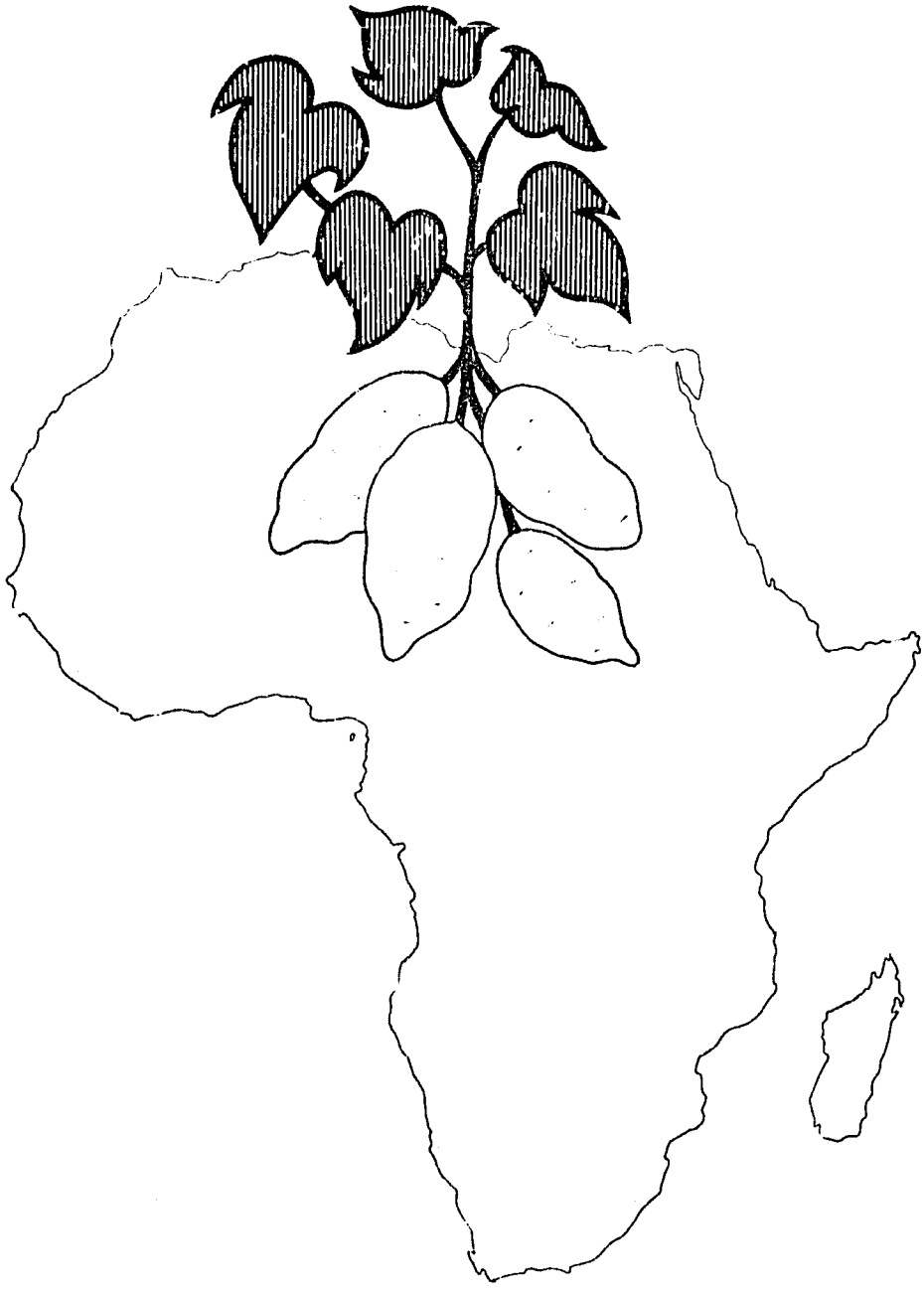
IMPROVEMENT OF SWEET POTATO (*Ipomoea batatas*) IN EAST AFRICA

with some references of other tuber and root crops

Report of the "Workshop on Sweet Potato Improvement in Africa", held at ILRAD, Nairobi, Kenya; UNDP Project CIAT-CIP-IITA, September 28-October 2, 1987.



INTERNATIONAL POTATO CENTER (CIP)

1988

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1988

Note:

Several papers in this publication were used as a source of information during the workshop and published unedited to make them available as soon as possible. Please do not quote nor include in databases. In special, an edited version of the paper by Dr. E. E. Carey (pp. 9-17) can be obtained from the author at CIP, Lima. The paper "Nematodes in tuber and root crops and their management" by Dr. P. Jatala (pp. 91-100) is being published as a chapter in the Proceedings of the 11th International Congress on Plant Protection, edited by E. Magollona, in the Philippines.

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WELCOME ADDRESS

James B. W. Matata

Distinguished Delegates, Ladies and Gentlemen,

It is with great pleasure that I am with you here on this first day of the Workshop on Root and Tuber Crops. Before I proceed, I would like, on behalf of the Government of Kenya and in particular the Ministry of Agriculture and the Ministry of Research, Science and Technology, welcome you to Kenya and request you to feel at home.

I am here on behalf of the Director of Research who is currently out of the country on other equally important engagements. He wishes you fruitful deliberations in this important Workshop.

An occasion like this one, ladies and gentlemen, provides us with an opportunity of reminding ourselves of the role of agriculture in the economic development of our countries. As you may be aware, agriculture is the main stay of the economies of the majority of African countries and it will remain so in the foreseable future. The Kenyan economy is agriculturally based with 85 percent of the population living in the rural areas. The bulk of the farming population is largely small-scale, growing staple food crop to meet household food requirements and a little surplus for sale.

In Kenya agriculture contributes about 35 percent to Gross Domestic Product (GDP). It plays a major role in providing food, energy and incomes to a vast proportion of the population, and provides raw materials for the country's manufacturing and distribution industries. Agricultural products constitute about 70 percent of the total exports for foreign exchange earnings. Lastly, agriculture employs about 75 percent of the total labour force and the formal wage employment in the sector constitutes about 17 percent of the total waged employment.

These statistics may not be directly relevant to the current workshop on Root and Tuber Crops, but they serve to remind us of the importance of agriculture in a developing country that is not endowed with oil and mineral resources.

Agricultural research has made very significant contribution to the growth of agricultural production in this country. Some of you might have heard of the successful story of hybrid maize in Kenya, especially in the sixties and early seventies. The quantum jumps that were made in agricultural research in this period are unlikely to be repeated because of the new challenges facing agriculture researchers in Kenya. These challenges stem mainly from:

1. Rapidly increasing population in the high and medium potential areas resulting in the sub-division of the land into small holdings for which appropriate production technologies are not readily available.

2. Forcing agricultural production into marginal and very marginal areas where little or no research work has been carried out to generate appropriate technologies.

3. Declining soil fertility due to continuous cropping of the same pieces of land.

4. Diseases and pests developing resistance due to over and improper use of the agricultural chemicals.

5. Constant droughts and dwindling water sources due to the destruction of vegetation and catchment areas.

6. Increasing costs of agricultural inputs such as fertilizers, pesticides, agricultural implements and machinery, etc.

These new challenges which, I am sure, are not peculiar to Kenya, have necessitated the reorganization and restructuring of the Kenyan agricultural research system with a major objective of addressing well-identified and formulated priority research programmes. The reorganized research system comes out with priority research areas placing maize, wheat, sorghum/millet, beans/grainslegumes, fruits and vegetables, and root and tuber crops in priority one. Of the five categories of crops, root and tuber crops have received the least research attention.

The Irish potatoes have been grown by the Kenyan African since 1917. By 1977 some 30,000 to 40,000 ha were being grown annually. Currently the crop is estimated to occupy 70,000 to 80,000 ha. Research in potatoes is of recent origin. Prior to 1970 potato research came under a unit of the Plant Pathology Section of the National Agricultural Laboratories. Emphasis was on late blight which is a major limiting factor in potato production as small-scale farmers can hardly afford control with fungicides. In 1970 a potato research station was established at Tigoni and has addressed itself to various issues including breeding, agronomy, production of basic seed, consumer acceptability, and storage. Because of the increasing demand, potato production is expected to grow at 5% per annum.

I am given to understand that the major emphasis of this workshop is on the other root and tuber crops particularly the Sweet Potato. I regret to mention that while I have given some statistics regarding the Irish Potato, I cannot readily give similar statistics on the Sweet Potato, Cassava, and other root crops; yet these crops are grown widely by a large proportion of the small-scale farming population. It is unfortunate that these crops are remembered during periods of shortages and famines, despite the knowledge that these crops can endure long spells of drought.

Due to frequent droughts resulting in food shortages, the Kenya Government now lays emphasis on drought tolerant crops. It is recognized that Sweet Potato, Cassava and other root and tuber crops have considerable potential in playing a more important role in food security. For this reason research on these crops is given national status and assigned to the Coast Agricultural Research Center, Mtwapa, for coordination. Other major collaborating research centers are Katumani, Embu, Kissi, and Kakamega. At the moment there is no specific funding for these crops. The British Government, through ODA has indicated willingness to fund the national root and tuber crops (including

Irish Potato research programme) of which the Irish potato component is already drafted.

As regards sweet potato, cassava and other root and tuber crops, adaptive research alone consisting of introduction and testing of varieties and developing agronomic packages should result in substantial payoffs in a relatively short period of time. This research should be coupled with processing and storage research, pricing and marketing organization.

While the International Potato Center (CIP) has concentrated on research and development of the Irish Potato, it is gratifying to learn that the Sweet Potato has been added to its mandate. Working in collaboration with the National Agricultural Research Systems, CIAT and IITA we look forward to accelerated generation and testing of technologies for Sweet Potato production under diverse agro-ecological conditions. At this point of my address, I wish to emphasize that the research priorities must be identified by the indegeneous researchers themselves. The international research centers are there to assist in the formulation and implementation of the identified national priority programmes and projects.

The purpose of this workshop is to bring together personnel from international research centers and researchers, extensionists and educators from national programmes on root and tuber crops, with the major objective of developing collaborative research and transfer programmes. The organization of international and regional meetings of scientists with the same concerns constitutes the first major contribution to the horizontal transfer of technology, on which developing countries should place increasing reliance if they want to achieve their potential and encourage the scientific solidarity which has become the key to emergence from underdevelopment.

The frequent occurrence of droughts resulting in food shortages should provide even greater encouragement to scientists in Africa to provide exchanges of information, genetic materials and, in particular, experience acquired in various programmes. It is through holding of numerous meetings that the African researchers will be able to break the isolation which constitutes one of the great handicaps facing scientists in developing countries.

In this workshop, papers and reports on root and tuber crops activities from various countries and international centers will be presented and discussed. It is hoped that the discussions will lead to a united strategy for improving and developing root and tuber crops. The recommendation and resolutions should be specific and address priority problems in root and tuber crops so that the policy makers and those responsible for implementing programmes are left in no doubt as what should be done.

Ladies and gentlemen, you have the enormous responsibility of participating in the achievement of food self-sufficiency in our developing countries. This self-sufficiency -a precondition for all other development- will be impossible without the contribution of agricultural research in general. Unfortunately, we have to recognize the fact that it is rare for African countries to devote more than 1% of the national product to research. The problems resulting from this lack of funds, often combined with shortage of qualified and experienced national researchers, can be partially solved by turning to International Agricultural Research Centers, three of which (CIP, IITA, and CIAT) are actively involved in this workshop.

I wish to thank the organizers of this workshop and in particular CIP, CIAT, IITA, and AVRDC for providing the financial support and choosing Nairobi as the venue for the workshop. I also wish to thank the participants and their respective institutions for responding to the invitation to participate in the workshop.

Wishing you fruitful deliberations, I now have the pleasure of declaring the Workshop on Root and Tuber Crops Improvement in Africa officially open.

RECOMMENDATIONS

1. INTRODUCTION

The recommendations that emerged from this workshop are based on TAC 43's draft report related to sweet potatoes which sets forth the possible working relationships between international agricultural research centers with responsibilities for this food crop. It indicates that while CIP has added sweet potatoes to its global research network it is expected to cooperate closely with AVRDC especially in South East Asia and cooperate with IITA to give particular attention to African problems. In both instances the spirit is to ensure that the work previously performed by these two centers is not overlooked or disregarded. The intent is rather to build on the comparative advantages of all Centers, and collaborating national programs, and regional networks with the goal of improving the availability of this crop as a food worldwide.

As such, the recommendations made here are designed to reflect the needs of participating national programs without making specific reference as to what institution, national or international, should undertake major responsibility for carrying them out. The participants felt that this was an issue which could be addressed as experience is gained undertaking collaborative research and transfer projects. However, the participants felt that clarity as to research and geographical responsibilities between the Centers was needed in the near future. This would enable and facilitate a more efficient and effective joint effort for sweet potato improvement during this transitional phase.

2. GROUP A. GENETICS AND BREEDING (EXCHANGE AND QUARANTINE)

1. That support be given to national programs to build up collections of wild and cultivated sweet potatoes. The collections should be characterized, evaluated, and maintained in the host country both for local and international use.

2. That regional clean-up and tissue culture facility(ies) and redistribution center(s) be established for sweet potato germplasm at convenient location(s) in Tropical Africa.

3. That national programs set up their own tissue culture facilities for maintaining and distributing germplasm.

4. That all accessions to regional collections be characterized and evaluated according to standard international methods, i.e., IBPGR descriptors, and that these be communicated to other countries for use in evaluation of materials collected.

5. That standardized evaluation procedures be developed and used for evaluation of breeding materials for major common biotic and abiotic stresses.

6. That breeders be encouraged to put special emphasis on developing cultivars for those important characteristics as determined by the countries, e.g., high, stable yields, earliness, resistance to important pests and diseases, drought resistance, earliness, quality, storability, and processing.

7. That a meeting of national quarantine officers and breeders and international center staff be held to promote and facilitate the exchange of germplasm amongst collaborating countries.

3. GROUP B. INTEGRATED PEST MANAGEMENT

1. That priority be given to identification of viruses in the region, development of diagnostic tools, and determination of relative importance of the diseases.

   In this context, it would be advantageous to explore alternatives for collaboration with lead institution in developed countries.

2. That epidemiological studies on virus diseases be considered important in IPM research.

3. That genetic material with apparent high levels of tolerance or resistance to viruses currently available in the region be considered as a part of the IPM research concept.

4. That major insects that cause damage to sweet potato, directly by feeding or by vectoring diseases be identified. Major emphasis should be placed onn identifying species and to studying the biology of weevils, aphids, and white flies.

5. That international agricultural research centers gather all information available on weevil control and make it available to national programs.

6. That all material introduced for use in medium to high altitudes be first tested for *Alternaria* sp., particularly in those countries where this is a problem.

7. That national programs continually assess pest constraints on sweet potato production which occur sporadically, e.g., nematodes, bacteria, and caterpillars.

8. That IPM efforts should include studies on the stored and processed sweet potatoes, including estimates of loss due to specific pests.

4. GROUP C. AGRONOMY AND PRODUCTION OF PLANTING MATERIALS

This group identified that in order to ensure adequate distribution of improved materials to farmers appropriate agronomic practices were essential and seed programs based on rapid propagation techniques starting from clean stocks would be needed. As such, the following research is recommended to be undertaken:

4.1. Agronomy

a. Soil fertility to maintain production of high yields. Such topics as intercropping, fertilizer application (green manure and inorganic fertilizer), and rotation should be considered.

b. Rapid soil cover to control erosion, moisture, and weeds. Such topics as planting methods, plant density, type of planting material, and planting on ridges, mounds, and on the flat should be considered.

c. Sequential or continual harvesting versus single cycle with storage in the ground.

d. Continuous detopping to increase production of roots, planting material, and fodder/vegetable.

4.2. Production of Planting Material

a. Evaluation of rapid propagation methods, i.e., in vitro, stem cuttings, and nodal cuttings.

b. Development of "seed" schemes to supply healthy stocks to farmers.

c. Supports to national programs for diseases detection methods, clonal maintance and production, information on rapid propagation methods and agronomy; supply of pathogen-tested material to be utilized by national seed programs; upon request from national programs, the Centers could catalyze the development of their seed schemes according to availability of expertise and funds; and exchange of information among countries.

5. GRUOP D. POSTHARVEST TECHNOLOGY AND SOCIOECONOMICS

5.1 Postharvest Technology

a. That a standardized socioeconomic survey be conducted in the countries of Africa to determine the need of postharvest storage or processing in each country with specific emphasis on:

- Quantity of roots available or storage or processing

- Specific time periods during the year when storage may be necessary.
- Length of storage required.
- Competition with other food crops.
- Economic benefits of storage and processing.

b. That efforts be made to develop and screen/evaluate germplasm and new varieties for characteristics important in postharvest storage, and processing.

c. That collaborative research efforts should be undertaken to develop and test improved methods for storage and processing, taking into special consideration the acceptability of the stored or processed product in particular countries.

5.2 Socioeconomics

Socioeconomic studies should be conducted on all aspects of sweet potato production prior to initiating individual or collaborative research. The development of improved technology should start and end with the farmer and consumer. However, it is recognized that all facets of sweet potato production and research cannot be studied simultaneously. Therefore, it is recommended that topics be prioritized according to needs of the national programs. It is also recommended that in initial studies strong support be provide by the Centers who have previous experience with this type of research.

6. HUMAN RESOURCE DEVELOPMENT

a. Since all groups indicated training to be important to the topics under discussion, training as part of human resource development, should be considered a complementary item to each recommendation. Areas of priority suggested were germplasm management, virus detection and identification, rapid propagation techniques, postharvest technology, IPM, and socioeconomic research methodologies.

b. That communication was an important element to the overall success of sweet potato improvement in Africa, and efforts snould be initially made to collect existent information on priority on postharvest issues. This initial efforts of collecting information should be followed by the development of a systematic approach for disseminating updated research results applicable not only to researches in national systems but also to extensionists.

c That a directory of sweet potato researches, educators, and extensionists be developed for the purpose of establishing linkages and promoting the flow of information related to the improvement of sweet potato.

THE DEVELOPMENT OF A CASSAVA VARIETY TRIAL NETWORK
A CASE STUDY FROM COLOMBIA

F. E. Carey[1]

1. INTRODUCTION

Last year, in collaboration with workers in the Colombian national agricultural research institution (Instituto Colombiano Agropecuario-ICA), the cassava breeding section of CIAT's (Centro Internacional de Agricultura Tropical) cassava program established a number of variety trials in which farmers did virtually all of the evaluations. On the basis of last year's results, we established a new set of trials this year in which groups of farmers as well as agronomists from ICA will do the evaluations.

The goal of this work is to provide cassava farmers with new varieties. We believe that this goal will be attained rapidly and efficiently through a close cooperation between researchers and farmers. By working closely with farmers in the evaluation of cassava clones researchers will be more aware of the farmer's needs, and will be able to move rapidly to meet those needs.

In this paper, I will first present the reasons why we believe that a close collaboration among farmers, national agricultural research institutions and international agricultural research institutions can aid greatly in the selection of new cassava varieties. Then I will describe the methods used and some of the results from last year's trials. Finally, I will describe the design of this year's trials and our hopes for the development of this methodology in the coming years.

2. THE NEED FOR COLLABORATION BETWEEN FARMERS AND RESEARCHERS IN CASSAVA VARIETAL SELECTION

There are several problems which researchers at the international agricultural research centers and their colleagues in the national programs must face when trying to provide improved varieties to cassava farmers. First, cassava is grown under a wide range of edaphic and climatic conditions. In these different environments cassava is subjected to various diseases and pests which are often specific to particular environments. It is very unlikely that one or even a few improved cassava varieties will be adapted across the range of environmental conditions under which cassava is grown. It is, thus, necessary to select genotypes which are adapted to specific environments.

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[1]Centro International de Agricultura Tropical, Apartado Aéreo 6713, Cali Colombia.

A second problem facing researchers trying to provide farmers with new varieties is the range of uses to which cassava is put, and the differing quality requirements which these uses have. There is a great deal of variation in quality characteristics among cassava genotypes, so that a clone which is of high quality for one purpose may be of low quality for another purpose. Additionally, there can be a strong environmental influence on the quality characteristics of a given genotype. It is thus necessary to select new cassava varieties for specific uses and to thoroughly evaluate the stability of their quality characteristics over sites and years.

A third problem facing cassava researchers is that of llimited resources. Cassava and other small farm crops have historically been neglected, and in many cases continue to receive too little of total (also limited) national agricultural research budgets.

A fourth problem is the multiplication and distribution of planting material, which slow the process in vegetatively propagated crops.

A variety trial program which is carried out in close collaboration between farmers and researchers has characteristics which should help to overcome the problems mentioned above.

First, collaboration between researchers and farmers will allow for multilocational testing of cassava clones under on-farm conditions by people (farmers) who are most familiar with the quality requirements of the crop in their area.

Second, since the farmers will do most of the trial management, it should be possible for one agronomist to run more trials than if he had to manage all of the trials by himself. Third, if new varieties are selected by farmers, then multiplication and distribution of seed will already be under way. Finally, by evaluating the reasons for selection or rejection of the clones being evaluated by farmers, we will gain information on selection criteria which are important to farmers. This information will aid in the selection of new materials.

A further strong reason for working closely with farmers in the selection of new cassava varieties is that cassava farmers are aware of the advantages that can be gained by adopting new varieties and thus are interested in evaluating new genotypes. Table 1 shows that during a thirteen year period the principal variety grown by farmers in Media Luna, Colombia has changed twice. In each case the old variety succumbed to disease problems and was replaced by a new variety which had been recently introduced to the area. The variety which was predominant in 1974, Secundina, had also replaced another previously dominant variety in the area. The variety Verdecita was introduced to the area through a CIAT-run regional trial, but the other two varieties were introduced and selected by farmers entirely independently of researchers. By working closely with farmers on the selection of new varieties, we will be combining forces to enhance the efficiency of an already existing system of varietal introduction, evaluation, selection and distribution.

3. FIRST SET OF TRIALS ESTABLISHED WITH FARMERS

In May/June of 1986, in collaboration with workers in ICA, we distributed stakes of advanced selections from the CIAT cassava breeding program to farmers at several sites in Colombia. In this presentation, I will concentrate on the trials conducted in the north coast region, the most important cassava-producing area of Colombia. Individual farmers in four sub-regions of the north coast were given small packet (about 25 stakes per clone) of planting materials of each of three or four clones to be tested. In all 16 advanced selections were tested and each was replicated four times in each of the sub-regions in which it was tested. The seed was given to farmers as a gift with our only request being that they evaluate it as they saw fit to, and that they consent to be interviewed on the results.

In February of this year, we interviewed the farmers on the results of their evaluations using a questionnaire designed for the purpose. During these interviews we hoped to find out what the farmers thought of our clones in comparison with their own varieties. Additionally, we asked farmers for detailed information about their local varieties in order to find out what characteristics were most important. The initial questionnaire was to be modified based on this year's results so that in the future the results of trials could be easily taken by the collaborators who distribute the seed in each area.

The first year's trials gave us mixed results. Among the problems encountered were the following:

1. Because we distributed seed to the farmers somewhat late (in May, while planting is normally done in April), they did not feel that they could adequately evaluate our clones in comparison with their own varieties.

2. Many farmers did not clearly understand that they were supposed to evaluate the clones independently. We found that they were waiting for us to visit them to make the evaluations.

3. Farmers also told us that last year was so bad that even their own varieties did not do well, and they were thus reticent to make comparisons with our clones.

Among the positive results which came out of the trials were the following:

1. Many of the farmers were multiplying the seed which they had received in order to evaluate it again this year.

2. A few selections were made by farmers on the clones evaluated and they gave us reasons for their selections.

3. We learned the characteristics of the local varieties which were most important to farmers.

4. Farmers were interested in the methodology of the trials and gave us suggestions for modifications which would improve it.

So this year farmers are continuing the evaluations which they began last year and the local collaborators will interview the farmers using a simplified questionnaire to see what their results are.

4. SECOND SET OF TRIALS ESTABLISHED WITH FARMERS

Because of the inconclusive results from the first set of trials, and because individual farmers are still evaluating the clones which they received last year, we decided to try something different this year. Individual farmers who received only a limited proportion (three) of the total number of clones evaluated in an area had expressed an interest in seeing all of the clones being evaluated. Because of limitations on seed availability, we did not feel that we could give planting material of all of the clones which we were evaluating to each of the farmers in a region. It occurred to us that by placing one trial containing all of the clones to be tested in an area on one farm with a farmer who was a member of a group of farmers, that we could achieve exposure of our clones to a number of farmers at one time.

This year we have established ten trials with groups of farmers in the north coast region. The clones in the trials are not replicated within sites, but are replicated to varying degrees across sites. The trials use farmer management and technology, but we have specified the planting arrangement. This will allow us to make up to three separate harvests to evaluate for yield and quality from early through late harvest dates. At harvests we will take agronomic data, perform quality analyses (taste tests of fresh-cooked roots) and interview farmers about their opinions of the clones being evaluated. The data for each trial will be collected by the collaborator who is responsible for that trial. Individual farmers will be able to take stakes from selected clones to their own farms for further testing. Subsequent follow-up will be done by the local collaborator using a standard questionnaire.

The ICA agronomists who are running the trials in the north coast this year will meet to evaluate the results of the trials and to make decisions about next year's trials. An ICA cassava breeder is taking responsibility for coordinating these trials throughout Colombia. Thus, the role of CIAT will become less dominant, and will be confined to participation in the evaluation and planning sessions and to selection (in collaboration with ICA) of new cassava clones for evaluation through the trial network.

5. CONCLUSION

The idea of running trials with groups of farmers seems promising because a single trial can be used to expose a group of individuals to the clones under evaluation. The trials in the north coast of Colombia are being conducted with members of the newly-established cassava drying organizations. These organizations produce dried cassava chips for animal feed. The advantage of doing trials with the cassava drying organizations is that they will make evaluations for both eating quality and for the less demanding use of suitability for drying. Thus, the likelihood of finding new cassava varieties is probably greater than if we were working with farmers who only sold their cassava for fresh consumption.

While this variety trial network is at an early stage in its development, the response of all those involved in its management has been enthusiastic. We are hopeful that this method of varietal evaluation will provide a model for the development of such networks in other countries and that it may also prove usefulfor other crops.

Changes in the importance of cassava varieties over time in the area of Media Luna, Magdalena, Colombia[a]

Year	Clone	Area planted (%)	Percentage of plants infected by: Caribbean mosaic	Diplodia manihotis	Fusarium spp.	Germination (%)
1974[b]	Secundina	95	10	-	-	85
	Others	5	0	-	-	85
1978[b]	Secundina	80	30	5	0	70
	Venezolana	20	10	-	-	85
1982[c]	Secundina	40	70	30	20	60
	Venezolana	40	0	2	0	85
	Others	20	0	1	0	85
1984[c]	Secundina	5	100	65	25	35
	Venezolana	85	0	10	5	80
	Verdecita	5	0	0	0	85
	Others	5	0	0	0	85
1987[c]	Secundaria	0.1	100	90	90	15
	Venezolana	35.0	0	50	30	50
	Verdecita	65.0	0	15	10	80
	Others	4.9	0	5	2	80

[a]Data collected by Carlos Lozano, CIAT.

[b]Data for these years are estimates based on memory.

[c]Data for these years are estimates based on field surveys.

FARMERS'EVALUATIONS OF M CUB 43 IN TWO SUB-REGIONS OF THE NORTH COAST

BETULIA, SUCRE

3/4

1. RATHER POOR YIELDS OK ROOT APPEARANCE FOR FRESH MARKET BUT SMALL ROOTS. SOME ROOT ROT. RUCHA. TOO BRANCHY PLANT. PROBABLY WON'T REPLANT.

2. CONFUSION DURING PLANTING - LOST IDENTITY OF MATERIALS.

6. HIGH YIELD, GOOD EATING QUALITY. GOOD ROOT APPEARANCE FOR MARKET. NOT VERY GOOD PLANT TYPE FOR QUALITY SEED PRODUCTION. WILL REPLANT WHAT SEED HE HAS.

0. EATEN BY COWS.

LA COLORADA, MAGDALENA

2/2

28. GOOD YIELDS AT 6 MONTHS. EXCELLENT QUALITY. HEALTHY FOLIAGE, GOOD LEAF RETENTION. WILL REPLANT ALL SEED.

31. GERMINATION BUT THEN SUCCUMBED TO "LA PLAGA".

VARIETAL CHARACTERISTICS REQUESTED BY FARMERS

GOOD FOR FRESH MARKET

- High starch content
- Good to eat
- Dark cortex and white root flesh

EXCELLENT YIELDS

EARLY YIELDS - BEST PRICE IS IN NOVEMBER (7 MONTHS AFTER PLANTING)

GOOD GERMINATION

RESISTANCE TO DROUGHT - HOLDS ROOT QUALITY LIKE BLANCA MONA

NOT TOO MANY STEMS

- Should have plenty of stems (La Colorada)

Characteristics of Venezuela (M COL 2215?), the Predominant Variety in the North Coast, as described by farmers in four subregions of the coast

OS	Subregion			
Characteristics	Betulia Sucre N = 6	El Carmen Bolivar N = 7	Sabanalarga Atlántico N = 9	La Colorada Magdalena N = 10
Is the farmer's main variety	X (6/6)	X (6/7)	X (8/9)	X (10/10)[a]
high yielding	X	X	X	X
Early yielding:				
-In comparison with other varieties	X	X	X	X
-Can be harvested from 3-4 months of for home consumption	X	X	X	X
-Can be harvested from 6-7 months on for fresh market	X	X	X	X
Has excellent properties for the urban fresh market (dark skin, white flesh, excellent eating quality and post-harvest storage life of about 3 days)	X	X	X	X

[a]Venezuela has about equal importance with Manihoica P-12 at this location.

PRAPAC NETWORK
POTATO IMPROVEMENT PROGRAM FOR CENTRAL AFRICA: BURUNDI, RWANDA AND ZAIRE

S. Nganga and K. J. Brown[1]

1. INTRODUCTION

This paper deals with the planning organization and improvement of the PRAPAC Network (Program Regional Pour l'amelioration de la Pomme de Terre en Afrique Centrale) established through a collaborative network agreement between Burundi, Rwanda, and Zaire Governments and CIP in September, 1982.

2. CONCEPT OF PRAPAC

Over a period of five years in which CIP was involved with successful Belgium funded bilateral Potato Improvement Programs for Burundi and Rwanda, these governments began talking about Potato Research cooperation within CEPGL (Community Economique pour Pays des Grands Lacs) which encomposses Burundi, Rwanda, and Zaire. The basis of informal talks for a CEPGL network were:

1. Neighbouring countries with geographic and environmental similarities.

2. Common potato production problems.

3. Need to share scarce research and development resources for potato production such as skilled manpower, funds and research of common interest.

4. Interest by CEPGL countries to associate with CIP in this collaborative project. CIP's main role being facilitation of newly available technology developed at source in CIP and its collaboration world wide.

5. Need to formalize linkage for Potato Improvement through an official Governments' accord signed on September 30, 1982 in Bujumbura.

6. The availability of a common donor willing and interested in network concept.

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[1]International Potato Center, Apartado 5969, Lima 100, Perú.

3. PLAN OF NETWORK OPERATION

3.1. Common Projects

At the Burundi meeting, decisions were made by the Governments to identify research areas of priority and allocate research responsibility to each of the collaborating countries. Thus the division of research areas were:

RWANDA

- Seed Production Technology
- Late Blight Research
- Training component for PRAPAC

BURUNDI

- Bacterial Wilt Research
- Post-harvest and utilization

ZAIRE

- Agronomy for wide environmental adaptation inclusive of mixed cropping
- Seed and germplasm

CIP

- Technical support by CIP source and Regional scientists and to share network experience at CIP.
- Provide new technology and appropriate germplasm
- Short term consultancy within CIP and from CIP's international collaborators
- Specialized courses for PRAPAC scientists
- CIP was requested by CEPGL collaborators to post an initial PRAPAC Coordinator.

3.2. Program Network Structure and Coordination

It was decided that the network structure should include:

1. Directors Committee made up of:

   - Director of ISAR Rwanda
   - Director-General ISABU Burundi
   - President's Delegate General INERA, Zaire
   - CIP Regional Representative
   - (Donor representative as an observer)

2. Executive Committee made up of National Potato Leaders in the PRAPAC Countries and the PRAPAC Coordinator appointed in consultation among the Directors of PRAPAC and CIP.

3.3. Roles of Committees

3.3.1. Directors committee

- Define research priorities for each country
- Evaluate and approve Work Plans and Annual Reports of PRAPAC
- Approve budgets
- Hold decision meetings not less than once a year or as often as necessary in the course of the PRAPAC activities in the year.
- Make all decisions that affect objectives of the PRAPAC

3.3.2. Executive committee

- Propose new projects
- Prepare Work Plans
- Propose budgets
- Execute research projects already approved
- Prepare Annual Reports and publications
- Meet not less than twice a year or as necessary and to submit their reports to Directors Committee

3.3.3. Coordinator

- Appointed to work alongside national leaders - as Liaison Officer to advise, communicate and inform on PRAPAC matters
- Organize meeting of the Executive Committee
- Organize Training - In-service for PRAPAC functionary
- Identify and organize consultancies
- Arrange periodically - suitable evaluation of PRAPAC research projects
- Responsible for Annual Report and Progress reports of PRAPAC
- Initiate any ideas suitable to proper function of PRAPAC in consultation with Directors Committee
- Assist in staging the Directors Committee Venue in consultation with Directors Committee

4. RESOURCE ALLOCATIONS

4.1. Rwanda

From own resource have 6 degree level scientists including two Ph. D. The GOR have allocated land and facilities for PRAPAC - Coordinator and Regional Training Center to be built from Donor Funds, and PNAP (National Potato Program) facilities for joint PRAPAC research so allocated to Rwanda.

USAID through FSIP have allocated some linkage funds to Rwanda for PRAPAC research.

4.2. Burundi

Have two Burundais degree level scientists. GOB have allocated ISABU land and facilities for collaborative network research. Part of the Burundi input includes Belgium specialist technicians in Bacterial Wilt. There is USAID bilateral component to support the PRAPAC research through USAID Kajondi Project.

4.3. Zaire

Have through INERA, the potato project team of two degree scientists and four technicians all of whom are paid for by Zaire Government. This team have excellent potato research at Kivu which is linked with CIP regional work. There are no donor funds for the Zaire PRAPAC Component.

4.4. Donor Funding

1. Multilateral by USAID-REDSO through CIP USD 1'557,000 to fund network coordination and training.

2. Bilateral for PRAPAC

   - Rwanda ESIP/USAID - USD 277,000
   - Burundi Kajondi/USAID - USD 377,000

These funds were made effective in February 1986.

POSSIBLE DONOR ASSISTANCE

1. We would suggest currently that Donor funds be available for Zaire to make her a more equal partner to the Network Collaboration.

2. Uganda - Western Uganda has similar conditions and environment as Rwanda and the Nile Crete Zone where research findings can easily apply to Uganda. The

peoples also speak similar dialects. There is a steady research team in Kalyengere Uganda made up of three degree graduates and several technicians in three stations. These scientists are carrying out research under most stringent conditions e.g. lack of facilities mobility and funds to buy basic research essentials.

It is recommended that a Donor consider funding Uganda as part of PRAPAC networking.

In 1985 Uganda applied to become a member of the CDA network but this has not yet take shape.

3. Donors may also need to look into assisting expansions of programs such as those of Improved Seed of value to small farmers to show pay-off for research on improved adapted germplasm agronomy and post-harvest utilization.

6. RESEARCH PROGRESS AND PROJECTIONS 1986/1987

6.1. Bacterial Wilt - Burundi, ISABU

A new screening strategy has been developed to avoid total loss of newly introduced genetic material due to infection with the pathogen. Germplasm will first be multiplied and evaluated for adaptation and agronomic characteristics under "clean" conditions, before its real resistance to Bacterial Wilt (BW) will be evaluated under BW pressure.

To test BW resistance a new method of screening is under evaluation. Clones will be planted in a "clean" field and within each row of 10 tubers a BW infected tuber will be placed as source of inoculum. The progress of the disease within the row will be the indication for resistance of each clone.

6.2. Storage - Burundi, ISABU

A technology to be able to plant seed potatoes 50 days after their harvest has been developed. A fluctuation in temperature of 32ºC - 35ºC during the night and 13ºC - 16ºC during the day over a period of 20 to 25 days will break the dormancy of the seed. After the adaptation of this technology is completed, research emphases will be placed more on ware potato storage.

6.3. Late Blight - Rwanda, ISAR

A large set of tuber families, introduced from CIP Lima, Peru has been screened for its resistance to LB. Evaluation of more advanced material is underway.

The scheme of germplasm evaluation for resistance to LB is well established. Check

plants will be incorporated in the experimental design, however, in an earlier stage of experimentation.

6.4. Seed Technology - Rwanda, ISAR

Research on the use of TPS on farmers level indicated that the production of small tuberlets was preferred over the use of transplants. There is a need for a well adapted and resistant progeny. Progeny evaluation is planned for the next season. In-vitro culture has been introduced to maintain and multiply a healthy stock of planting materials. With the in Belgium trained technician a rapid multiplication scheme of clean material will be established.

6.5. Agronomy - Zaire, INERA (Kivu)

Crop association research indicated that maize intercropped with potatoes would be best planted 10 days after the potatoes are planted. More research in this area is underway.

6.6. Adaptation - Zaire, INERA (Kivu)

Cultivar evaluations were conducted at 4 locations. Variety Gahinga appeared to produce best under the Zairien conditions, but was relatively infected with BW: 18%.

Clonal evaluation indicated clone 380606.6 to be very productive, yielding 34 t/ha.

7. TRAINING ACTIVITIES

Specialized training course on TPS, organized by CIP Kenya and Rwanda, from July 1 to July 11. One participant from Rwanda and one from Burundi.

In country training course, Zaire, Kivu, Mulungu, August 11-14, 1986. Potato Production Course, 23 agronomes.

Three month specialized training on potato production from April till June in the Netherlands, organized by IAC, Wageningen, one participant from Rwanda.

8. EXECUTIVE COMMITTEE MEETING

An Executive Committee Meeting was held in July 24, 1986, at Mulungu, Zaire.

Progress in the PRAPAC research project was discussed as well as the proposal for naming new varieties, exchange of genotypes, training and the financial status of PRAPAC and the position of Zaire.

The naming of new varieties was decided to be an agro-political issue and not a technical problem, which should be decided upon by the Directors Committee.

For the exchange of genotypes as well as a strategy to exchange new technologies a proposal has been developed, which was discussed in the Directors Committee meeting early October 1986, in Nairobi, Kenya. The financial situation of PRAPAC and in particular the bilateral support for the Zairien program was discussed. It was understood that USAID could not approve bilateral support for INERA as it does for ISABU and ISAR. It was proposed and approved by all members of the Directors Committee that the research program of INERA, Kivu could be supported in the form of supplies only out of the coordination budget. For this purpose a cash-advance has been established by the PRAPAC Coordinator at INERA, Mulungu: Z40,000 ($650). A regular interaction between the PRAPAC Coordinator and the Chief of the Zairien Potato Program will stimulate proper use.

9. CAPITAL INVESTMENT

A work-vehicle for the Coordinator's use has been purchased: Toyota Hilux, double cabin, 4WD.

A family car for the Coordinator's family has been purchased: Peugeot 305.

10. CONSTRUCTION

Plans for a house for the Coordinator have been approved by the GOR as well as the plans for a Training Center, both to be constructed at the PNAP Station at Ruhengeri. Plans for a house were by mistake changed in a 3 bedroom house instead of a 4 bedroom house. However, the director of ISAR will correct this quickly. After approval of the plans by USAID/REDSO bids will be solicitated and construction started. Plans of ISAR for a Training Center to be constructed at Ruhengeri were discussed in the Director's Committee meeting in Nairobi, early October 1986.

11. PROGRAM NEXT SIX MONTHS TO MARCH 1987

11.1. Construction

Construction of 4 bedroom house at Ruhengeri will be started, after approval plans by REDSO, Nairobi, Kenya. With the approval of the plans for the house the PRAPAC-bilateral budget can be implemented.

Plans for Training Center will be discussed at PRAPAC Directors' Committee Meeting. Approval of the existing plans of ISAR for a Training Center by Director-General - PRAPAC and REDSO will be expected.

11.2. Training Activities

An in-country training course on potato production in northern Kivu, Zaire, was organized in collaboration with CAPSA early November, 1986.

A seed technology workshop will be organized in 1987 including the development of a strategy for seed exchange of new genotypes.

APPENDIX I

Training

In-country:	- Production - Agronomy - Storage - Bacterial Wilt
Network Special:	- Seed Production and TPS - Germplasm Management - Bacterial Wilt - Late Blight
Individual Training:	- Tissue Culture for seed improvement - Rapid Multiplication techniques - Bacterial Wilt - Seed selection
Programs Developments:	- Workshops on review of available technology - Executive meeting - Directors meeting - Consultancy

SWEET POTATO PRODUCTION IN THE DEVELOPING WORLD

Wanda Collins

Sweet potato is unquestionably one of the most important food crops in the developing world. It is one of only seven crops which are produced at a level of more than one million metric tons per year. Accurate data on sweet potato production are very difficult to obtain for several reasons. For example, it is seldom traded on international markets and does not appear in any international trade data. Secondly, it is often a subsistence crop in many developing countries and is consequently grown in small amounts as a pure stand and intercropped with other production agriculture crops. Because sweet potato plants can continue to yield over a long period of time, one crop may be harvested for as long as six years. For these reasons and others, production data for sweet potato may often be "best guesses" rather than verifiable numbers.

The most often quoted source of production data for sweet potato and many other developing world crops is FAO which publishes annual summaries for world crops. However, FAO continuously revises its estimates for crops according to information updates it receives. The result of this procedure is that one can never be sure that the data one is using is the most accurate and up-to-date information that exists for that crop. The safest way to obtain the most reliable estimate is probably to average over years for a long period of time; however, this still does not remove the effects of problems listed above.

For the purpose of the following discussion of sweet potato production in the developing world, I have chosen to use either three or five year averages obtained from the latest available FAO production data (1985). In addition, I am using data compiled by Horton (CIP) which uses the same or similar data but may be averaged over different years.

Sweet Potato, as stated above, is only of 7 crops produced at the level of 100 million metric tons per year. It is surpassed by only the major grain crops, potatoes, and cassava (Table 1). Distributions of the production of all root and tuber crops and in particular, sweet potato is shown in Table 2A. The developing world, as defined by FAO grows 72% of all root/tuber crops but grows 98% of the hectarage of sweet potatoes. These hectares are located in three major regions of the world -Africa, Far East, and Latin America- which account for 92% of the hectarage in the world and 94% of that in the developing world. China has been removed from the Far East line in the table and displayed alone to demonstrate its tremendous dominance of statistics on sweet potato. Africa follows China with the second largest hectarage (13%).

On table 2B actual production (000mt) and average yield are shown for the same areas. China alone produces 84% of the total production of sweet potatoes in the developing world and has an average yield (mt/ha) well above that of the developing world as a whole. The other major producing areas have average yields far below the developing world average which suggests that drastic improvement is possible.

Table 3 lists the countries with highest average production as listed by FAO. Some of these countries are part of the developing world but many are developed nations. Most of these countries, but not all, produce sweet potatoes only in small amounts which might bias estimates of average yield. However, the figures also point up the potential increases in yield which might result from the implementation of various strategies to increase yields (i.e., better varieties and cultural practices).

Trends in world sweet potato production plotted by Horton (CIP-Lima) for the period 1969-1985 show a decrease in production in developed countries. However, production in developing countries showed an increase during most of that time with a slight decline after 1975. During that time, Africa has shown fairly steady increasing production trend.

Table 1. Comparison of production of world food crops at annual levels of one million metric tons

Crop	Annual Production[a] (000 mt)
Wheat	509,469
Rice	462,884
Maize	430,109
Potato	299,330
Barley	172,681
Cassava	131,989
Sweet Potato	114,321

[a]1983-85 Average; Source FAO Production Yearbook, 1985

Table 2. Distribution of Production of Root and Tuber Crops in General and Sweet Potatoes in Particular in the World

A. AREA UNDER PRODUCTION (000 HA)

Location	All Root/Tuber Crops	Sweet Potatoes
World	46,905	8,216
Developing world	33,668	8,082
% of world	72	98
Africa	12,791	1,054
% of World	27	13
% of Dev. World	38	13
China	9,798	5,314
% of World	21	65
% of Dev. World	29	66
Far East	5,268	865
% of World	11	11
% of Dev. World	16	11
Latin America	4,174	325
% of World	9	4
% of Dev. World	13	4
TOTAL	32,031	7,558
% of World	69	92
% of Dev. World	95	94

Source: 1985 FAO Production Yearbook of Agriculture

Table 2. Continued

B. PRODUCTION (000 mt) OF SWEET POTATOES IN DEVELOPING WORLD

Location	Production (000 mt)	Yield (mt/ha)	Area (000/ha)
Developing World	111,716	13.8	8,082
Africa	5,954	5.6	13
% of Dev. World	5	40.6	13
China	93,684	17.6	5,314
% of Dev. World	84	127.5	66
Far East	6,964	8.1	865
% of Dev. World	6	58.7	11
Latin America	2,200	6.8	325
% of Dev. World	2	49.3	4
TOTAL	108,802	14.4	7,558
% of Dev. World	97	104.3	94

Source: 1985 FAO Production Yearbook of Agriculture

Table 3. Potential sweet potato yields as reflected in highest country yields.

Country	Yield (mt/ha)
Egypt	26.3
Sudan	25.9
Bahrain	20.0
Hong Kong	30.7
Israel	40.0
Japan	23.1
Korea	24.2
Italy	21.3
Cook Islands	26.8
Niue	25.0

AVRDC SWEET POTATO RESEARCH PROGRAM

Romeo T. Opeña and Paul M. H. Sun[1]

1. INTRODUCTION

The Asian Vegetable Research and Development Center (AVRDC), established in 1971 and located in subtropical Taiwan, selected sweet potato as one of its principal crops because of high nutritional value, high energy source, low input requirement (15), and importance in Asia, AVRDC's immediate mandate region. Sweet potato ranks seventh in total production among the world's food crops (9), and has played a very important role as a food source in Asia and Oceania. Asia, alone, accounted for 91% of the world's sweet potato production in 1985, producing 102 million metric tons (9).

Albeic sweet potato is a tropical crop, most clones presently grown by tropical environments. Moreover, sweet potato does not traditionally receive high production inputs in the developing world. It is, therefore, not surprising to note the sub-par productivity of this crop in the farmers' fields in the tropics (25). The well-recognized potential of the sweet potato to alleviate the vitamin A deficiency of starch-rich diets in poor countries has not been fully realized because of wise use of white- and yellow-fleshed cultivars which contain no or very low B-carotene.

There is unquestionably a great potential use for sweet potato as food and feed in Asia as well as other tropical regions. These facts provide the rationale for AVRDC's continuing research attencion on the sweet potato.

The AVRDC sweet potato research program aims to develop and disseminate improved technology in the form of adapted genetic materials and appropriate management practices for the tropics with particular emphasis on fitting the crop to post-rice cropping systems.

2. MAJOR THRUSTS OF SWEET POTATO RESEARCH AT AVRDC

Sweet potato production in the farmers' field is constrained by a complex of problems, both biophysical and socio-economic in nature (10, 15, 25). Research at AVRDC is linked, therefore, among a broad collection of disciplines to enable the development of integrated technological solutions to the major production constraints in the tropics. Plant breeders, plant physiologists, plant pathologists, entomologists, chemists, horticulturists, cropping systems specialists, and other relevant disciplines work jointly in achieving the desired goals (16).

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[1]Director, Crop Improvement Program, and Deputy Director General, respectively, Asian Vegetable Research and Development Center, P.O. Box 42, Shanhua, Tainan, Taiwan 74199, Republic of China.

In the sweet potato, the target utilization types include the following: staple/feed type, dessert type, and vegetable leaf type especially for small farm/home garden systems.

Research thrusts under the Crop Improvement Program cover the following areas: development of high and stable yielding, widely adapted clones; improvement of acceptability and nutritional quality of sweet potato for human consumption and animal feed; exploration of germoplasm resources for resistance to major insect pests and diseases as well as other desirable characters and incorporation of such traits into breeding lines; studies on the nature and distribution of the major sweet potato viruses and development of an effective virus-indexing method to enable safe international germoplasm exchange.

The goal of the research activities under the Production Systems Program (PSP) is the develop and assess the crop's production systems as a low cost energy and vitamim A source under tropical conditions. Research thrusts are in the following areas: development of cultural practices, with special emphasis on wet season production; integrated management practices for disease and insect pest control; evaluation of sweet potato as animal and human food component; and cropping systems research.

Important corollary activities carried out by a support unit, the GRSU (Genetic Resources and Seed Unit), include collection, cataloguing, maintenance and distribution of genetic resources.

3. ADVANCES IN AVRDC'S SWEET POTATO RESEARCH PROGRAM

3.1. Initial Progress

Emphasis in crop improvement during the first decade of the program was laid on the development of breeding lines with high nutritional value, especially B-carotene content, high yield, early maturity to fit them to post-rice cropping systems, adaptability to low input, and resistance to sweet potato weevil. The potential of sweet potatoes for animal feed, industrial uses, and leaf tips for vegetable greens were explored.

Orange-fleshed (high B-carotene content), early-maturing, dessert-type clones which could be grown under low input, post-rice cropping systems were successfully, developed (25). Clones which met the criteria for animal feed/industrial uses, and vegetable leaf tips have also been bred and distributed to international cooperators.

Development of management practices to ease the constraints of biotic and abiotic stresses of the hot, humid tropics has complemented the progress in developing improved clones (25, 2-7).

In order to further refine the goals of the AVRDC sweet potato program, AVRDC scientists conducted a general survey of sweet potato production and utilization in Asia and the Pacific in 1983 (14). Biological and enviromental factors were listed as

the most serious production constraints in the above survey. Of the respondents, 70% reported serious problems with diseases and pests whereas 40% cited problems of adverse environments. Unavailability of improved cultivars, partly due to limited germoplasm exchange, and postharvest problems of storage, processing, and marketing, were listed as the next most important constraints.

3.2. Refined Targets and New Developments

The 1983 production survey indicated the most pressing production constraints that the AVRDC'c sweet potato research program needed to address. As a consequence of the survey, AVRDC scientists refined the research targets to include the following major areas: intensified breeding for disease and pest resistance; evaluation of available genetic resources for tolerance to the major environmental stresses; enhancement of dry matter content and concomitant improvement of eating quality and nutritional value; improvement of sweet potato as vegetable greens; development of tissue culture and virus-indexing techniques for safe international germplasm transfer; exploration of other means to control sweet potato weevil, e.g., sex pheromone. The progress that had been achieved in the above research thrusts is summarized below.

4. MINIMIZATION OF BIOLOGICAL CONSTRAINTS

4.1. Sweet Potato Weevil (Cylas formicarius)

The sweet potato weevil is the most destructive pest in tropical and subtropical regions. Since the establishment of AVRDC, our entomologists have screened the entire germplasm collection numbering over 1,000 accessions. Despite these efforts, none showed a stable resistance to weevil. Similarly, in the other institute like IITA (International Institute for Tropical Agriculture), no single cultivar with consistent weevil resistance has been bred (19).

Efforts are now underway to explore related Ipomoea species and new introductions for potential resistance to the sweet potato weevil. Preliminary evaluation of interespecific hybrids between 6x cultivated sweet potato and its 4x relatives (Ipomoea trifida) showed no or low weevil damage (7, 13, 17, 18, 20). However, confirmation of resistance and further backcrosses to recover the desirable traits of the cultivated species are necessary.

Since no useful genetic resource for weevil resistance was evident from AVRDC's previous work, the development of effective and economical control measures has been accorded high priority. Pre-plant dipping of cutting in 0.05 to 0.10% carbofuran OPsution or three weekly applications of two kg ai/ha carbofuran in the field were found effective in controlling the weevil population though the latter method proved uneconomical (3). AVRDC entomologists have also been involved in the past two years in a pilot weevil eradication program in Penghu Island using the combined methods of field sanitation (eradication of wild Ipomoea weeds serving as alternate weevil hosts), cultural methods (deep banking and hilling-up of sweet potato rows), sex pheromone, and insecticide application (pre-plant dipping of materials on 0.05 to 0.10 % carbofuran solution).

4.2. Vine Borer (*Omphisa anastomasalis*)

The sweet potato vine borer is a common pest in Asia and the Pacific, and is especially serious in the semi-arid areas. In 1981, AVRDC entomologists identified two accessions, namely, I 55 (PI 324889) and I 92 (PI 308208), with moderate levels of resistance. Because of the difficulty in inducting I 92 to flower, I 55 is the only current source of resistance available for breeding so far. Selection among its segregating populations are now ongoing (7).

AVRDC entomologists have also explored vine borer control through insecticides. Under experimental conditions, the most effective, thus far, is monthly application of carbofuran granules at the rate of 2.0 kg ai/ha (1).

4.3. Scab (*Elsinoe batatas*)

AVRDC pathologists have developed a suitable method for in vitro propagation of the causal organism, the mass screening technique via artificial inoculation, and the disease scoring method. Further improvement of the seedling screening of segregating population are underway (7). The importance of the scab disease and the requirement for resistant lines in the tropical countries necessitated the initiation of scab resistance project at AVRDC in 1985. The resistance of some cultivars has already been confirmed in several screening tests (6). Cultivars V2-30, GI 6, and GI 13 are being used as sources of resistance in the AVRDC program.

5. MINIMIZATION OF ENVIRONMENTAL CONSTRAINTS

The importance of cultivars that are tolerant to flooding, excess moisture, and drought was evident front the 1983 survey. The AVRDC germplasm collection was screened for tolerance to these stresses to identify useful genetic resources (3).

5.1. Flooding

In the screenig of 372 accessions under flooded condition, only three accessions, namely I 100 (PI 318848), and I 423 (Tainan 17), yielded more than 10 tons per ha and were considered to possess relative tolerance to flood stress (3). In another screening, breeding line CN 1108-13 and local cultivar TN-57 were rated as tolerant based on their storage root-forming ability under flooded condition (4). Both clones maintained a high leaf area index and leaf number under flooding stress suggesting that perhaps these two traits may be useful indicators of flooding tolerance. High day/night temperatures (39 /25 C) were also observed to aggravate the effects of flooding stress (4). Clones with numerous storage roots such as CN 1121-312 also tended to give the highest yield potential under both flooded and non-flooded conditions.

5.2. Excess Moisture

Under the hot, wet conditions of Taiwan, 230 accessions were screened for ability to tolerance excess moisture. Fourteen entries outyielded the local wet season cultivar, Tainung 63. The best four lines, namely I 597 (NG 7570; PNG), I 444 (Kin-men; Taiwan), I 549 (Piksin; PNG), and I 435 (Nakamurasaki; Japan) were especially promising, with marketable root yields of nearly 20 tons per ha, comparable to the performance of AVRDC's elite wet season clones. Interestingly, 11 of the 14 accessions were introductions from the highlands of Papua New Guinea where annual rainfall is close to 2,500 mm (3). In a field study of seven cultivars and breeding lines during the hot, wet season, varieties with smaller, more numerous storage roots like CN 1121-312 tended to maintain high yields under excessive moisture conditions (4). This clone, as may be noted from the previous section, also gave the highest yield under flooding stress.

5.3. Drought

Although AVRDC does not have a truly dry environment, evaluation for drought tolerance is normally achieved by screening materials during the dry season with no irrigation. Twenty-nine accessions were screened in this manner, of which, none was superior to the local cultivar, I 444 (Kin-men). This cultivar also showed moisture tolerance and was identified, therefore, as having good environmental adaptability (3). More recently, AVRDC plant physiologists have developed a potentially useful drought tolerance screening method using moisture-level testing PVF strips (4). In storage root yielder, confirming the previously known high yield potential of this clone in the field.

6. IMPROVEMENT OF NUTRITIONAL QUALITY AND ACCEPTABILITY

A number of methodology research have been carried out in support of this thrust. AVRDC chemists developed an efficient analytical system based on sweet potato flour and are presently capable to analyze the chemical composition for dry matter, fiber, sugar, protein and B-carotene from about 200 samples a day using the Technicon Infra-Analyzer (5, 21). This rapid analysis enables breeders to screen a large number of genotypes for chemical attributes.

Basic studies on the consistency of traits among seedling and subsequent vegetative generation have been conducted to identify appropiate selection techniques (27). As a result of such studies, rigorous selection is now practised on stable traits such as dry matter content and color of root skin and flesh in the early stages of breeding. On the other hand, only moderate selection pressure is applied to traits with high genotype environment interactions, e.g., root yield and content, until the replicated evaluation stages for the breeeding materials have been reached.

6.1. B-carotene and Protein

Initially, AVRDC scientists emphasized the development of tropical-adapted, dessert type cultivars, with high B-carotene and protein contents. Clones were subsequently developed with over 9 mg of B-carotene per 100 g resh weight and more than 7% protein on a dry weight basis (2).

However, moist texture and low dry matter content of these lines proved to be unacceptable to the sweet potato consumers in Asia and the Pacific. Ironically, the orange-fleshed clones with high B-carotene content tend to have moist texture compared to clones with other flesh colors. The efforts to raise the dry matter of orange-fleshed clones have been continued and orange flesh was combined in selections CN 1108-15 with the preferred dry texture. Dry matter content of these clones is about 26% during the wet season (3). This program is ongoing.

6.2. Dry Matter Content

Except for a few specific products such as canned sweet potatoes, high dry matter content is always a desirable property and the most important factor to make sweet potatoes a better competitor in the feed and starch industry (21). Sweet potato cultivars with high dry matter content have better marketing appeal for feed and starch extraction. While yet unconfirmed, high dry matter might also contribute to longer postharvest storage life of the sweet potato roots.

High correlation between specific gravity and dry matter content allows the use of a brine solution for rapid, in-field screening to eliminate clones with low dry matter in the early stage of the selection process (6, 7).

Progress has been attained to simultaneously raise the dry matter content and yield of new AVRDC breeding lines (17). The average dry matter content of the entries in the preliminary yield trials during the hot, wet season was raised from 26% in 1981 to 1986 (17, 18).

7. EVALUATION OF SWEET POTATO AS ANIMAL AND HUMAN FOOD COMPONENT

7.1. Protein Digestibility

One of the major limitations of including sweet potatoes in feed formulations is its poor protein digestibility. A review of the previous research activities in Taiwan and at AVRDC on this subject was done recently (21). Trypsin inhibitor, an anti-nutritional factor, has been proposed to be associated with protein digestibility. Analysis of trypsin inhibitor activity revealed that it is positively correlated with protein content of sweet potato root. However, cultivars and accessions which exhibit lower trypsin inhibitor activity and better starch property for digestibility have been identified (17, 18). Preliminary results indicate that it is possible to develop cultivars which do not require cooking before feeding them to hogs (4).

7.2. Improvement of Sweet Potato Vegetable Greens

Sweet potato greens such as leaves, stems, and petioles have high nutritional value, especially Vitamins A and B2; and can tolerate the adverse tropical enviroments and their associated constraints such as diseases and pests, better than many other leafy vegetables (26). In spite of these advantages, lack of high yielding tender cultivars makes sweet potato greens unpopular. Research in this area has generally been neglected.

Preliminary studies on yield, nutritional and eating quality of the leaf tips of breeding lines and selected accessions led to the conclusion that further efforts to enhance the utilization of sweet potato greens are needed (22, 23, 24). An expanded improvement program for vegetable greens was therefore, initiated in 1982 to select cultivars with better tenderness as well as bush or semi-bush plant habit which generally show better tip yield than conventional prostrate types.

Several lines were identified to exhibit a bush habit with good eating quality and with edible tip yields of 10 to 13 tons per ha (3, 4). CN 1367-2, a yellow-leafed clone, shows superior tenderness. This special purpose clone has been distributed for international adaptability trials.

7.3. Undesirable Quality Factors

Flatulence caused by the sweet potato is well-know to Asian consumers although its nature is not fully understood.

Studies at AVRDC indicated that starch property and edible fiber are probably the major flatulence-causing substances in the sweet potato (21). Currently available techniques to quantify the flatulence factors are inadequate. Research on improved assay techniques and nature of flatulence factors is needed (21).

Poor palatability of sweet potato caused by weevil infestation is considered as another undesirable quality factor. Certain compounds like terpenoids and polyphenols are produced by sweet potato roots as a natural defense to weevil infestation. Terpenoids impart bad flavor and are also toxic to animals. AVRDC chemists showed that even very low terpene concentrations drastically reduce sweet potato palatability (21). An effective control method for sweet potato weevil is therefore an important prerequisite for good sweet potato quality, both for human and animal consumption.

8. IMPROVEMENT OF INTERNATIONAL GERMPLASM EXCHANGE

8.1. Virus Indexing and Multiplication of Disease-Free Stocks

International exchange for wide-scale testing of improved sweet potato breeding materials has always been constrained by strict quarantine regulations.

A virus-indexing scheme has been instituted by AVRDC scientists as a self imposed requirement to insure that only "clean" stocks are provided to AVRDC's international cooperators. Because of the uneven distribution of sweet potato viruses within infected plant tissues, virus elimination procedures such as meristem tip culture, heat or chemotherapy have to be followed by a particularly thorough virus indexing (4, 5, 11, 12). This is why we are using both ELISA tests and grafting in the AVRDC virus indexing scheme (Fig. 1). The international distribution of AVRDC's advanced sweet potato clones has been suspended since mid-1985 until all important stocks have been through the above scheme.

The AVRDC plant physiologists have developed a system of producing small storage roots from leaf cuttings which, when applied to virus-indexed plantlets from meristem culture, offers certain advantages because storage roots are easier to ship, handle, and store than plantlets in test tubes (5).

8.2. Nature and Distribution of Major Viruses

Three major sweet potato viruses have been isolated from sweet potato in Taiwan feathery mottle virus (FMV), sweet potato latent virus (SPLV), and sweet potato yellow dwarf virus (SPYDV). Two other viruses, the white fly-transmitted leafcurl and a mosaic disease have also been reported.

9. GENETIC RESOURCES ACTIVITIES AND GERMPLASM DISTRIBUTION

Considerable sweet potato genetic materials have been assembled by several national programs in Southeast Asia and the Pacific regions. In order to avoid the deterioration and loss of these collections, AVRDC and IBPGR agreed to assemble a duplicate collection at AVRDC. IBPGR designated AVRDC as the major repository of sweet potato germplasm for Asia and the Pacific Regions. With the construction of a post-entry quarantine screenhouse (donated by IBPGR) and development of safe methods of handling new introductions, efforts are currently underway to introduce the important collections from the national programs.

9.1. Germoplasm Collections and Maintenance

A total of 1,219 accessions, mostly donations and/or germplasm exchange with national programs and research institutions, is maintained at AVRDC. Of this collection, 70% come from Papua New Guinea, Taiwan, and the USA. A field genebank method is used to maintain an active collection of 1,187 accessions from 32 countries (8). As the above method requires large space, is labor intensive, and highly vulnerable to both biotic and abiotic stresses, duplication of the collection in in vitro culture is used as a backup. Thus far, 745 accessions are already maintained in this manner and it is expected that the entire collection will be in tissue culture by the end of 1987.

9.2. Characterization and Documentation

The IBPGR sweet potato descriptors have been adopted in characterizing the entire collection for the above-ground parts and storage roots. To date, description is nearly complete for the entire collection, with the exception of floral characters (8). Major character groups in this description include those of the vine, leaf, flower, storage root, biochemical characters, and pest reaction.

A computerized central germplasm database consisting of passport and characterization data is now being set up at AVRDC using the HP 3000 minicomputer and the software package MINISIS.

9.3. Germplasm Distribution

Although suspended later, intensive distribution of the most advanced clones from the AVRDC sweet potato program was carried out three years ago. Since then, 11 clones have been officially released by the national programs (Table 1).

10. FUTURE PLANS

The research activities presented are the current major thrusts of the AVRDC sweet potato research program. In addition, we foresee the intensification and/or expansion of research in the general areas given below.

10.1. Crop Improvement Program

- Further stabilization of yield and widening of adaptability through resistance to enviromental stresses such as excess moisture, poor soil fertility, drought, etc., and incorporation of disease and pest resistances.

- Further improvement of dry matter yield storability, eating and nutritional quality.

- Enhancement of genetic exchange through virus-indexed materials as well as improved true seed gene pool for selection by national programs.

- Further improvement of the in vitro germoplasm multiplication scheme to anable rapid and safe preservation of clones. The virus-indexing methoo will be updated to include as many of the potential virus problems as possible.

10.2. Production Systems Program

- Further improvement of cultural practices for sweet potato production under humid tropical conditions.

- Studies on cropping systems including sweet potato such as intercropping to maximize production efficiency of available resources.

- Improvement of production and quality of sweet potato vegetable leaf tips through cultural management.

- Development of appropriate postharvest technology for the tropics.

- Socio-economic studies to generate information related to the major sweet potato consumption and production patterns in AVRDC's target.

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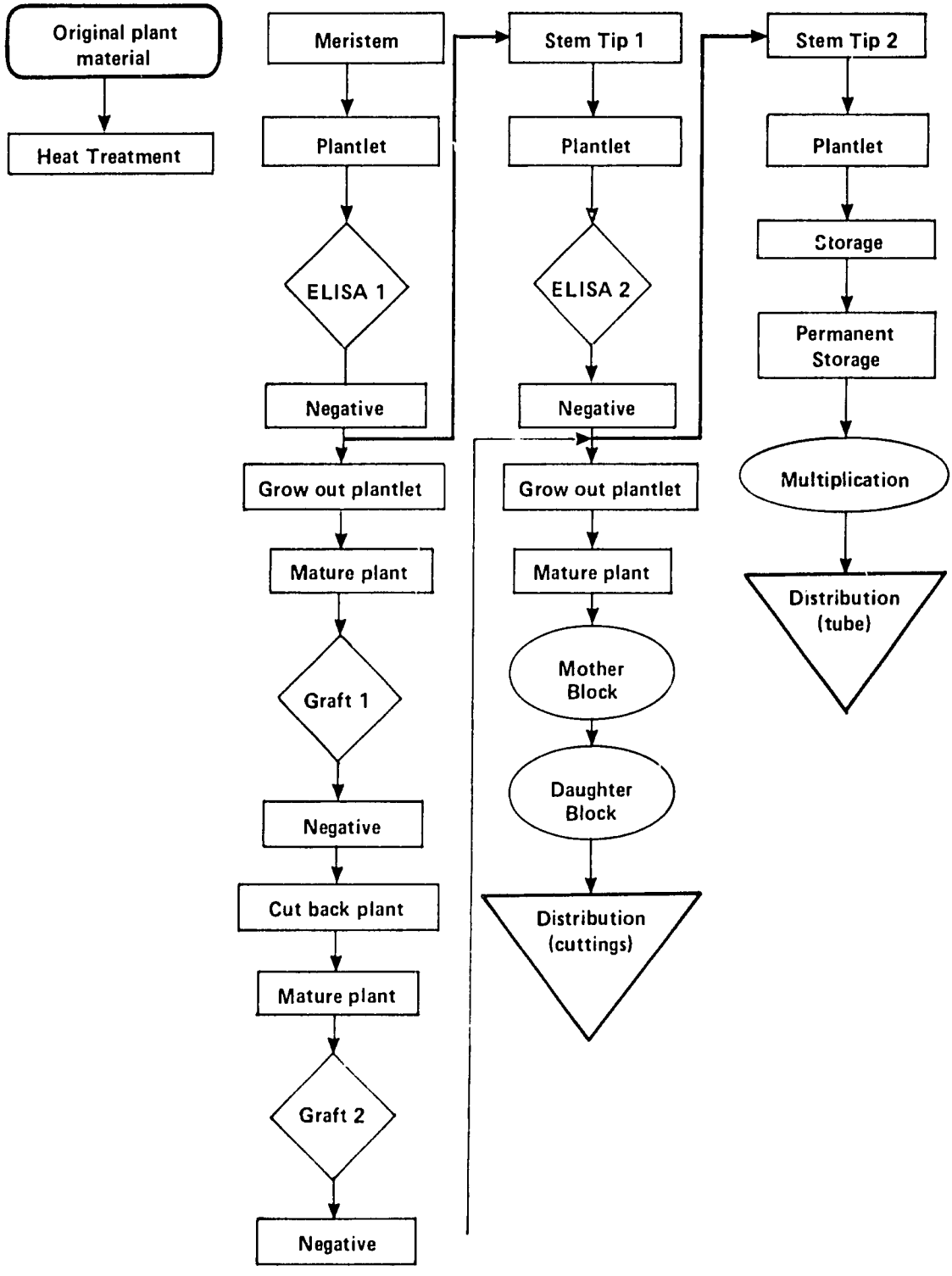

Table 1. Official releases of AVRDC sweet potato germplasm in the last three years.

AVRDC ID No.	Local Name	Year	Country	Special Attributes
BNAS White		1985	Bangladesh	High yield, good shape and root size, yellow flesh.
AIS 0122-2	Kamala Sundari	1985	Bangladesh	High yield, excellent shape and uniformity, deep orange flesh, moist dessert type, for wet and dry season.
Tinirining		1985	Bangladesh	High yield, good shape and root size.
CI 693-9	BPISP-2	1985	Philippines	High yield and good adaptability.
I 367	Lo 323	1983	Philippines	Deep orange dessert type, good moist taste, for wet and dry season.
CN 942-47	CN 942-47	1984	Tahiti	High yield/dry matter, light orange dessert type, good slightly dry taste, for wet and dry season.
CN 1028-15	CN 1028-15	1984	Tahiti	High yield/dry matter, yellow orange animal feed type, good slightly dry taste, moisture tolerant/wide adaptation
CN 1038-16	CN 1038-16	1984	Tahiti	High yield/dry matter, yellow animal feed type, poor dry taste, for wet and dry season.
CI 590-33	CI 590-33	1984	Tahiti	High yield/dry matter early.
CI 591-14	CI 591-14	1984	Tahiti	High yield/dry matter, early.
CI 591-14/Au Marie Vareau	No. 7	1984	Tahiti	High yield/dry matter, early.

IN VITRO SWEET POTATO GERMPLASM MANAGEMENT

John H. Dodds[1]

1. PROPAGATION

Sweet potato is normally field propagated by the use of stem cuttings, however under in vitro conditions a wide range of methods are available for micropropagation.

1.1. Propagation by Single Node Cuttings

Sweet potato germplasm can be introduced into in vitro culture in the form of a nodal cutting. When placed onto an appropriate culture medium the axillary bud is induced to grow and the result is the development of a new in vitro plantlet. It is important to note that this type of propagation involves the growth of an existing morphological structure, the axillary meristem. The hormone/nutrient conditions of the medium simply play a role in breaking the dormancy of the axillary bud and promoting its rapid growth. Several laboratories have developed media or single node propagation of sweet potato (1, 2, 3). Care must be exercised however that the culture conditions do not allow the formation of callus and subsequent de novo regeneration of plantlets, as will be shown in a later section this has been shown to affect the genetic stability of the genotype (4,5).

Most laboratories grow in vitro plantlets under long day (16 hrs light 3000 lux) conditions at 25-28ºC. Under these conditions in vitro propagation rates are rapid and a single node cutting will have grown the full length of the culture tube and be ready for subculture after 6 weeks.

Several laboratories have shown that in vitro plantlets of sweet potato produced from single node cuttings can easily be transferred to non sterile conditions, for example transplant to jiffy pots, and in some cases plantlets have been transplanted directly to the field.

1.2. Propagation in Liquid Culture (Stem Segments)

From experience gained with other crops, especially potato, it is known that under certain conditions the speed and labour requirements for propagation by single node cuttings limit the potential production. As in potato, it is possible to micropropagate sweet potato in flasks (250 cm^3) containing liquid culture medium. Whole stem segments 5 to 8 nodes long are prepared by removing the apical tip and

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roots. This stem segment is then inoculated into the flask so as to be bathed by the culture medium. The liquid medium contains gibberellic acid to break the dormancy of all the axillary buds along the length of the stem segment. Shoots develop from this and in 3-4 weeks the flask is full of vigorously growing sweet potato shoots, (6). The flasks containing shoots can be a source of plant material either for preparation of single node cuttings of stem segments depending on the needs or the program.

1.3. Propagation by Plantlet Regeneration

The sweet potato is developmentally a highly "plastic" plant. It has been possible to regenerate de novo in vitro plantlets from almost all plant parts when placed into culture. Several scientists have been able to successfully regenerate plantlets of sweet potato from cultured stems, petioles, roots and leaf discs, (7). In all cases the first step is the formation of callus at the cut surface, the size and type of callus varies between treatments and genotypes. When given an appropriate hormonal stimulus it is possible to induce the de novo formation of meristems within these calli which then eventually form a regenerating plantlet.

A number of disadvantages exist to using this method as a standard propagation method. Firstly the labour involved in dissecting off these individual plantlets would make the method cost ineffective within a production program. Secondly, callus derived plantlets are likely to have undergone minor or major genetic abberations during the callus stage, (8) thus, the regenerated plantlets would not be genetically the same as the original genotype. In a clonally propagated crop these types of genetic changes would probably be unacceptable to the producer or program.

2. SOMATIC EMBRYOGENESIS

Plantlet regeneration de novo can take place through two possible routes, organogenesis, that is direct organ formation as described in the preceding section or by embriogenesis, the direct formation of embryos from somatic cells. The induction of somatic embryos has been reported in many plants (9). In a few cases somatic embryos are being encapsulated to form "synthetic" or "clonal" seeds.

Somatic embryogenesis has been reported in one genotype of sweet potato (10). However, to my knowledge no analysis has been made as to the genetic stability of these embrios. Since they are also derived from a callus/cell suspension there is a high probability that the plantlets are not all genetically identical.

3. THE IMPORTANCE OF ANALYSIS OF GENETIC STABILITY IN IN VITRO PROPAGATION (AND CONSERVATION) PROGRAMS

This section of this review is equally important both to propagation and conservation. In a clonally propagated crop it is important to know that each propagule is "true to type," even small modifications could accumulate in the crop from

one generation to the next and may affect uniformity and yield. In the case of conservation of clonal germplasm a detailed analysis of genetic stability in culture is vital. Clonal germplasm storage involves the maintenance of specific gene combinations (genotypes). If a plantlet should come out of storage with a different gene combination to that which it entered with, then the validity of the storage method must be questioned.

Our ability to detect genetic changes during propagation and storage are however only as good as the detection methods available.

Many germplasm collections evaluate the stored genotypes routinely on the basis of morphological characters of the plantlets when grown under controlled conditions. If the plants show different morphological characters, ie. leaf form, tuber or storage root colour change, then we know some genetic change has probably taken place. However, if the plants appear the same this does not mean that no change has occurred, it means we cannot detect it. For example a change in a virus resistance gene could not be detected on the basis of morphology.

A number of biochemical methods are currently used in both potato and sweet potato to study genetic stability, these being soluble protein patterns and iseonzyme analysis. Although these are highly effective methods for looking for variation in gene products they do not look for changes in the genes themselves. Novel methods such as restriction length polomorphism analysis is now being investigated as a more sensitive way of looking for genetic changes. It is important that major germplasm repositories and seed programs use the most sensitive methods available to determine the genetic fidelity of their storage and propagation systems. In the case of CIP, morphological, soluble protein and enzyme analysis is routinely performed on both potato and sweet potato collections. If and when a more sensitive restriction enzyme method for gene analysis becomes available its inclusion in CIP's routine methods should be considered.

4. IN VITRO CONSERVATION OF SWEET POTATO GERMPLASM

A number of clonal in vitro sweet potato collections exist in many national programs and international organizations (11, 12). There are many advantages to placing vegetatively propagated germplasm in an in vitro rather than field maintained form and these have been described previously (13).

A number of techniques exist for in vitro conservation, each with certain advantages or drawbacks.

5. LIMITING GROWTH MEDIA

Many years of research has gone into the development of propagation media for sweet potato where the objective has been to optimize rapid in vitro growth. In the case of conservation the objective is to limit growth to a minimum while maintaining viability

of the cultures. By this means it is possible to maximize the time between transfers (sub cultures) of the in vitro plantlets. At CIP, for example, in the case of potato in TLD (long term in vitro storage) transfers are needed only once per year by most clones and in some cases only once every three years.

Experiments to limit sweet potato growth in vitro, in our own and in other laboratories have depended on the use of hormonal growth retardants, ie. ABA (Abscisic acid), growth inhibitors ie. B995, CCC (chloro choline chloride), or osmotic regulators such as high sucrose concentrations or the addition of osmotic sugars such as mannitolor sorbitol (14). The difficulty with these types of studies is that different genotypes will react differently under these conditions. When a large germplasm collection has to be maintained in vitro the objective of the studies must be the development of a conservation medium that is widely applicable to a broad range of genotypes. Several storage media have been reported for sweet potato, however again it should be emphasized that storage media should not allow induction of callus that may lead to genetic abberations.

6. REDUCED TEMPERATURE STORAGE

The growth rate of in vitro plantlets can obviously be restricted by reducing the incubation temperature. The optimal growth temperature for sweet potato in vitro appears to be between 28-30ºC. If the cultures are moved to a temperature of 8ºC we have found that survival time is less than 1 month. The optimal reduced temperature for genotypes studied to date would appear to be 15ºC, but this needs further confirmation. As in the case of other crops maintained in vitro, ie. cassava, potato, yams, etc., it is possible to apply both reduced temperatures and osmotic/hormonal growth retardants at the same time. At the present time I believe the use of osmotic stress and reduced temperature (5ºC) to be the most realistic and cost effective way to maintain a large sweet potato germplasm collection.

7. CRYOPRESERVATION

In the last decade there has been much interest in the use of cryopreserving (-196ºC) plant materials in liquid nitrogen as a way of conserving germplasm (15, 16).

This type of cryo-conservation is used routinely for storing animal cells and bacteria. The situation withplants is however more complex. It has been possible to freeze and thaw in viable condition plant cells from many plants, however, these single cells then pass through a callus to regenerate whole plants causing genetic abberations. If intact plant structures such as meristems or embryos are frozen, their size (multicellular) leads to a problem of ice crystal formation within the tissue. Survival rates of frozen multicellular structures are low and little or no study has been made on the stability of the regenerated plant (with the exception of cassava). The concept of cryopreservation is one that would revolutionarize plant germplasm storage and as such deserves more investigation. However, in the short to medium term I do not see this as a viable option to sweet potato clonal in vitro repositories.

8. PHYTOSANITARY STATUS OF SWEET POTATO GERMPLASM COLLECTIONS

The successful introduction of a sweet potato plant to in vitro culture would imply that the plantlet is probably free from bacterial, fungal and mycoplasma infections. The plantlets may still however be infected with viruses or viroid. The maintenance of the plantlets in vitro (rather than in the field) does, however, limit further viral degeneration of the collection that could result from cross contamination. It is therefore possible to enhance the phytosanitary status of a collection by in vitro introduction. It is also beneficial to virus/viroid eradication programs to already have the germplasm in vitro. When germplasm is to undergo evaluation an obviously optimal phytosanitary status is required.

9. MANAGEMENT OF SWEET POTATO IN VITRO GERMPLASM COLLECTIONS

The size of any given germplasm collection will vary and the problem of managing a collection of several thousand accessions are distinct from those with fifty accessions. However, with any in vitro germplasm collection care and consideration must be given to the following points: 1) How many replicates should be kept of each accession. 2) Should duplicate accessions be held by another institution. 3) What safeguards can be made against errors in data maintenance. 4) How often should the collection be checked. 5) Which accessions are the most valuable in case of emergency. In the case of CIP a computer data base is being established on the sweet potato collection. This should allow us (using the potato collection as a model) to maintain continual records of the in vitro collection and make the maximum amount of information and material available to developing country national programs. It should also facilitate inter-centre information flow on the status of any or all in vitro accessions.

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VIRUS DISEASES OF SWEET POTATO IN NIGERIA

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1. ABSTRACT

In Nigeria, the sweet potato virus disease (SPVD) is caused by an aphid-transmitted and a whitefly-transmitted component. Only when both components are present, disease symptoms appear in sweet potato. The aphid-transmitted component of the sweet potato virus disease complex in Nigeria has been identified as a virus similar or identical to sweet potato feathery mottle virus. The causal agent involved in the whitefly-transmitted component has not been fully identified.

Additionally, a "leaf curl" disease was identified in Nigeria. Its symptoms in sweet potato are typical leaf curl. These viruses often occur together in the field.

Virus indexing is done by ELISA, and ISEM, as well as by grafting to I. setosa. ELISA proved to be useful only when both aphid and whitefly components are present.

In order to be able to detect the two components of SPVD individually, a simple, complementary grafting technique is used whereby a seedling clone (TIb 8, s.c.9), preinfected separately with aphid and whitefly components, is used for grafting. This method proved to be highly sensitive and thus, plants may be reliably indexed, even when only one component is present.

Indexing for the leaf curl disease is done by grafting to I. setosa. Also TIb 8, s.c.9 is susceptible to "leaf curl" and, therefore, reveals presence of this virus when used for indexing.

In epidemiological studies, it was observed that the aphid-transmitted component is more wide-spread than the whitefly-transmitted component.

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2. INTRODUCTION

Virus diseases showing a wide range of symptoms have been recorded in sweet potato (Ipomoea batatas L.) wherever the crop has been grown. Various symptom combinations of vein-clearing, stunting, feathery mottle, chlorotic spots, mosaic, leaf curl, leaf strapping, etc., have been reported from Kenya (Sheffield, 1957; Hollings et al., 1976), Ghana (Clerk, 1960), Israel (Loebenstein and Harpaz, 1960), Nigeria (Robertson, 1964; Shaefers and Terry, 1976; Rossel and Thottappilly, 1985, 1987), USA (Hildebrand, 1960; Moyer and Kennedy, 1978; Cadena-Hinojosa and Campbell, 1981), Argentina (Nome, 1973), Taiwan (Chiu et al., 1984; Rossel and Thottappilly, 1987), Japan (Ide and Sakamoto, 1984), Australia (Taylor and Stubbs, 1971) and New Zealand (Over de Linden and Elliott, 1971). However, only a few of the causal viruses have been fully characterized.

Hitherto, virus diseases of sweet potatoes have been described based largely on symptomatology, host range and vector relationships (Martin and Hernandez, 1966; Nome, 1973). Further information, such as biochemical properties and serological relationships, are needed for classifying these viruses. Without such information, one cannot tell if some of the diseases described are caused by strains of only one virus or by different viruses. For the same reason, the extent of distribution of these viruses is largely unknown.

Some confusion has also arisen from the wide varietal differences in reactions of sweet potato, and from complex infections with two or more viruses. Most of the viruses reported are aphid-transmitted in a nonpersistent manner and have filamentous particles typical of the potyvirus group. The relationship among the aphid-transmitted viruses in sweet potato are poorly understood, because little is known about the viruses reported from various parts of the world. Other virus diseases, such as "vein-clearing" in Israel, "yellow-dwarf," and "leaf curl" in Taiwan as well as "virus B" and/or "sweet potato mild mottle" in Kenya have whitefly vectors. Transmission of feathery mottle virus (FMV) has been claimed for both aphids (Webb and Larson, 1954) and whiteflies (Hildebrand, 1959).

3. THE SWEET POTATO VIRUS DISEASE COMPLEX IN NIGERIA

In Nigeria, leaves of infected sweet potato plants show vein-yellowing, irregular chlorosis or both, often in combination with various degrees of malformation and leaf narrowing. In highly susceptible genotypes, plant growth may be severely stunted. In certain varieties, systematic necrotic spotting can occasionally be observed, usually followed by leaf abscission, superficial stem necrosis or both. Similar symptoms have also been observed in Togo (Nienhaus, 1980) in Burundi, Cameroon, Liberia, Sierra Leone, Tanzania, and Zaire (Hahn, 1979) as well as in Gabon, São Tomé, Rwanda, Costa Rica (Rossel and Thottappilly, 1985), and Côte d'Ivoire (Fauquet and Thouvenel, 1987). Hahn (1979) studied loss of tuberous root yield due to SPVD in sweet potato showing symptoms of the disease and estimated that yield of fresh tubers was reduced by 78% in plants showing SPVD symptoms.

Schaefers and Terry (1976) were the first to separate two inefective agents from a sweet potato disease complex. One is a potyvirus which is transmitted by aphids in a

nonpersistent manner. It is latent in sweet potato, but produces marked vein-clearing and leaf twisting in Ipomoea setosa. So they named the virus sweet potato vein-clearing virus. The second agent is transmitted by the whitefly Bemisia tabaci and is also latent in sweet potato. However, I. setosa plants showed stunted growth, accompanied by a general chlorosis. They named this component sweet potato chlorotic stunt virus. The two disease agents together produce severe symptoms in sweet potato. Depending upon the cultivar, vein-clearing, puckering, leaf strapping, chlorosis, and stunting may occur.

Further investigations have revealed that the aphid-transmitted component of SPVD can, with difficulty, be mechanically transmitted from sweet potato to Nicotiana benthamiana inducing leaf crinkling and puckering (Rossel, unpublished). This virus resembles those of the potyvirus group in all aspects, including the induction of ultrastructural features, which look like pinwheels. The aphid-transmitted component causes systemic interveinal chlorotic spots and vein-clearing in I. setosa and I. nil.

In order to produce an antiserum against the aphid-transmitted component, a new isolate code-named as SPV-Y, which was maintained in N. benthamiana, was purified from this test plant. Leaves of infected N. benthamiana showing characteristic symptoms of infection were harvested 15 days after inoculation. The tissues were homogenized in 0.1 M potassium phosphate, pH 7.7 containing 0.001 M cysteine plus 0.01 M EDTA and 0.1% 2-mercapto-ethanol. The juice was passed through cheese cloth and was then clarified with 8% n-butanol. After precipitation with PEG, and one high-speed centrifugation cycle, the virus was further purified by centrifuging twice in cesium chloride gradient at 38% (w/t) at 30,000 rpm in a Beckman SW-41 rotor for 20 hours. A rabbit was immunized by intramuscular injection of the virus preparations at weekly intervals, followed by two intravenous injections. In SDS-agar gel diffusion test, the antiserum reacted very strongly with juice from SPV-Y infected N. benthamiana.

In addition, the enzyme-linked immunosorbent assay, ELISA (direct double antibody sandwich method) was developed as described below. To remove any antibodies against healthy proteins which may be present in the antiserum against SPV-Y, the antiserum was repeatedly absorbed with sap from healthy N. benthamiana until no further precipitate was formed. The gama-globulin fraction from the absorbed antiserum was purified by ammonium sulfate precipitation and by filtering through a column of DE-cellulose. A gamma globulin coating of 1.0 ug protein/ml and a conjugate dilution of 1/250 gave the best results. In tests of several buffers for extraction or dilution of the antigens, the best results were obtained with 0.25 M potassium phosphate buffer (pH 7.0) containing 0.1 M EDTA and 0.25% sodium sulphite. Similarly, an antiserum against sweet potato feathery mottle virus (FMV) supplied by Dr. J. W. Moyer (USA) was used to develop an ELISA test in order to survey for presence of FMV in Nigeria.

In SDS-agar gel diffusion tests, the SPV-Y antiserum reacted with diseased sweet potato samples from within Nigeria. Similarly, the sweet potato samples and the crude juice from SPV-Y infected N. benthamiana reacted very strongly with FMV antiserum. Further samples of diseased sweet potato collected within Nigeria, as well as N. benthamiana infected with SPV-Y reacted similarly in ELISA when these samples were tested with SPV-Y antiserum and with FMV antiserum. With both antisera, it was possible to detect the virus in crude juice up to the same dilution, varying between 1/250 to 1/625. Thus, it seems that the newly obtained isolate SPV-Y, like isolates of

the SPVD-poty component which had earlier been obtained in N. benthamiana, is serologically closely related to or identical with FMV.

Concentration of virus in leaves varies considerably and seems to be highest in very young leaves. Older leaves collected from symptom-showing plants gave inconsistent results.

In other studies, sweet potato plants infected with the aphid-transmitted component alone and kept in insect-free screenhouses were tested in ELISA using SPV-Y and FMV antisera. No reactions were obtained with either of the antisera. This confirms that the concentration of the aphid-transmitted component (feathery mottle virus-FMV) in the absence of the whitefly-transmitted component of the disease, is too low to be detected by ELISA.

However, when the whitefly-transmitted component is introduced to the plants pre-infected with the aphid-transmitted component, this component becomes readily detectable by ELISA and typical virus symptoms appear. Thus, ELISA is not useful for the indexing of symptomless sweet potato materials when only the aphid-transmitted component is present. In such cases, one has to rely on complementary grating to pre-infected test clones. However, in I. setosa and I. nil infected with the aphid-transmitted component alone, this component can be detected by ELISA.

4. THE WHITEFLY-TRANSMITTED COMPONENT OF SPVD

The nature of the whitefly-transmitted component of sweet potato virus disease complex is still not known with certainty, although at IITA, long, fragile filamentous particles have frequently been observed with the electron microscope. To confirm this finding and to reveal the true nature of the agent, attempts were made to purify virus from I. setosa plants that were inoculated by viruliferous whiteflies. But the plants did not show clear sypmtoms of virus infection even after whitefly transmission. Therefore, all inoculated I. setosa plants were used for purification of the agent.

Leaf and stem tissues were ground in 0.25 M potassium phosphate buffer (pH 7.5) containing 0.25% sodium sulfite, 0.01 M EDTA, and 0.2% polyvinyl-polypyrrolidone, and passed through a double layer of cheesecloth; 6.5% n-butanol was added to the sap, which was stirred for 2 h and then centrifuged at 5,000 rpm for 10 mins; 8% PEG was added to the supernatant. The pellet was collected by centrifugation and resuspended in 0.02 M phosphate buffer (pH 8.2) containing 0.1% mercaptO-ethanol (PB). After low-speed centrifugation, the supernatant was centrifuged at 25,000 rpm for 2h in a R-35 Beckman rotor. The pellet was resuspended in PB as before. Cesium chloride was added to this preparation to a concentration of 38% (w/v) and centrifuged for 18h at 30,000 rpm in a SW-41 Beckman rotor. A light cut clearly visible band in the middle of the tube was collected and examined in an electron microscope. Filamentous particles slightly longer than those of the aphid-transmitted component (a potyvirus), were observed. Further work is being done to confirm this finding and to elucidate the etiology of the whitefly-transmitted component.

5. INDEXING

The observation that the aphid and whitefly-transmitted agents were latent in sweet potato and that dual infection was necessary for symptom expression (Schaefers and Terry, 1976), and our finding that even with the highly sensitive serological technique, ELISA, the aphid-transmitted virus cannot be detected in sweet potato plants unless it is accompanied by the whitefly-transmitted component, have necessitated the development of alternative and efficient indexing methods.

A simple approach-graft technique, in which cuttings are clipped together with ordinary laundry pegs was devised for this purpose (IITA, 1981; Rossel, unpublished; Rossel and Thottappilly, 1985). A highly susceptible sweet potato seedling clone (TIb 8, s.c.9) was used. It had been selected from a seedling population grown from seed of the clone, TIb 8 (Tropical *Ipomoea batatas* No. 8, a germplasm introduction at IITA), that is highly susceptible to SPVD. While maintaining some healthy plants (TIb 8, s.c.9-H), we divided and subcloned the test clone into two preinfected sections: one with the whitefly-transmitted agent (TIb 8, s.c.9-W.F.) and another with the aphid-transmitted virus (TIb 8, s.c.9-A). Enough cuttings of these can thus be routinely produced for indexing, without further preinfection.

6. VIRUS INDEXING PROCEDURES USED AT IITA

At the International Institute of Tropical Agriculture (IITA), we use the following indexing procedures:

1. Sap inoculation to *N. benthamiana* and *Ipomoea setosa*
2. ELISA and ISEM
3. Grafting to *I. setosa*
4. Complementary grafting.

Using these indexing procedures, IITA is able to send virus-resistant lines (Hahn et al., 1981) in the form of tissue cultures (Ng, 1987).

To improve our methods of virus detection and indexing, we are producing monoclonal antibodies against SPVD-components in a collaborative effort between IITA and the U. S. Department of Agriculture (USDA) laboratory in Beltsville, Maryland. Using monoclonal antibodies, we will be able to identify strains or variants of a given sweet potato virus.

There is little doubt that monoclonal antibodies can be utilized to detect the presence of a common epitope as well as by using antibodies to a specific epitope, one can detect specific strains. The superior discriminatory capability of monoclonal antibodies compared to polyclonal antisera is further enhanced by the fact that unlimited supply of monoclonal antibodies of known quality and specificity can be achieved. Virus disease indexing will definitely benefit from the possibility of

potentially unlimited supply of monoclonal antibodies of known quality and specificity. The ambiguities and limitations of the present serological indexing procedures will be eliminated as monoclonal antibodies are available and complement the traditional antisera.

In addition to the highly sensitive serological techniques like ELISA and immunosorbent electron microscopy (ISEM), that combine the specificity of serological reaction with the sensitivity of the electron microscope, we have recently started working on dot-blot immuno-assay and western blot. The ultimate goal of these activities is the development of more rapid, efficient and safer procedures for the transfer of vegetative materials.

7. SWEET POTATO LEAF CURL

A disease showing upward rolling of leaves and marked swelling of veins on lower sides of leaves was first observed in Nigeria during the dry season in 1984. The symptoms were most prominent on young infected plants. However, these plants recovered during the rainy season. Again in the 1987 dry season, pronounced symptoms were observed in the field and it was possible to transmit the causal agent by grafting to healthy sweet potato clones (TIb 8, s.c.9-H). Successful transmission induced leaf curl symptoms. No transmission was obtained by sap inoculation. It could be transmitted from infected sweet potato to healthy sweet potato and I. setosa by grafting and by whiteflies (Bemisia tabaci).

A similar disease is reported from Taiwan (Liao et al, 1979; Chung et al., 1985; Rossel and Thottappilly, 1985), and Japan (Ide and Sakamoto, 1984). Little is known about the particle structure of the agent responsible for "leaf curl" in Taiwan, although rod-shaped particles were thought to be involved (Chung et al., 1985). In the absence of an antiserum to the leaf curl agent, very little could be concluded about the exact identity of leaf curl in Nigeria.

Symptomatology and whitefly transmission show that the sweet potato leaf curl in Nigeria is similar to the one described from Taiwan. Further work is in progress to elucidate the etiology of this disease.

8. EPIDEMIOLOGY

To complete the story of the SPVD complex, we present here some findings concerning the epidemiology of the disease. Whereas the disease as such is caused by simultaneous infection with two totally different viruses that have different vectors and that are individually latent in sweet potato, the spread pattern of SPVD in the field, obviously, is determined by the individual dissemination characteristics of each of the two components.

In spite of what may be expected from a vegetatively propagated crop like sweet potato, SPVD, generally, occurs at low incidence in this crop in Nigeria, as well as in

other countries in Africa. Infection percentages, both in experimental plots with new, improved genotypes, as well as in farmers' grown crops, are in the order of 1-5%, whereas one would ordinarily expect infection to increase until all plants in the field are affected. Considering the fully systemic nature of the viruses involved, this low incidence can only be the result of absence of vector transmission, or of some kind of self-elimination mechanism operative in the crop when vector transmission does occur.

In early experiments on SPVD at IITA (Rossel, unpublished), it was unequivocally established that vector transmission does occur; however, incidence was shown to be quite low. In one experiment it was observed that only three out of 25 seedling plants, grown in a seedling bed in the field, unprotected from virus vectors, had become infected with the whitefly-transmitted disease component in the course of one growing season (5 months). Monitoring of infection was done by complementary grafting to a test clone, TIb 8, s.c.9-A, which for this purpose had earlier been pre-infected with the aphid-transmitted component of SPVD.

In another experiment, 25 plants each of the "aphid" and of the "whitefly" sections of the earlier mentioned test clone, TIb 8, s.c.9, were planted in pots and kept in the open, unprotected from insect vectors, but isolated from diseased plants. In this case, only one plant became diseased in each of the two series, which shows low natural infection pressure of the whitefly-transmitted component of SPVD. It also shows that natural infection pressure of the aphid-transmitted component may be low, provided there are no diseased plants in the vicinity.

In the 1986 field experiment conducted at IITA, and designed primarily to assess yield reduction by SPVD complex in a moderately susceptible variety, high natural infection pressure of the potyvirus-component was confirmed. In this experiment, covering one rain-fed growing season, an average of 6-7 plants out of 25 in each of 4 replications had become infected with the aphid-transmitted component. Plots planted to diseased plants and included in the lay-out of this experiment provided for ample infection sources nearby, thus reflecting natural conditions comparable to the situation in farmers' fields. In the same experiment it was confirmed that the natural infection pressure of the whitefly-transmitted component is very low; in fact, in the experiment described above, it was found to be effectively zero, as no infected plants were found among the total of one hundred in the experiment.

Diseased plants in susceptible cultivars are generally severely stunted and often tend to become fully overgrown by healthy ones. In contrast, diseased plants of highly tolerant or moderately resistant varieties exhibit a growth vigour that is comparable to non-diseased plants and they do not get overgrown by healthy ones.

As cuttings for the next season's crop are taken randomly from the available stem material, it seems obvious that in highly susceptible varieties most, and possibly all of such cuttings are taken from non-diseased plants. As such, it may be assumed that actual disease incidence represents an equilibrium situation in which, over the years, no further increase or decrease of incidence takes place. It is the net result of, on the one hand, infection with the whitefly-transmitted component of seemingly healthy plants, and on the other hand, of selection of seemingly healthy plants to provide the cuttings for the following season's crop.

Thus, disease incidence in the equilibrium situation is dependent on the level of resistance of the clone concerned, because the latter determines the chances of cuttings for new crops being taken from diseased plants. In other words, the less susceptible a clone is, the better the chances are that cuttings are being, and have over the years, been taken from diseased plants, and that a crop of such a variety has become uniformly diseased. This can often be seen in such varieties in the field. In one "resistant" local variety, (Dukukpuku) grown in Eastern Nigeria, not a single diseased plant could be found; yet, this variety was shown to be uniformly infected with both components of SPVD and may thus be considered resistant to SPVD. A similar phenomenon was observed in tolerant varieties showing mild symptoms only. Various clones found on farmers' fields show mild disease symptoms. It was observed that such clones do so in every, or nearly every plant.

Usually every plant in a crop is infected with the potyvirus component. Thus, the occurrence of SPVD and its incidence in the equilibrium situation result from super-infection with the whitefly-vectored component. The disease thus behaves as if it were whitefly transmitted, which explains most of the confusion in the literature on sweet potato viruses.

Where one component (the aphid-transmitted potyvirus) has a very considerably higher infection incidence than the other and where this component is totally symptomless, the component becomes rapidly established in the total population of plants because there would be no self-eliminating mechanism operative for this component.

Another important aspect of the epidemiology of SPVD is the fact that it takes a comparatively long time (up to 3 months) for plants to develop symptoms after infection with the whitefly-transmitted component. Thus, most of the obviously diseased plants in a crop result from infections with the whitefly-transmitted component of their mother plants during the preceding growing cycle. Therefore, ultimate incidence, besides being strongly influenced by tolerance level of the genotype involved, is also strongly dependent on the natural infection pressure of the whitefly-transmitted disease component. Apparently the natural infection pressure of this component is quite low in various countries of West Africa, as well as in East Africa.

9. FURTHER AREAS OF WORK

In laboratory studies, Schaefers and Terry (1976) determined that the aphid-transmitted component is transmitted most efficiently by the aphids, Myzus persicae and Aphis gossypii, and less efficiently by A. citricola. There is further need to elucidate the role of non-colonizing, transient vectors (Atiri and Thottappilly, 1985) because these may disseminate several viruses accidentally during host finding (Hull and Selman, 1965; Swenson, 1968; Atiri et al., 1986). It is known that there are wide variations in the transmission of a particular virus by different aphid species, or even within forms of a given species (Thottappilly et al., 1972, 1977).

Bemisia species have a wide host range. They have been observed breeding in tomatoes, sweet potatoes, cowpeas, cotton, tobacco, peppers and cassava. According to

Leuschner (1977) the life cycle of Bemisia varies with temperature; and the variations are observed in the different seasons of the year. Leuschner also observed that whiteflies usually fly only short distances. However, whiteflies can be transported by wind over longer distances. Further work on the biology and feeding behaviour of whiteflies on sweet potato may explain why there is a low incidence of the whitefly-transmitted component of SPVD in the crop.

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VIROLOGY

I. N. Njoroge

1. VIRUSES

Viruses are minute infectious entities affecting potatoes. They cause a number of diseases which although seldom lethal, reduce plant vigor and yield potential and quality of seed tubers. There is a large number of viruses which attack potatoes but the most common ones are PLRV, PVA, PVX, PVY, PVS, PVM, TMV, and PSTV.

2. SYMPTOMS CAUSED BY PLANT VIRUSES

Virus diseases identification is complicated by wide symptom variation due to virus strain differences, plant response, plant response in relation to maturity and duration of infection, varietal response differences and environmental influences. Symptoms of virus disease infection on the plant are reduced growth rate, resulting in various degrees of dwarfting or stunting of the entire plant. The most obvious symptoms of virus-infected plants are usually those appearing on the foliage. The common types of symptoms are mosaics and ring spots characterized by the appearance of chlorotic or necrotic rings on the leaves. Internal net necrosis may also be noticeable when the stems or tubers are cut cross-sectionally.

3. TEST FOR VIRUS DISEASES

Visual observation alone cannot be a reliable diagnostic procedure for virus disease identification. These test applied are numerous e.g. the use of indicator plants, grafting, insect transmission, Igel-Lange test (deep blue staining of phloem sieve tubers after 10 minute 1% aqueous solution in blue) and the serological techniques. The later is the most dependable. It is based on simple principle that when a given amount of virus (antigen) is mixed with a given amount of antibodies (antiserum) the molecules upon contact form a complex aggregate which is soluble at first but with the complex aggregate molecules increase in size they precipitate out of solution. The most commonly applied serological tests are the:

1. Microprecipitation test
2. Latex test

3.1 Enzyme-Linked Inmunosorbent Assay (ELISA)

Virology research has had a break through in the recent development in serology using the ELISA (Enzyme-Linked Inmunosorbent Assay). This technique provide extremely

sensitive test for virus presence in plants and has for the first time permitted the identification of certain viruses difficult to detect in potatoes. The application of ELISA to detect the virus in tuber and other plant material has resulted in improved indexing techniques. It is a reliable method although laborious to perform because it follows a longer procedure than the other conventional techniques.

4. PRINCIPLE

In this method the viruses in the test samples (antigen) foliage, sprouts tubers are trapped and immobilized by specific antibodies (antiserum) absorved on a solid surface (polysterene microtitre plates). Trapped viruses are then reacted with further specific antibodies to which an enzyme has been linked. After washing enzyme-labelled antibodies which has complexed with the trapped viruses are detected colorimetrically or visually after adding a suitable substrale.

5. MAJOR KNOWN POTATO VIRUSES

PLRV - Potato leaf roll virus
PVY - Potato virus Y
PVA - Potato virus A
PVX - Potato virus X
PVS - Potato virus S
PVM - Potato virus M
PVT - Potato virus T
PMTV - Potato mop-top virus
TRV - Tobacco rattle virus
AMV - Alfalfa mosaic virus
PAMV - Potato aucuba mosaic virus
TRSV - Tobacco ringspot virus
TBRV - Tomato black ring virus
TSWV - Tomato spotted wilt virus
APMV - Andean potato mottle virus
APLV - Andean potato latent virus
PYVV - Potato yellow vein virus
PSTV - Potato spindle tuber viroid

6. INDICATOR PLANT VIRUS INDEXING

Test Plant	Virus
Chenopodium quinoa	PVS, PVX, APLV, TBRV
Chenopodium amaranticolor	PVS, PVX, TBRV
Datura metel	PVM
Datura stramonium	PVX, TBRV

Gomphrena globosa	PVX, TBRV
Lycopersicon esculentum "Rutgers"	PSTV
Nicotiana bigolovii	APLV
Nicotiana clevelandii	PVY, PVX, APLV, TBRV
Nicotiana debneyi	PVS, PMTV
Nicotiana tabacum "Samsun"	PVY, TBRV
Nicotiana tabacum "White Barley"	PVY
Phaseolus vulgaris "Red kidney"	AMV, PVM
Phaseolus vulgaris "Black turtle soup"	AMV
Scopolia sinensis	PSTV
Solanum demissum x S. tuberosum "A-6"	PVA, PVY
Solanum demissum "SdA"	PVA
Solanum demissum "SdY"	PVY

Serology tests are utilized as follows:

Precipitation tests for: PVX, PVY, PVS, and PVM
Latex tests for: PVX, PVS, PVY, APLV, APMV
ELISA tests for: PVX, PVS, PVY, and PLRV.

PROCEDURES FOR VIRUS INDEXING

L. F. Salazar[1]

The production and maintenance of pathogen-free plants requires of sensitive and reliable methods of pathogen detection. Even though sensitive methods for detecting viruses and viroids have been developed in recent years their application is limited by the plant species in which detection is intended. For the detection of viruses and virus-like agents in sweet potatoes several factors need to be studied:

- Identification of sweet potato viruses and study of the relationships between the many diseases observed.
- Evaluation of potential techniques and procedures to determine the most effective strategy for each virus-host combination.
- Thorough testing of techniques to ensure they have a broad spectrum of virus strains recognition.
- Study the life cycles of viruses and of sweet potato to determine the most appropriate time for virus indexing.

1. ASSAYS AVAILABLE

All the information so far available has been obtained with Sweet potato feathery mottle (SPFMV). SPFMV seems to be a good model for these studies, however, there always exist a risk that the information obtained cannot be directly applicable to other viruses and virus-host combinations. Therefore, studies for each virus-host combination are desirable.

2. INDICATOR HOSTS

Indexing for SPFMV has been conducted by grafting scions from sweet potatoes into *Ipomoea setosa* or other sensitive *Ipomoea* spp. (3,5). All other viruses so far reported in sweet potatoes are known to infect *I. setosa* and *I. nil*. In spite of the considerable time required to index for virus through indicator plants, these two hosts can be utilized for virus indexing until other reliable techniques can be identified. The conditions for best symptom development in indicator plants should be determined with each virus. For SPFMV cotyledons of indicator plants are more susceptible to

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mechanical inoculation (1). However, graft-inoculation of indicator plants is more reliable than mechanical inoculation, especially to index for other viruses which are not transmitted mechanically.

3. SEROLOGICAL TECHNIQUES

The enzyme-linked immunosorbent assay (ELISA) has been used to detect SPFMV directly from sweet potatoes (4). However, the variability in SPFMV concentration in sweet potato shoots (2) and the fact that the virus is often present below the limits of detection by ELISA makes the serological approach an unreliable procedure at present. In a study carried out at CIP (s Table 1), ELISA detected SPFMV in mature sweet potato plants only from symptomatic leaves but not from those not showing symptoms. In the same comparison graft-inoculated I. nil was more reliable than ELISA or observation of symptoms in stem cuttings for detecting SPFMV. In an attempt to overcome above difficulties in testing for SPFMV by ELISA Esbenshade and Moyer (4) suggested to test two shoots per plant, using a composite samples of three leaves from each shoot.

Dot-blot or NC-ELISA seems to be slightly more sensitive and produces less background or non-specific reactions than the direct ("sandwich") procedure when testing for viruses directly from sweet potatoes.

4. ANALYSIS OF NUCLEIC ACIDS

Two techniques offer possibilities to be applied in indexing. Double-stranded DNA (dsRNA) molecules are produced in plants as a result of infection with RNA viruses. They constitute the replicative forms (RF's) or replicative intermediates (RI's) of the particular virus. Since these dsRNA's occur in a characteristic electrophoretic pattern with each RNA virus infection their identification can be used as a method of virus detection. So far dsRNA patterns for SPFMV have been studied (J. Abad and J. Moyer, personal communication) but the reliability and sensitivity of an indexing procedure using these patterns have not been yet determined.

The nucleic acid spot hybridization (NASH) has been already developed for assaying viroids and some viruses. The method is based on the development of DNA complementary (cDNA) to a portion of the virus genome which upon incorporation into a vector (plasmid or bacteriophage) can be grown at will in a bacteria. This cDNA can be labeled with radioactive isotopes or enzymes and used as a probe for detecting, by hybridization, the target virus nucleic acid. A SPFMV cDNA has been developed (J. Moyer, personal comm.) but their reliability and sensitivity in a virus indexing system has not been determined.

5. VIRUS PATHOGENESIS AND INDEXING

The practical importance of studies on viral pathogenesis has been recognized since SPFMV is known to be highly "variable" and unevenly distributed during the development of the sweet potato plant (2,4). Whether the same is applicable to other viruses is not known. Therefore, the use of arbitrary sampling procedures used to assay other crops are inadequate for assaying SPFMV and should be determined for other viruses.

Table 1. Relative efficiency of three methods for detection of SPFMV from sweet potato

Method	Proportion of detection[a]	Percentage of detection
ELISA		
leaves with symptoms	43/43	100.0
leaves without symptoms	0/43	0
Stem-cuttings[b]	20/43	46.51
I. nil[c]	43/43	100.0

[a]Numerator: No. of positive samples; denominator: total No. of samples.

[b]Stem cuttings from field grown plants were planted in the greenhouse, observed for symptoms and the presence of SPFMV confirmed by ELISA.

[c]*I. nil* grafted with scions from above stem cuttings developed symptoms and the presence of SPFMV was confirmed by ELISA.

6. CONCLUSIONS

The development of a virus indexing system for sweet potatoes requires careful detailed evaluation of existing techniques in relation to the developmental biology of sweet potatoes.

At present, the complete identification of virus diseases must receive high priority. Meantime this can be achieved and other more efficient techniques and procedures for virus detection can be evaluated, testing for viruses by means of indicator plants is the most logical approach. In order to broaden the spectrum of detection other indicator plants from the pool used in virus identification should be included. The evaluation of other species in the Convolvulaceae might prove extremely useful.

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BACTERIAL AND FUNGAL DISEASES OF SWEET POTATO

Wanda Collins

1. INTRODUCTION

Sweet potatoes are attacked by a number of disease-causing fungi and bacteria. Most of these diseases had been described by 1930 and few new ones have been discovered since then. Disease organisms attack both the above-ground and below-ground plant parts. Those of most concern attack the below-ground storage roots which are the most important commercial product. However, damaging foliar attacks may also cause serious losses.

Diseases of storage roots can be generally grouped according to whether the major damage occurs under growing conditions in the field or after harvest in storage or in transit. But, sweet potatoes are vegetatively propagated, and many organisms can be spread through the use of infected transplants. These organisms can survive in the soil to cause infection of stems or roots, and to reinfect new storage roots as they are harvested. Therefore, all stages of the growing and life cycle of sweet potato may be important in disease control of any one organism.

Several excellent reviews of sweet potato diseases have been published in the past. The following review of bacterial and fungal diseases gives the common name, causal organism, a brief description of symptoms and general control measures.

Diseases which cause major damage during the growing cycle of sweet potatoes include both foliar diseases and root diseases (both fibrous root and storage root). (Table 1).

2. FOLIAR DISEASES

Many foliar pathogens attack sweet potato. Fortunately, most of these are of little economical concern causing only minor damage. However, one disease, leaf scab caused by Sphaceloma batatas (also recognized by perfect stage Elsinoe batatas), is devastating on sweet potatoes in many parts of the tropical world. This disease is not known in the temperate growing areas of sweet potato. The disease is recognized by small brown lesions which appear on the veins of the leaves. These lesions become corky, the vein then shrinks which causes the leaf to curl in a characteristic symptom of this disease. On the stems, purplish lesions appear and coalesce to give the appearance of a scab. Growing sweet potatoes in a portion of the rainy season gives this fungus an excellent environment in which to develop as it appears to do well in wet conditions.

One other foliar pathogen which has been reported to cause severe damages in some areas is sweet potato foot rot, caused by Plenodomus destruens. The disease is

characterized by dark spots which develop on the stem at the soil level. These dark lesions gradually encircle the stem which blackens and dies.

3. ROOT DISEASES

The majority of economically important diseases of sweet potato occur on the storage roots themselves. Many of the pathogens also attack the fibrous root system and cause yield losses through losses to this system. Some also cause lesions on the stems. However, the major loss occurs when the storage root itself is attacked. Symptoms occur which make the root unsalable as a commercial product. In addition, many of the roots which occur in storage and transit occur as a result of harvest injury which exposes the roots to post-harvest decay organisms present in the soil but result in losses occuring later. Quite often diseases will typically occur in the growing cycle of the plant. However, many of them may carry over into the postharvest cycle and increase in importance. For this reason it is sometimes impossible to determine whether the most important part of the disease cycle is pre-harvest or post-harvest.

3.1. Bacterial Soft Rot

Is caused by *Erwinia chrysantemi*, and causes rots on sweet potato roots and stems as it does on many other economically important crops. The disease has serious implications for tropical areas because the conditions are perfect for development of symptoms. A typical moist, mushy rot develops in the roots. This rot may progress very rapidly under favorable conditions (high temperatures and moisture) and damage will be severe. A stem rot may also develop which provides an excellent source of inoculum at harvest. Roots that have been damaged in any way during the harvest procedure may be exposed to bacteria and the disease may progress very rapidly after exposure.

3.2. Sweet Potato Scab or Soil Pox

Is caused by the actinomycete *Streptomyces ipomoea* and is characterized by necrosis of fibrous roots which results in one type of yield loss by inhibiting storage root development and decreasing the effectiveness of the uptake root system. Further yield loss is caused by the development of dark brown to black lesions on fleshy roots. These lesions usually develop around the root hairs. As they grow larger they develop a very characteristic sunken, cracked appearance and may actually pull away from surrounding tissue. This disease is favored by warm, dry conditions and high soil pH. Some resistance is available; however, it is advisable to avoid contamined fields.

3.3. Fusarium Wilt or Stem Rot

Is caused by the fungus *Fusarium oxysporum* f. sp. *batatas*. It is species-specific for sweet potato and results in wilted and dying plants in the field. First symptoms

of this disease are yellowing and dying of older leaves followed by a general wilting of the plants. The vascular tissue is discolored from the base and the stem may actually split. Tremendous losses occur if a susceptible variety is used; however, levels of resistance are quite high and easily incorporated into new varieties with a rigorous but simple screening program.

3.4. Circular Spot

Is caused by *Sclerotium rolfsii* is a soil-borne pathogen which causes circular lesions on the storage roots. Lesions are light brown and may be confused with *Streptomyces ipomoea* lesions. Since it is a long-lived soil-borne pathogen, crop rotation is of some value. Resistance has been identified.

3.5. Black Rot

Is caused by *Ceratocystis fimbriata* affects both storage roots and underground stems. This is one of several diseases that can occur both before and after harvest. In the field dark circular lesions may extend into the vascular tissue. Continued growth of the fungus may result in the entire root rotting. Once a diseased root is harvested, spores can be transmitted to other roots and can gain entry through wounds. While black rot still occurs in some places, it has been largely eliminated through a strict sanitation and rotation program.

3.6. Scurf

Is caused by *Monylochaetes infuscans* appears as small brown lesions limited to the surface, or periderm, of the storage roots. These lesions gradually coalesce until they may cover the entire root. While the fungus does not penetrate beyond the outer layers of the periderm (the remainder of the storage root is sound and edible), the root is unsightly and usually not marketable. If small lesions are present at harvest, these will continue to develop and coalesce in storage. The fungus may be spread from root to root in storage in many ways including through the air. The use of only the upper portions of plants as vegetative propagative material will likely prevent spread of the disease as it is limited to stem tissue near the root. Other controls include crop rotation and avoidance of infested fields.

3.7. Charcoal Rot

Is caused by *Macrophomina phaseolina* and is similar to black rot in that both the storage roots and underground stems are attacked with lesions occurring at the soil line. Roots that are infected change from brown to black and become like charcoal with sclerotia formed in the rotted areas. Since sclerotia are also produced on the stem part of the plant, roots may be exposed to inoculum as they are harvested. If damaged during harvest, they may be infected quite easily. As with many other diseases of this nature, sanitation plays a major part in control of the disease.

3.8. Java Black Rot

Is caused by Diplodia gossypina (Diplodia theobromae, Diplodia tubericola, Botryodiplodia theobromae) and is another rot that seriously affects roots after harvest. Roots rot very slowly, gradually becoming mummified. Fungal pycnidia can be seen over the surface of the root. foliar symptoms may also be observed at the base of stems. Sanitation is the major form of control for this disease.

3.9. Dry Rot

Is caused by Diaporthe batatis, is also primarily a storage rot.

3.10. Soft Rot

Is caused by Rhizopus stolonifer (Rhizopus nigra) and is a very serious storage disease favored by high relative humidity. The roots become very moist and soft. Very prominent aerial mycelia of the fungus form rapidly on the outside of infected roots. The aerial mycelium also provides an excellent source of spores for infection of nearby roots by air or insects. Roots rot very quickly once infected with the fungus. Again, sanitation is a major form of control.

3.11. Surface Rot

Is caused by Fusarium oxysporum and is a storage rot. Infections are usually a result of invasion of the pathogen after harvest damage. While surface lesions may grow larger as the roots are stored longer and coalesce over the surface, they rarely extend deeply into the root. Many affected roots are edible if the surface rot is removed. Control of this disease is based on very careful harvest and post-harvest handling and sanitation in the storage facility.

3.12. Storage Rot

Is caused by Fusarium solani and, while similar to surface rot discussed above, it is different from surface rot in that the rot may penetrate deeply into the root. This penetration can be used to deliniate the two diseases. Infected root tissue may be brown or even orange. White mycelium is visible in cavities which are formed in the storage root. There is a difference in the extent of the penetration of the rot depending on both cultivar and fungal isolate. Sometimes the rot extends only to the vascular ring and other times the entire root may be affected.

As mentioned before, many other fungi attack both roots and foliage of sweet potato. A more complete list of these fungi is presented in Table 1.

Table 1. Bacterial and fungal diseases of sweet potato.

Causal Organism	Common Name (if known)
Bacteria:	
Streptomyces ipomoea	Scab, pox
Erwinia chrysantemi	Bacterial soft rot
Fungi:	
Ceratocystis fimbriata	Black rot
Diaporthe batatatis	Dry rot
Diplodia gossypina	Java black rot
Fusarium oxysporum	Surface rot
Fusarium oxysporum f. sp. *batatas*	Wilt, stem rot
Fusarium solani	End rot, storage rot
Macrophomina phaseolina	Charcoal rot
Monilochaetes infuscans	Scurf
Plenodomus destruens	Foot rot
Rhizopus stolonifer	Soft rot
Sclerotium rolfsii	Circular spot
Sphaceloma batatas	leaf scab
Fungi reported on sweet potato but which cause minor damage:	
Albugo ipomoea-pandurata	White rust
Alternaria spp.	Leaf spot
Cercospora spp.	Leaf spot
Coleosporium ipomoeae	Rust
Phyllosticta spp.	Leaf spot
Phytophtora crytegea	Root rot
Pythium ultimum	Root rot
Rossellinia spp.	Storage rot
Sclerotinia sclerotiorum	Storage rot
Septoria spp.	Leaf spot
Trichoderma spp.	Storage rot

MAJOR SWEET POTATO INSECT PESTS: RECOMMENDATIONS

K. V. Raman[1]

1. INTRODUCTION

Sweet potato is often damaged or destroyed by a group of insects which have become a major limiting factor in their production. A brief outline is given of major pests found in Peru and those existing elsewhere which should be effectively controlled prior to moving sweet potato germplasm.

2. MAJOR PESTS IN PERU

Several surveys have been made in Peru (Anon. 1973; Ortiz & Wong, 1982; Cetraro, 1982; Sánchez 1986). Recently CIP has also conducted field surveys in the coastal Cañete Valley of Peru. Following are some of the major pests encountered in the foliage, stems and tuberous roots:

2.1. Foliar Pests

Four lepidopterous pests have been considered to be major pests. Larvae of these pests feed on foliage causing irregular shaped holes. Severe damage leads to considerable loss in foliage. These pests were identified in collaboration with the insect identification and beneficial insect introduction institute at Beltsville, Maryland, USA.

1. *Brachmia* sp. near *jugata* (Gelechiidae) in Peruvian published literature this pest is reported as *Trichotaphe* sp.

2. *Ochyrotica fasciata* (Pterophoridae)

3. *Sylepta helcitalis* (Pyralidae)

4. *Cosmopterix* sp (Cosmopterigidae) This pest is often reported as *Bedellia minor*.

Taxonomic confusion seems to be a problem in identification of some of these pests. At CIP properly identified specimens are maintained and can be made available to interested quarantine programs.

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2.2. Stem Feeders

Euscepes postfasciatus (Coleoptera: Curculionidae) weevil larvae have been encountered feeding inside the stems. This pest is commonly referred to as the West Indian sweet potato weevil and is reported to occur in West Indies and Caribbean, Central and South America.

2.3. Storage Root Pests

Larvae of Diabrotica spp. (Coleoptera: Chrysomelidae) and Euscepes postfasciatus (Coleoptera: Curculionidae) cause extensive damage. Diabrotica spp. causes irregular shallow holes while the other causes mining inside the storage root.

3. MAJOR PESTS NOT REPORTED IN PERU

The sweet potato weevil, Cylas formicarius elegantulus and Cylas puncticollis (Coleoptera: Curculionidae) are the two most destructive pests in many countries.

3.1. C. formicarius

This species is extensively pantropical, from W. Africa, through to E. Africa, S. Africa, Madagascar, Mauritius, Seychelles, India, Bangladesh, Sri Lanka, S. E. Asia, China, Philippines, Indonesa, Papua and New Guinea, E. Australia, Solomon Isles, Hawaii, Samoa, Fiji, Caroline, Gilbert, and Mariana Isles, S. USA, W. Indies, Mexico, and Northern S. America (Guyana and Venezuela).

3.2. C. puncticollis

Only occurs in Africa, being recorded from Burundi, Cameroon, Chad, Congo, Guinea, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, and Uganda (Hill, 1975). The biology and control of sweet potato weevil have been reviewed extensively in Anon. (1984).

4. DAMAGE AND PEST STATUS

Adults of both species are found on the leaves and stems of sweet potato plants which they eat; the larvae bore into the stems and storage roots which develop rooting patches. C. formicarius is more common and more damaging. Larvae which bore through the roots leave dark stained tunnels. Damage continues storage, which makes these weevils even more important as pests.

5. RECOMMENDATIONS FOR SWEET POTATO GERMPLASM TRANSFER

1. Sweet potatoes entering CIP must have information on whether it was grown in a sweet potato weevil free area. The sweet potato weevil pheromone can aid in surveys and should be used as a monitoring tool.

2. All material (cuttings, storage roots) should be inspected by an Entomologist, any material found infested with sweet potato weevils not reported to occur in Peru should be destroyed.

3. Fumigation may aid in controlling some pests this aspect needs more research.

4. Germplasm for export should be grown preferably in a quarantine greenhouse.

5. All storage roots prior to shipment from CIP should be treated with suitable insecticide.

6. Emphasis should be given in future to more material in-vitro. This will eliminate all the pests mentioned above.

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MAJOR SWEET POTATO INSECT PESTS ATTACKING FOLIAGE, STEMS AND TUBEROUS ROOTS IN PERU

	Foliage	Stems	Roots
Coleoptera:			
Chrysomelidae	*Diabrotica* sp.		*Diabrotica* sp.
Curculionidae		*Euscepes postfasciatus*	*Euscepes postfasciatus*
Lepidoptera:			
Pterophoridae	*Ochyrotica fasciata*		
Gelechiidae	*Brachmia* sp.		
Cosmopterizidae	*Cosmopterix* sp.		

MAJOR SWEET POTATO INSECT PESTS AND SELECTION FOR RESISTANCE TO THE SWEET POTATO WEEVIL *Euscepes postfasciatus* (Fairmaire)

K. V. Raman[1]

1. INTRODUCTION

There are a number of pest species that attack sweet potatoes in developing countries, and the best potential for control appears to be in the development of generically resistant plants. Plant breeders in collaboration with entomologists at United States Department of Agriculture (USDA), Asian Vegetable Research and Development Center (AVRDC), International Institute of Tropical Agriculture (IITA) and International Potato Center (CIP) are now attempting to develop resistant varieties against the sweet potato weevil complex. Information on pest species, their distribution and economic importance is generally lacking in developing countries. During 1985, CIP's pest management research team implemented a field monitoring study to identify major pests occurring in Peru. Later in 1986, research began on screening and identifying resistance to the sweet potato weevil, *Euscepes postfasciatus* damaging the storage roots.

2. MAJOR PESTS IN PERU

CIP in collaboration with national scientists conducted field surveys at La Molina, located on the eastern outskirts of Lima at 12 05'S latitude and 238 meters elevation and Cañete, located 100 Km South of Lima. Both these sites are in the Peruvian desert and sweet potato production is under irrigation. Two other sites where surveys were conducted included San Ramon and Yurimaguas. San Ramon is located at 11 08'S latitude on the east of Andes at 800 m elevation. Average annual precipitation is 2,000 mm occurring mainly from October-May. Yurimaguas site is nearest the equator at 5 41'S latitude at 180 meter elevation located in Huallaga River Basin. Average annual rainfall is 2,134 mm. June-August are months with less rainfall. Field surveys at above sites included in making periodic D-Vac samples; sampling with hand nets; leaf and storage root samples. Following are some of the major pests encountered in the foliage, stems and tuberous roots.

2.1. Foliar Pests

Four Lepidopterous pests have been identified. Larvae of these pests feed on sweet potato foliage causing irregular shaped cavities. Severe larval feeding leads to defoliation. These are:

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[1]International Potato Center, Apartado 5969, Lima 100, Perú.

a. Brachmia sp. near jugata (Gelechiidae). In Peruvian published literature this pest is reported as Trichotaphe sp.

b. Ochyrotica fasciata (Pterophoridae)

c. Sylepta helcitalis (Pyralidae)

d. Cosmopterix sp. (Cosmopterizidae)

Cosmopterix sp. is often reported as Bedellia minor. Programs in integrated pest management (IPM) require accurate taxonomic information of the pest. From our experience, it appears that there is a considerable amount of confusion in sweet potato insect taxonomy. In order to solve this problem, CIP is collaborating with the Insect Identification and Beneficial Insect Introduction Institute at Beltsville, Maryland, USA, and the Entomology museum located at Universidad Nacional Agraria (UNA) La Molina, Peru. Properly identified specimens are maintained at CIP and UNA which can be made available to interested quarantine or national program.

2.2. Stem Feeders

Lepidopterous larvae have been frequently encountered mining sweet potato stems in Yurimaguas. Identification of this pest is now in progress. Euscepes postfasciatus (coleoptera: Curculionidae) weevil larvae have been encountered inside the stems. This pest is commonly referred to as the West Indian Sweet Potato Weevil and is reported to occur in West Indies, Caribbean, Central and South America.

2.3. Storage Root Pests

Larvae of Diabrotica spp. (coleoptera: Chrysomelidae) and Euscepes postfasciatus (coleoptera: Curculionidae) cause extensive damage. Diabrotica spp. causes irregular shallow holes on the outside of the root, while the other causes mining inside the storage root. Damage roots have dark stained tunnels and are unfit for consumption or use as planting material. Table 1 summarises the major pests occuring in Peru.

Table 1. Major Sweet Potato Insect Pests attacking foliage, stems and tuberous roots in Peru.

	Foliage	Stems	Roots
Coleoptera:			
Chrysomelidae	Diabrotica sp.		Diabrotica sp.
Curculionidae		Euscepes postfasciatus	Euscepes postfasciatus
Lepidoptera:			
Pterophoridae	Ochyrotica fasciata		
Gelechiidae	Brachmia sp.		
Cosmopterizidae	Cosmopterix sp.		

3. MAJOR PESTS NOT REPORTED IN PERU

The Sweet Potato Weevil complex belonging to the genus Cylas are probably the most important destructive pests of sweet potatoes in many developing countries. Two species reported to be important are, Cylas formicarius and Cylas puncticollis. C. formicarius is extensively pantropical, from West Africa through to East Africa, South Africa, Madagascar, Mauritius, Seychelles, India, Bangladesh, Sri Lanka, Southeast Asia, China, Philippines, Indonesia, Papua and New Guinea, East Australia, Solomon Isles, Hawaii, Samoa, Fiji, South United States of America, West Indies, Mexico, and Northern South America (Guyana and Venezuela). In many countries of Latin America (Caribbean, Central America and Northern South America) C. formicarius is a major pest problem. C. puncticollis is only reported to occur in Africa. The distributional trends of each species needs to be further documented by additional collecting. There appears to be no host data for each of the pest species except as it pertains to agricultural crops. There is almost no data on parasites of immature stages of Cylas.

4. SCREENING FOR RESISTANCE TO SWEET POTATO WEEVIL *E. postfasciatus*

4.1. Sweet Potato Accessions

A total of 329 native cultivated cultivars from the CIP germplasm were grown in a field at La Molina, Peru to increase the root stock. Unsprouted, recently harvested roots were screened under laboratory conditions at 24±2 C in Lima.

4.2. Insect Collection and Rearing

Damaged roots with the weevil larvae were collected in Yurimaguas. These roots were transported in sealed plastic containers to Lima. Infested roots were spread in a plastic tray and caged with muslin cloth. Adult weevils emerged in 3 to 4 weeks. These weevils were transferred to fresh healthy roots in a plastic tray with an aid of camel hair brush. These roots were caged. Oviposition took place on the surface of roots. When newly laid eggs are transparent and inserted into punctures and then covered with a transparent cement which later turns black. This cement protects eggs against parasites, predators and desiccation. Eggs hatch in approximately 7-10 days. The newly emerged larvae feeds and moves deeper and deeper into the roots. As a result, the upper surface of root may appear unblemished, while internally the tissue may be severely damaged. Larval development is usually rapid, varying between 20-30 days after which pupation occurs. Pupae are formed in a cavity within the tunnel which is produced as a result of larval feeding. Pupal stage lasts approximately 7-9 days. Adults are formed within the pupal chamber. They are small black weevils measuring approximately 3.5 mm long and 1.6 mm wide. Adults emerge through the large exit holes made on the root surface. Males and females vary in size and this feature can be used to separate them. Populations contain approximately equal numbers of both sexes.

4.3. Screening for Damage and Adult Development

Two roots from each of the 329 primitive cultivars from CIP germplasm were evaluated for larval damage. Roots were placed individually in one liter plastic container and infested with ten adult weevils and caged with muslin cloth. Damage was appraised 60 days after infestation by estimating the percent damage on external root surface. Roots were then cut in half and damage internally was estimated using a visual scale. The accessions with no damage were considered as highly resistant (HR) and received a class rating of 0; those with 1-25% flesh damage were considered resistant (R) and received a class rating of 1; 25-50% as moderately resistant (MR) with class rating of 3; 50-75% as susceptible (S) with class rating of 4; 75-100% as highly susceptible (MR) and were rated as class 5. Adult development was also evaluated by counting the total weevil population developed at 60 days.

Table 2. Resistance levels of 329 Clones of sweet potato to the sweet potato weevil Euscepes postfasciatus damage. La Molina, 1987.

Levels	No. of Clones	%
Highly Resistant (HR)	15	4.55
Resistant (R)	23	4.55
Moderately Resistant (MR)	60	18.23
Susceptible (S)	74	22.49
Highly Susceptible (S)	157	47.72

4.4. Results and Discussions

Resistance to the sweet potato weevil E. postfasciatus has not previously been a major sweet potato research objective. In preliminary screening trials 15 clones (see Tables 2, 3, and 4) have been identified. Table 2 shows the relative resistance categories for the 329 clones evaluated in laboratory. Table 2 gives details of common native names, the location where the cultivars were collected. Details on flesh color indicate a wide variation. Table 3 gives details on damage and adult development in the 15 selected resistant clones. The flesh damage and adult development in these clones were remarkably low. No adults developed in any of these clones, indicating that probably these accessions had high levels of antibiosis.

These accessions warrant further testing. The material is currently being multiplied for reconfirmatory resistance evaluation in field and laboratory.

Table 3. Selected clones in preliminary test for resistance to the sweet potato weevil *Euscepes postfasciatus*. La Molina, 1987.

Code	Native name	Department	Flesh color
ARB 389	Yema de huevo	Ancash	Dark cream
RCB 16	Lirio	Arequipa	White
RCB 17	Torreblanca	Arequipa	Light yellow
RCB 68	Parna Blanca	La Libertad	Cream
RCB 105	Porfirio	Ica	Dark orange
RCB 118	Morado Ecuatoriano	Tumbes	Yellow
RCB 120	Guiador	Ica	Yellow orange
RCB 130	Precolombino de Paracas	Ica	Yellow orange
RCB 280	Blanco de Calango	Lima	Cream
DLP 101	Estrella	Lambayeque	White
DLP 103	Trujillano	Lambayeque	White
DLP 189	Blanco	Piura	Cream
DLP 295	Blanco	Arequipa	White
DLP 542	-	Huanuco	Cream
DLP 543	-	Huanuco	Dark cream

Table 4. Highly resistant clones to the sweet potato weevil Euscepes postfasciatus. La Molina, 1987.

Code	External Damage %	Internal Damage Rate	No. of Adults Recovered
ARB 389	100	1	0
RCB 16	40	1	0
RCB 17	35	1	0
RCB 68	90	1	0
RCB 105	70	1	0
RCB 118	87	1	0
RCB 120	40	1	0
RCB 130	40	1	0
RCB 280	55	1	0
DLP 1[illegible]	25	1	0
DLP 103	30	1	0
DLP 189	10	1	0
DLP 295	20	1	0
DLP 542	50	1	0
DLP 543	100	1	0
ARB 80	90	5	152
ARB 377	100	5	147

G-1: 0% damage
G-5: 100% damage

5. CONCLUSIONS

Research in sweet potato pest management is a very recent activity at CIP. Priorities established through earlier planning conferences include in developing useful IPM programs for Diabrotica sp. E. postfasciatus and the sweet potato stem borer. Initial emphasis has been on implementing a field monitoring study to evaluate the pests in Peru. Current emphasis is on screening for resistance to E. postfasciatus and Diabrotica sp. in the germplasm maintained at CIP. Clones or accessions identified for resistance need to be evaluated regionally or nationally where Cylas spp. occurs. Cooperation in this aspect is essential as Cylas spp. are not reported to occur in Peru. More effort is definitely needed in detection and management of sweet potato weevil and other pests. CIP's pest management research team will attempt at developing useful control components for major pests. These components [illegible]ll then have to be tested in collaboration with national programs to develop the most appropriate IPM strategy for sweet potato pests.

NEMATODES IN TUBER AND ROOT CROPS AND THEIR MANAGEMENT

P. Jatala[1]

1. ABSTRACT

The role of nematodes in causing crop losses is well documented for Irish potatoes, cassava, yams, and sweet potatoes. Little is known about the action of nematodes on other tuber and root crops on a global scale. Although over 60 nematode species attack potatoes, Globodera pallida, G. rostochiensis, Meloidogyne spp., Pratylenchus spp., and Nacobbus aberrans are considered as limiting factors for potato production on a global scale. A considerable yield reduction of cassava is attributed to the infection by M. incognita and M. javanita. These nematodes attack sweet potatoes, yams, tannia, and taro. Additionally, Scutellonema bradys and Rotylenchulus reniformis attack yams and sweet potatoes respectively. Although several nematode species attack Xanthosoma sagittifolium, Colocasia esculenta, Oxalis tuberosa, Arracacia esculenta, Ullucus tuberosus, and Tropaeolum tuberosum, their importance are of regional concern. In addition to their direct effect, many plant parasitic nematodes can also interact with other pathogens and cause disease complexes. There are several methods of control for reducing the nematode populations to levels below damage threshold densities. Utilization of resistant cultivars, nematicides, cultural methods, and biological control in an integrated management system would be the most sensible means of utilizing resources to combat these nematodes.

2. INTRODUCTION

Tuber and root crops are probably the most important food commodities produced by many countries. Over 3 billion people consume these crops on a fairly regular basis. According to the FAO 1980 estimates, every country in the world produces one or more root crops. While potatoes are produced in more countries, sweet potatoes are generally grown in smaller volumes in more developing countries than any other root crop (Horton, Lynam & Knipscheer, 1984). The origin and history of tropical tuber and root crops are well documented (León, 1977; Coursey and Booth, 1977; Coursey and Haynes, 1970; Salaman, 1949; Burton, 1966; Yen, 1982). However, the actual contribution and potential of these crops as the world's food supply is poorly understood. Aside from various production constraints, these crops are attacked by many pests and pathogens that can cause significant yield losses. Nematodes are among some of the important factors that cause yield and quality reduction of these crops. Discussed here are five major crops: potato Solanum tuberosum, sweet potato Ipomoea batatas, cassava Manihot esculenta, yams Dioscorea, and two main genera of cocoyams, taro Colocasia esculenta

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and tannia Xanthosoma spp.; and four minor crops: oca Oxalis tuberosa, olluco Ollucus tuberosus, arracacha Arracacia esculenta, and mashua Tropaeolum tuberosum. However, because the author had more information available on potatoes, sweet potatoes, and cassavas, more space is allocated to these crops. All the above mentioned crops are used as a part of the daily diet in many countries. Although there are several other important root and tuber crops that are also grown in many countries, they are not principal daily food components and, therefore, are not discussed here.

3. POTATO

Potato, S. tuberosum, originating from the Andean highlands of South America, is a major food crop in many countries. Potatoes are grown in more countries than any other single crop, with the exception of maize. It is the only tuber crop produced in significant amount in developed countries. While potato occupies fourth place in importance among the major food crops, in terms of dry matter production per hectare it is the third highest on the list. It ranks first and third in the list of the edible energy and protein production per hectare per day, respectively (Horton, Lynam & Knipscheer, 1984).

In recent years potato production has spread gradually out of its traditional cool environmental conditions into hotter and, generally, drier areas. It is becoming increasingly attractive as a winter crop in many irrigated, arid areas of large, commercially oriented farms. Recently, the production of this crop has been expanded to relatively warm and humid zones which is optimum for the development of many pathogens and pests, including nematodes.

So far, the possibilities of reducing the total production cost per hectare have been rather limited (Vander Zaag & Horton, 1983). However, recent developments in the production of potatoes from true potato seeds (TPS) would provide an alternative to overcome the increasing cost of production.

Of the factors which adversely influence the production of potatoes from tuber seeds or TPS, nematodes are among the most important pest constraints. Currently, distribution of nematodes in most potato-growing areas of the world is well known. While infestation in some countries and production areas may be regarded as minor, in other areas high infestations cause severe yield losses. Beside yield reduction some nematodes affect tuber quality. Meloidogyne-infected tubers can become unmarketable and undesirable for human consumption. If used as seed, infected tubers may be an inoculum source and spread the nematodes (Jatala, P., 1975; Jatala, P., 1986). Although over 60 nematode species are known to be associated with potatoes, only a few are of major consequence. Potato cyst nematodes Globodera pallida and G. rostochiensis are, by far, the most important nematodes of potatoes and have received the most attention in the world literature (Jensen, Armstron, & Jatala, 1979). They are believed to have evolved along with their principal hosts, potatoes, probably in Peru or Bolivia. Brucher (1960) suggested, however, that the mountains of northern Argentina, where the pests occur in inaccesible places, may be their center of origin. The fact remains that they were introduced to Europe, probably in the mid or late 19th century, on South American potatoes imported for breeding purposes (Winslow, 1978). They have since spread to most potato growing areas.

In addition to their direct damage, they are known to interact with other pathogenic organisms and cause disease complexes (Grainger & Clark, 1963; Harrison, 1971; Jatala, Gutarra, French & Arango, 1976). There are several races within each species and considerable advances have been made in the race identifications of these important pests (Canto-Saenz & Scurrah, 1978).

Currently, the major research thrust in controlling G. pallida and G. rostochiensis continues to be the development of resistant cultivars. The majority of resistant cultivars produced to date are resistant to race R1A of G. rostochiensis. Recently, however, a cultivar resistant to races P4A and P5A, the most important races of G. pallida, has been developed (Llontop 1987). Resistance and other control measures, such as chemical and cultural practices, together with the application of biological entities in an integrated control approach, can help in maintaining the nematode populations below the damage-threshold.

Meloidogyne species also rank among the important nematode pests of potatoes. Root-knot nematodes are cosmopolitan in distribution and have a rather wide host range. The four most frequently encountered species of M. incognita, M. javanica, M. arenaria, and M. hapla occur in diverse climates. However, M. hapla is basically found in cooler regions of the world. M. incognita is probably the most widely distributed species, followed by M. javanica. Their wide distribution parallels their importance as the major pests of potatoes. In addition to reducing yield, their infection affects tuber quality (Jatala, 1975). They are also known to interact with several fungi and bacteria, causing severe yield losses. Interaction of these nematodes and Pseudomonas solanacearum has been well documented (Jatala, French, & Gutarra, 1975; Jatala & Martin, 1977a, 1977b).

Control measures basically consist of the use of pesticides, as well as some cultural practices. However, great advances have been made in the transfer of resistant genes from the wild tuber-bearing species into cultivated forms (Mendoza & Jatala, 1985). The outlook for obtaining resistant cultivars is quite promising. Utilization of the fungus Paecilomyces lilacinus in controlling Meloidogyne populations has shown to be quite successful (Jatala, 1986). However, utilization of all the control methods in an integrated form will help in the proper management of these pests. Potato rot nematodes Ditylenchus destructor and D. dipsaci and root-lesion nematodes Pratylenchus spp. are also important nematode pests of potatoes. Pratylenchus species have a rather wide host range and interact with other organisms in production of disease complexes. Other nematode species, such as Belonolaimus spp., Nacobbus aberrans, Rotylenchulus reniformis, Tylenchorhynchus spp., Xiphinema spp., Longidorus spp., Trichodorus and Paratrichodorus spp., and Helicotylenchus spp. are often found to be associated with potatoes. Although they often cause severe damages to potatoes, they are primarily of regional importance. Control of these nematodes is basically oriented towards the application of nematicides and, to a lesser degree, cultural practices.

4. SWEET POTATO

Sweet potato, a native of tropical America, is widely grown in more developing countries than any other crop, yet the information on the crop's production zones and

practices is not complete. It is a relatively short maturity crop tolerant to a wide range of growing conditions. Sweet potatoes can be grown in relatively infertile soil with few inputs and can withstand periods of irregular drought and rainfall (Horton, Lynam & Knipscheer, 1984). Sweet potatoes rank 4th and 6th on the list of dry matter production per hectare and edible energy production per hectare per day, respectively. Although a large number of nematode species are found to be associated with sweet potatoes, few are of economic concern. The most important nematode species attacking this crop is M. incognita. This nematode seems to do well in light, friable, sandy loam soil which happens to predominate and constitute the major portion of the world's sweet potato-growing areas. M. incognita requires warm temperature for completion of its life cycle and on sweet potatoes generally undergoes 4 to 5 generations per growing season (Jatala & Russell, 1972). Therefore, it is capable of increasing its population to a level of economic importance in a rather short period. Meloidogyne hapla also attacks this crop, but its distribution is limited to the cooler temperate regions of the world. Although M. javanica infects the roots of sweet potatoes quite readily, it cannot complete its life cycle on this crop. Therefore, if the initial nematide population is high, it causes a pruning effect which will be overcome by the vigorous growth and excessive lateral root production. These nematodes play an important role in production of disease complexes. M. incognita interacts with Fusarium spp. and causes severe wilting and premature plant death. Although there are cultivars resistant to Fusarium spp., their resistance may be broken in the presence of M. incognita. Therefore, it is of utmost importance to either search for dual resistance or incorporate the resistance to these two organisms. Many cultivars developed in the USA and Japan carry various degrees of resistance to root-knot nematodes. Studies show that some of the International Potato Center's sweet potato germplasm collection from Peru have resistance to M. incognita. It appears that the gene base for resistance to M. incognita is predominant in the sweet potato collections from Papua, New Guinea, followed by those from the Philippines and Irian Jaya, and decreases in frequency as the distance from Papua, New Guinea is increased. The frequency of resistant clones from Peru, Colombia, Ecuador, and Mexico, the regions considered as the centers of origin of sweet potatoes, is about 6%. The sweet potato storage roots can serve as a reservoir for Meloidogyne and be an aid in the transfer of this nematode. Hot water and chemical dip treatment of storage roots immediately after harvest may kill the nematodes inside. Another nematode of major importance is Rotylenchulus reniformis, which is widely distributed in the warm tropical regions of the world. This nematode also interacts with Fusarium spp. in the development of disease complexes that can be a limiting factor to production. Limited information is available on the resistance of sweet potatoes to R. reniformis.

Pratylenchus species also attack sweet potatoes, are widely distributed in the warm tropical regions of the world, and have a rather wide host range. They also interact with other pathogens in the development of disease complexes. Little is known about the resistance of sweet potatoes to these nematodes.

So far, in addition to limited available resistant cultivars, the major effort for controlling nematodes has been placed on the use of nematicides. However, recent developments in the field of biological control indicate the possibility of using this method of control. Integrations of cultural practices, together with the use of chemicals, resistance, and biological entities in an appropriate management system should be considered in strategies for the control of nematodes on sweet potatoes.

5. CASSAVA

Cassava Manihot esculenta originated in tropical America. However, exact time and location of domestication and its direct ancestors are not known. Similarly, its occurence in a wild state is not known and its evolution as a species is directly linked to selection under cultivation by man (Horton, Lynam & Knipscheer, 1984). Originally, it was probably selected for enlarged roots, ability to propagate from stem cuttings, and erect plant type (Jennings, 1976). By the beginning of the 19th century it had been effectively distributed throughout the tropics. Because of its long growth period, its cultivation is primarily limited to the tropics and subtropics and is the most widely grown root crop in wide agro-climatic conditions (Flach, 1982). It is, however, exclusively grown in Asia, Africa, and Latin America. It has the ability to produce economic yields under relatively marginal soil and rainfall conditions. It is particularly adapted to tropical soils and is tolerant to low soil pH and high aluminum content. Mycorrhizal association is common and effective in the phosphorous uptake and utilization. Its other salient characteristics include: its high carbohydrate yield per unit of land and labor, its compatibility with a variety of associated crops, and its indeterminate harvest period. Due to the above mentioned characteristics, it is essentially a small farm and subsistence crop. It is one of the very few crops that rarely requires the application of fungicides, pesticides, and herbicides. This is probably due to the fact that they are either tolerant or resistant to various pests and pathogens. Similarly, fertilizers are not commonly used in the cassava production systems.

Although several factors influence the production of this crop, nematodes are considered as one of the major constraints. Because of its distribution in the warm tropics, a large number of nematode species are known to be associated with its roots. Comprehensive lists of nematode species associated with cassava and their distribution as reported in the literature were given by two authors (Caveness, 1980) and (Hogger, 1971). Although the list of nematodes associated with cassava is rather large, only a few are of major consequence. The plant parasitic nematodes most frequently found associated with cassava throughout the world are Pratylenchus brachyurus, Rotylenchulus reniformis, Helicotylenchus erythrinae, H. dihystera, Scutellonema bradys, Meloidogyne incognita, and M. javanica. M. incognita and M. javanica are apparently the most important nematode parasites of cassava. Their distribution, requirements for environmental conditions, rate of multiplication, and wide host range make them the principal nematological concerns for cassava production. Meloidogyne arenaria and M. hapla are also reported on cassavas (Tanaka, Chalfoun, and the Abreu, 1979). However, they are not of major importance, particularly M. hapla, which is a rather cool climate nematode of temperate regions. Pratylenchus brachyurus, Helicotylenchus spp., and R. reniformis are probably the nest group of plant parasitic nematodes that can economically affect cassava production. They are frequently found in abundance in the roots of cassava. As in previus groups, they have a rather wide host range and, therefore, intercropping susceptible hosts with cassavas is not recommended. Most of the nematodes mentioned above can interact with soil-born microorganisms and cause losses of economic importance. However, information of such interactions on cassavas is rather scarce. It is important to note that as cassava production moves into monoculture and new high-yielding varieties are released, nematodes have the potential to cause severe reduction in yield and quality. However, variations in responses of different cassava varieties to nematodes, such as M. incognita and M. javanica, suggest

that the use of tolerant and resistant cultivars may be the most practical method for managing these nematodes on this crop. In addition to the use of resistant cultivars, limited amount of literature is available on the use of nematicides for controlling nematodes in cassava. Preplant application of Aldicarb, Carbofuran, and Bunema increased the yield of storage roots (Gapasin, 1981). Cassareep, a by-product of cassava industry, was apparently effective in controlling the populations of M. incognita and M. javanica in cassava (Da Ponte, Franco, 1981). Intercropping cassavas with unsuitable hosts apparently reduces the nematode populations. Intercropping and the use of resistant cultivars are apparently the most economical means of nematode management in small farm production of cassava.

6. YAMS AND COCOYAMS

Yams and cocoyams are grown in the tropics throughout the world. However, the main production area of these crops is the savanna region of West Africa. Yams, Dioscorea rotundata and D. alta, and other species are indigenous to West Africa found from the Ivory Coast to Cameroon. The two main genera of cocoyams are Colocasia esculenta Taro and Xanthosoma sagittifolium Tannia. While Colocasia originated from Southeast Asia and spread to Africa and the Americas, Xanthosoma originated in South and Central America, later spread to Africa, and is rapidly replacing Colocasia in West Africa. Nigeria is, by far, the largest producer of yams and cocoyams. As in cassava, potato, and sweet potatoes, yams rank among the highest on the list of major food crops. They rank second on the list of edible energy production per hectare per day and prestigious components of the West African diet (Horton, Lynam & Knipscheer, 1984). As in other crops, a large number of plant parasitic nematodes are associated with the roots of yams and cocoyams. However, Meloidogyne incognita, M. javanica, Rotylenchulus reniformis, Pratylenchus spp., and Scutellonema bradys are the most important nematode pests of these crops. Scutellonema bradys attacks D. rotundata and D. alta and causes severe yield losses. D. rotundata is an efficient host of M. incognita.

Although X. sagittifolium is not a satisfactory host of M. incognita race 2, high populations of this nematode can reduce corn yield (Caveness, Wilson, & Terry, 1981).

Since yams and cocoyams are generally intercropped with other crops, the data on the effect of nematodes on yields can be misleading unless presented with the yield of the intercrop. Apparently, many varieties of cocoyams are resistant to Meloidogyne spp. and R. reniformis. Utilization of resistant cultivars, together with chemical control rotation and intercropping, is the most appropriate means of managing nematode populations in the yam and cocoyam production systems.

7. OCA, OLLUCO, ARRACACHA, AND MASHUA

These crops are principally grown in the Andean region of South America with the exception of arracacha which is grown in both South and Central America. Oca Oxalis tuberosa is an important crop of the cold areas of the Andes, grown in elevations of over 3000 m.a.s.l. It is cultivated from Bolivia to Venezuela as a minor crop,

considered of less importance than the potato, but more important than Olluco. There are several kinds of Oca: the bitter, which has white tubers; and the sweet, with tubers of various colors. Because of high content of calcium oxalate in the tubers, they cannot be eaten immediately after harvest. After various days of exposure to sun, the complete maturity is reached and tubers can be eaten cooked or raw.

Olluco Ullucus tuberosus, endemic to the Andes, constitutes one of the staple food crops in the region. It is primarily grown from Bolivia to Colombia and is an important tuber crop after potato and oca. Tubers vary in shape and color. As in potatoes and oca, they are often dehydrated and made into chuño. It replaces potatoes in certain zones of the cold altiplano where the excess of humidity becomes a limiting factor to potato production. Several nematode species are known to be associated with oca and olluco. However, Thecaveermiculatus andinus, Nacobbus aberrans, and Meloidogyne spp. are among the most important nematode pests attacking these crops. Information on the resistance of these crops to nematodes is rather scarce. Nevertheless, variations in the behaviour of different cultivars of both of these crops to nematodes indicates the possibility of resistance as a means of control. Due to the fact that they are basically small farm crops with limited economic input, chemical control of nematodes is a rare practice.

Arracacha Arracacia esculenta is a perennial herb, native of Mexico to Peru. Its fleshy, large roots have an agreeable flavor which constitute an important food item among the people of Central America and Andean regions of South America. From the Andean region of South America, its center of origin, it was successfully introduced to mountainous regions of Brazil and Central America. Although attempts were made to introduce this crop into Europe, it has not become successfully established in that continent. Recently, it has been introduced to India and Eastern Africa. Colombia is, however, probably the largest producer of this crop. Of the nematode species attacking this crop, Meloidogyne spp. are of major importance. Chemical control of these nematodes on arracacha has been successful, but is rarely considered in small farm production systems.

Mashua Tropaeolum tuberosum probably originated in the altiplano zones of Peru and Bolivia. It is an annual crop that produces cone-shaped tubers similar to oca in form and color. It is the least popular of the tubers and root crops of the region. The tubers are not palatable when eaten raw. They must be cured by the sun prior to cooking. They are also dehydrated to form chuño, as in potatoes, oca, and olluco. Of the nematode species attacking this crop, Nacobbus aberrans and Meloidogyne spp. are of major concern. Although chemicals are successful in controlling the nematodes no control measures are taken to reduce nematode attack.

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IMPORTANT NEMATODE PESTS OF SWEET POTATOES

Parviz Jatala[1]

Sweet Potato, a native of tropical America, is widely cultivated in tropical and warm temperate climates. Although in these habitats a large number of important plant parasitic nematodes affect a diversity of plants, food and fiber crops, only a few are of major importance to sweet potato cultivation.

The most important nematode species attacking sweet potato is Meloidogyne incognita which occurs in the areas where sweet potato is well adapted for cultivation. This nematode seems to do well in light, friable soils such as sandy loams which happens to predominate and constitute the major portion of the world's sweet potato growing area. M. incognita requires a warm temperature for completion of its life cycle and on sweet potatoes generally undergoes 4 to 5 generations per growing season. Therefore, it is capable of increasing its population to a level of economic importance in a rather short period. Meloidogyne hapla also attacks this crop, but its distribution is limited to the cooler temperate regions of the world. Therefore, the economic loss due to this nematode is rather restricted and not of major concern. Although M. javanica attacks the roots system of sweet potatoes quite readily, it cannot complete its live cycle on this crop.

Therefore, if the initial soil population is high, they cause a pruning effect which will be overcome by the vigorous growth and excessive lateral root production. Root-knot nematodes in addition to exerting a direct pressure on the root system, such as the root pruning effect, galling and root necrosis and tuber splitting, they play an important role in production of disease complexes. M. incognita interacts with Fusarium sp. and causes severe wilting and premature plant death. Although there are cultivars resistant to Fusarium species, their resistance will be broken in the presence of M. incognita. Therefore, it is of outmost importance to either search for dual resistance or incorporate the resistance to these two organisms. Many cultivars developed in the USA and Japan carry various degrees of resistance to root-knot nematodes. Preliminary studies showed that several cultivars of the CIP germplasm collection from Peru also have resistance to M. incognita. Therefore, utilization of these cultivars in developing progenies with multiple resistance to M. incognita and Fusarium spp. is not difficult and should receive high priority. Major emphasis in developing Meloidogyne resistant cultivars was initiated in 1953 at the Oklahoma State University and Louisiana State University and many resistant cultivars were developed by 1965. Similar efforts were made by the breeders in Japan and as a result, the number of resistant clones or cultivars are significant. It appears the gene base for resistance to M. incognita is predominant in the sweet potato collections from Papua New Guinea followed by those from the Philippines and the Irian Jaya and decreasing in frequency as the distance from the Papua New Guinea is increased. The frequency of

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[1]International Potato Center, Apartado 5969, Lima 100, Perú.

resistant clones from Peru, Colombia, Ecuador and Mexico, the regions considered as th center of origin of sweet potatoes, is about 6%. The edible roots or the "swee potatoes" can serve as a reservoir for Meloidogyne and be used for propagation c planting material. Results of potato tuber treatment indicate that the nematode within tubers can be killed by chemical dips immediately after harvest. Similar test need to be conducted for sweet potatoes to determine the efficiency of such treatment in eliminating nematodes from the root tubers. Utilization of the biological contro agents (Paecilomyces lilacinus) in the integrated control of these nematodes should b considered.

Another nematode of major importance is Rotylenchulus reniformis which is rathe widely distributed in the warm tropical regions of the world. This nematode als interacts with Fusarium species in development of disease complexes and can become limiting factor to sweet potato cultivation. Limited information is available on th resistance of sweet potatoes to R. reniformis. Unless the global importance of thi nematode on sweet potatoes is well established, screening and breeding for resistanc to this nematode should be on a limited scale.

Pratylenchus species also attack sweet potatoes and are widely distributed in th warm tropical regions of the world. Like root-knot nematodes, these parasites attack large number of plant species, restricting the use of rotation crops in the croppin system. They also interact with other plant pathogens in development of diseas complexes. Little is known about the resistance of sweet potato to these nematodes The wide distribution of the species of this nematode in the tropics where the swee potatoes are grown makes it imperative to search and develop resistance to thes nematodes.

Alternative measures for controlling these important nematodes need to b considered and investigated. Studies on the interrelationships of nematode-fungal an nematode-insect systems, warrants attention for developing a sound integrated pes management program.

POST-HARVEST TECHNOLOGY

George L. T. Hunt[1]

1. INTRODUCTION

Post harvest technology includes all actions and processes applied to a crop after harvest in order to preserve the maximum of its quantity and quality to provide food supplies and planting material. The choice and success of post harvest technology is governed at least partly by factors occuring before harvest and those connected with the timing and use of the stored produce.

Consideration of the post harvest technology for sweet potatoes requires that all these factors are taken into account and after recognition of the real problems that are to be solved, the appropriate solution may be developed taking into account the great amount of knowledge that currently exists at various places and institutions. This approach is in no way different from that required for solanum tuberosum potatoes or any other crop.

2. FACTORS AFFECTING POST HARVEST TECHNOLOGY

A brief survey of the factors which affect post harvest technology forms a check test against which the requirements for sweet potatoes may be considered. Some particular requirements are noted.

2.1. Physiology

All storage is closely governed by the physiological characteristics of the product. These characteristics must be understood so that the storage environment is modified so that the biological activity is reduced to the minimum.

2.2. The Need for Storage and Processing

One obvious question to ask at the outset is whether or not storage and processing are required and/or how long the produce must be preserved in relation to crop production cycles, food requirements and alternative foods.

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[1]Post-harvest specialist, CIP Region III, P.O. Box 25171, Nairobi, Kenya.

2.3. Variety and Storage Characteristics

Variety is connected most obviously with yield potential and consumer likes and dislikes. Storage characteristics are of prime importance as the whether or not short or longer terms storage is possible. The tolerance to higher temperature storage without undue loss and premature sprouting is vitally important if successful low cost storage for the hot tropics is to be made possible.

2.4. Resistance to and Control of Insect Pests

Resistance to the attack of insect pests is an important goal for the breeder. The biggest constraint to sweet potato production and similarly serious in storage is the sweet potato weevil - *Cylas formicarius elegantulus* and also *C. puncticollis* in Africa. The development of safe methods of insect pest control is an equally worth while objective and the integrated pest management approach is relevant.

2.5. Resistance to and Control of Disease and Rotting Organisms

Again an objective for the breeder and clone selection specialist, varieties having resistance to disease and attack by rotting organisms which affect storage, are clearly advantageous. Suitable prevention and control techniques are required.

2.6. Growth Conditions and Storage

Certain features of crop growth, usually stressful, may reduce storage potential. Varieties may differ in this respect. These effects should be recognized and understood.

3. EXISTING KNOWLEDGE

There are two sources of knowledge which must be considered at this time if progress is to be made in the development of improved post harvest technology without wasting resources on repetition and unnecessary work. These sources are:

- the farmer
- research and development institutions

3.1. The Farmer

Following the philosophy of 'farmer back to farmer', any improvement in post harvest technology must start and end with the farmer. In this way the following factors may be considered:

- the real problem may be defined

- the existing practices may be considered for possible adaptation

- local material and craft ability may be included in the new technology

- in time the proposed solution may be tested on the farm and further refinement made with the farmers involvement

- the partnership during development of the improved practice leads easily into adoption of the new methods

3.2. Research and Development Institutions

There are a number of national and international institutions which have collectively and individually a vast store of knowledge and continuing activity in the improvement of all aspects of the sweet potato crop. This knowledge and activity must be drawn together in two ways:

- To prepare a reliable and manageable reference manual describing the current state of the art in post harvest technology.

- To develop a collaborative framework in which future work will progress with the maximum efficiency. Already workshops have been held to make recommendations and directions on collaboration and areas of effort have been made.

4. COMPLEXITY AND SIMPLICITY

Working in the developing world, our objectives are most usually and importantly concerned with the small scale farmer who lacks financial and material resources. In the proceeding notes, some idea of the complexity of the problems are demonstrated. The challenge is to find inherently simple low cost improved post-harvest technology for the farmer. The move from complexity may be seen in another way. The excellent technology of the United States for example, in large scale sweet potato storage is a knowledge resource from which the developing world worker may take the basic principles and employ them in low cost systems. What one might call it "re-tuning technology."

Innovative low cost technology is required. To be able to produce cooler storage conditions at a low cost compared to refrigeration assisted storage would enable a vast quantity of roots to be stored for a meaningful time in hot climate areas. We cannot wait for the breeders to produce the universally tolerant super sweet potato. We are faced with a vast number of accepted food varieties which will continue to be grown.

5. THE CHALLENGE

A lot of farmers are growing this crop and they know a lot already. The challenge is to work as a world wide team with these farmers to develop realistic improvements in post harvest technology. Let us go out and get started. Have a go if it looks possible - it may work and we are on the way.

CIP'S HUMAN RESOURCES DEVELOPMENT PROGRAM

Manuel Piña Jr.[1]

1. INTRODUCTION

Since CIP's early days, it was recognized that improving potato production in Third World countries depended not only on CIP's ability to generate new technology, but, more importantly, on the abilities of researchers, extensionists, and educators in national potato programs to make use of the newly generated technologies.

CIP recognized that:

- national programs have the ultimate responsibility to reach farmers.
- information and expertise on potato production are not available in many developing countries.
- national programs must be capable of using new or improved technologies--germplasm and production techniques.
- the flow of technology transfer should operate in both directions, with the potential user participating in the selection of appropriate technologies.

These ideas formed the basis for CIP's human resources development program.

2. TRAINING OBJECTIVES

CIP's training program is based on the philosophy that research and extension efforts conceived and executed in collaboration with national programs will be more appropriate for the conditions of the country and have a longer-lasting beneficial effect than those conceived and executed independently by CIP. This philosophy is further based on the conviction that national programs are in the best position to examine the growing conditions of their crops, analyze government agricultural policies, assess research and training needs, and undertake the transfer of technology to farmers. CIP's training activities, therefore, are directed toward improving the abilities of national programs to:

- identify research priorities and needs

[1]Training and Communications Department Head, International Potato Center, Apartado 5969, Lima 100, Peru

- conduct research on priority problems
- use existent technology that has been identified as relevant to the country's needs
- evaluate research results from other sources under home-country production conditions
- participate in transferring appropriate technologies within their countries and surrounding countries.
- train others to identify existent technology and research needs, to conduct research and evaluate results, and to participate in the transfer process.

3. TRAINING INTERACTION BETWEEN CIP AND NATIONAL POTATO PROGRAMS

The process of planning collaborative research and training allows for a continual analysis of the state of national program development. Advanced programs are those where there is a demonstrated potential for increasing potato production and a national policy to increase production exists. Research and extension programs with stated objectives and credibility within the country complement the national policy. At the other extreme are national programs in countries that possess potential for increasing potato production, but where there is lack of national interest to improve production. CIP attempts to establish contact with the interested parties, even though organized programs do not exist.

Through communication between CIP regional staff and national program leaders, collaborative plans for research and training emerge. These plans address national production problems and, more importantly, reflect the contributions that can be made by existent expertise in transferring improved technology and in human resource development through training. Based on experience over the past 13 years with some 80 national potato programs, CIP offers two types of training: production-oriented and specialized.

3.1. Production-Oriented Training

It focuses on general principles of potato production and is designed to enable national researchers and extensionists to respond to farm-level production situations. This type of training is conducted only in the regions as international or in-country short courses. Advanced national programs provide direct input by assisting in organizing activities and by instructing. Conversely, in those countries where expertise is lacking, it is necessary for CIP to provide greater input.

3.2. Specialized Training

It concentrates on areas of research for which CIP is the principal source of information and experience. The objective is to provide researchers with additional

skills to conduct research. Various components of this training include: headquarters and regional specialized courses; mid-career and individual training; training of training assistants; postdoctoral training; and scholarships. Specialized training is similar to production-oriented in that the more advanced national programs provide greater training inputs than the less advanced ones.

For both types of training, where country programs do not exist, no CIP input is made until the countries have determined their research and training priorities. As national capabilities emerge, the need for direct input from CIP often diminishes. For example, advanced programs may need CIP only for certain specialized activities where expertise is lacking and may not need CIP at all for production training. This strategy is reflected in all planning for training.

4. PLANNING AHEAD WITH NATIONAL PROGRAMS

Recognizing the importance of capable manpower, CIP's regional staff, as well as other staff traveling to the regions, discuss training needs with national program leaders. During CIP's annual meeting in Lima, regional and headquarters staff plan training activities around these needs. National program leaders often participate in the discussions. From these interactions, CIP projects a five-year plan of group training activities that is revised annually. Plans for other types of training--mid-career or individual--are also reviewed.

This planning process ensures that:

- research topics of priority to CIP's mandate and individual country needs are included, particularly where emerging technologies are ready to be transferred and evaluated under local farming conditions.

- training is properly phased so that the topics are taught over a period of years at strategic sites around the world

- CIP's scientific staff know their future involvement and can plan accordingly

- national programs can plan ahead

- CIP's training and communications staff and scientists can prepare courses and training materials

This process, more specifically, allows national programs time to plan human resource development, identify candidates for training, prepare for involvement in the training, and budget for sharing the costs.

5. IN-COUNTRY TRAINING

In many countries, due to the developmental stage of national programs, training in the country addresses only production technology. The main advantages of in-country

training are that it can be specific to meet the needs of the country or potato-growing area and can involve extensionists who have a good understanding of local growing conditions and are in direct contact with farmers. Countries such as Mexico and India with strong, advanced potato programs have been running their own in-country production courses for many years.

6. IN-COUNTRY TRAINING THROUGH BILATERAL PROJECTS

Bilateral projects in countries like Nepal, Bangladesh, Bhutan, Rwanda, and Burundi have not only played an important role in establishing sound research programs but also have been instrumental in strengthening their own national capabilities to transfer technology to farmers through extensive training. These countries are now able to concentrate on teaching production technology to extensionists as well as leading farmers, plus the courses can be conducted in the vernacular languages by national scientists.

7. REGIONAL TRAINING

Regional training is the next step for countries capable of conducting their own in-country training. This horizontal transfer of technology between developing countries is essential if the capabilities existing in national programs are to be maximized. CIP still has an important part to play in regional training, especially in the teaching of specialized subjects like production of potato from true potato seed. Although some national programs have reached the stage where they can take a more active technical role, they rely on financial support from CIP especially for participants from other countries.

8. TRAINING IN COUNTRY NETWORKS

The country networks have a strong commitment to training, since one of the goals is the horizontal transfer of technology between countries. The ability of country networks to take responsibility for conducting training is well illustrated by PRECODEPA.

9. COMMUNICATIONS SUPPORT

CIP's long term plan to the year 2000 calls for "the development of a global communications network for the transfer of technology," involving national scientists, extensionists, and educators in research and training. Improved technology must be converted to information before it can be used by national programs. CIP's Communications Support Unit plays an important role in this process, which is essential if national programs are to adapt and transfer technology to their farmers.

Communications support is an essential element to plan, synthesize, produce, and evaluate publications and visuals aids, and also to assimilate and interpret feedback. Communications support plays an important role in the support of training activities.

10. PRODUCTION TRAINING MATERIALS

CIP's training materials are designed to be adapted by national programs to meet their specific needs. Most are prepared initially in English and translated into Spanish. Technical Information Bulletins (TIBs) and visual aids are prepared for intermediate level professionals and can be used for individual study, potato production, experiments, training, or adapted for use by farmers.

A special effort was made in 1985 to translate all of the TIB's into French, which was accomplished by the end of the year. To date, TIB's have been published by national programs in Hindi, Bengali, Farsi, and Chinese. Also, CIP's field guide entitled Major Potato Diseases, Insects, and Nematodes has been translated into Arabic.

11. SPECIALIZED TRAINING MATERIALS

For specialized training, instructors prepare their materials in the form of class notes or handouts. The format is similar to the TIB's, but subject matter is more technical, which enables the user to conduct research. After a specialized activity, training materials are published in the form of Specialized Technology Manuals (STMs); for example, STMs on germplasm management have been produced in Spanish, and on potato production in warm climates and potato production from true seed in English and Spanish.

12. INFORMATION SERVICES

A constant flow of the latest research information to national program researchers is essential for the development of a global communications network. CIP's library is primarily designed to provide specialized services for CIP scientists. This role, however, is rapidly changing as demand for providing services to 1500 national researchers who have received specialized training since 1978 is increasing.

13. INFORMATION SERVICE UNIT

In late 1985, special project funds were received to develop an Information Service Unit that would respond to the long-range information needs of potato researchers in the developing world. This three-year project will incorporate the services offered by CIP's library into a much broader context toward the development of a global communications network on potato. The Information Service Unit's objectives are as follows:

- develop and automated database of conventional and nonconventional literature of particular relevance to national researchers.

- assist national researchers to gain access to other databases, such as AGRIS and CAB

- provide additional services to national researchers, e.g., selected dissemination of information, specialized searches and bibliographies, and acquisition lists

- facilitate exchange of information among national researchers through financial and technical support to national scientific journals

- assess national program information needs continually

The Information Service Unit will also coordinate CIP's continuous follow-up system of training. This effort is designed to not only determine the impact manpower development activities are having on national research and extension activities, but to also be a mechanism for providing necessary support to national programs.

In closing we all must not forget that it is people we are trying to reach with improved production and germplasm technology. And, we must not forget that people not only live in large cities with access to many services and opportunities but also live in rural areas which are often hard to reach.

SWEET POTATO SEED PRODUCTION IN BURUNDI

José Luis Rueda[1]

In order to assure full distribution of improved materials amongst farmers, a seed programme based on rapid multiplication techniques starting from clean stocks is needed.

In that regard, and by special request from the Director General of ISABU for an extension of technical assistance in Burundi to sweet potato, a seed programme was started in 1987 with support of the International Potato Center, adapting to sweet potato all micropropagation techniques already widely used in potatoes.

Simultaneously, research is underway at CIP headquarters aimed to develop ELISA tests for the two viruses: mild mottle and feathery mottle.

1. THE SEED SYSTEM

- All clones selected by ISABU and thoses already in use will be sent to CIP headquarters for cleaning up and producing pathogen tested plant materials which are then sent back to Burundi in vitro for further utilisation in the multiplication process.

  Clones: Rusenya, IMBY 3102, LUBY 3074 from Burundi are on their way to CIP Lima at the moment, others will be sent in October/November this year.

- In vitro multiplication using mainly nodal cuttings as explant materials are used to increase pathogen tested plants at the in vitro laboratory in Gisozi. Quite simple equipment, such as a razor blade, a locally made transfer chamber (wood and plastic), rooting hormone and CIP propagation media[2] are employed for this purpose.

  Nodes are obtained in about four weeks time of culturing, plants are then dissected and transferred to other tubes with propagation media for further increase.

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[1]CIP Region III, B. P. 75, Bujumbura, Burundi.

[2]Murashige & Skoog basic media plus: 0.25 ppm giberellic acid, 2.0 ppm Ca panthotenic acid, 3% sucrose, and 0.8% agar.

[3]Administration Générale de la Cooperation du Développement of Belgium.

- In vitro plants with an average of four nodes are transplanted from the tubes to plastic cups with sterile soil and covered with a plastic bag for a period of hardening of 12 days.

- After hardening, plants are transplanted to plastic bags with sterile soil and placed under shade for 20 days. At this stage, plants are transplanted into insect proof seed beds for increase.

- Multiplication by other agricultural projects.

- Multiplication at community level.

- Distribution among farmers.

All operations are carried out as carefully as possible to avoid reinfection of plant materials. Plants will be randomly checked as part of the quality control system which will be implemented according to the limitations of our host country.

Presently, Nemanette (CIP 31 IT) is maintained and multiplied in vitro at Gisozi. 20 plants are actually growing in a locally constructed greenhouse at stage 4 of the multiplication scheme. As soon as these materials are available in sufficient quantities, they will be handed to the ISABU Sweet Potato Programme for further distribution.

In the near future, an in vitro laboratory will be equipped with the financial support of the AGCD[3] at Gisozi for the dual purpose of micropropagation of potato and sweet potato.

L'ANTHRACNOSE DE LA PATATE DOUCE (IPOMOEA BATATAS (L.) LAM) AU BURUNDI: DESCRIPTION DE L'AGENT CAUSAL ET MISE AU POINT D'UNE METHODE DE CRIBLAGE

A. Simbashizweko[1] et D. Perreaux[2]

1. INTRODUCTION

L'anthracnose de la patate douce est considérée comme la maladie fongique la plus dommageable à cette culture au Burundi, principalement dans les régions d'altitude. Les symptômes sur tige sont les plus remarquables. Ils débutent par de petites taches arrondies, foncées, qui évoluent en lésions noir sombre, ovaliformes, déprimées, aux bords nettement marqués qui peuvent s'etendre longitudinalement sur plusieurs centimètres. A partir de la tige, les lésions progressent vers les pétioles qui noircissent et se dessèchent, entrainant une défoliation plus ou moins importante de la plante. L'attaque directe des pétioles est aussi possible. Les lésions âgées montrent des craquelures longitudinales et leur centre devient grisâtre. Sur les cultivars sensibles, l'influence des lésions et leur extension latérale conduisent souvent à un dessèchement des cordes et parfois à la mort de la plant entière.

A notre connaissance, il n'existe pas d'evaluation précise de l'impact de cette maladie sur les rendements. Un essai préliminaire a cependant mis en évidence des pertes en poids de tubercules de l'ordre de 60% pour la varieté sensible TIS 2498 DB par rapport aux variétés résistantes Rusenya et Nsasagatebo, la variété TIS 2498 DB perdant 90% de ses feuilles entre le 2ème et le 6ème mois après la plantation (Simbashizweko, 1986).

Un champignon du genre Alternaria a été identifié comme agent pathogène responsable de cette maladie au Rwanda (Janssen, communication personnelle). Cet article résume les résultats d'un travail de recherche (Simbashizweko, 1986) dont les principaux objectifs étaient de confirmer et de préciser l'identité de l'agent pathogène, ainsi que de metre au point une technique de criblage pour tester la résistance des différents cultivars des essais variétaux du programme d'amélioration de la patate douce de l'ISABU.

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[1]Faculté des Sciences Agronomiques du Burundi, Bujumbura, Burundi.

[2]Division Défense des Végétaux, ISABU, Burundi.

2. MATERIEL ET METHODES

2.1. Isolement de L'agent Pathogène

Les isolements sont effectués à partir de cordes de la variété sensible TIS 2498 DB prélevées dans une parcelle de multiplication du centre ISABU de Murongwe (Kirimiro, 1450m). Après stérilisation superficielle par trempage pendant 5 minutes dans l'eau de Javel à 1% et rinçage à l'eau distillée, des fragements corticaux de bouture (± 4mm x 1 mm) sont prélevés tangentiellement aux lésions et disposés en boites de Pétri sur milieu à base d'extrait de carotte (extrait aqueux de 20 gr de carottes rapées dans 1 litre d'eau distillé, agar 20 gr) et d'extrait de feuilles de patate douce (extrait aqueux de 600 gr de feuilles dans 1l d'eau distillée, agar 24 gr). Après 4 jours d'incubation à 27°C, les champignons se développant seuls ou en association à partir de ces fragments son identifiés, purifiés et stockés sur milieu moisissures (Meyer 1959).

2.2. Test de Pathogénicité

Des boutures du cultivar TIS 2498 DB, plantées en pot à Bujumbura, sont inoculées 20 jours après leur plantation en y déposant à 10 cm du bourgeon terminal un disque de mycélium (diamètre 6mm) d'une culture incubée 4 jours à ± 27°C du champignon à tester, sur une blessure superficielle pratiquée à l'aide d'un percebouchon de 4mm de diamètre. Les boutures sont maintenues sous sacs plastique à l'ombre pendant 48 heures après l'inoculation. Pour un des tests de pathogénicité entrepris, 60 boutures sont inoculées et réparties en 3 lots: un premier lot demeure à Bujumbura (830 m); un deuxième est dirigé vers Murongwe (1450 m) et le dernier vers Gisozi (2100 m), pour étudier l'influence des conditions d'incubation sur le développement des symptômes.

2.3. Caractérisation Taxonomique

Les descriptions et mesures de caractérisation de l'agent pathogène sont effectuées sur des cultures incubées 4 jours à 27°C à l'obscurité sur les milieux à base d'extrait de feuilles de patate douce et d'extrait de sol (extrait aqueux d'un kg de sol porté à 1l, complémenté de dextrose 1gr; extrait de levure 0.1 gr; KH_2PO_4 0.2 gr; agar 20 gr), sur lesquels les fructification d'Alternaria sp. sont les plus abondantes. Des échantillons de cordes malades ou des cultures de l'agent pathogène ont d'autre part été adressés au service d'identification du Commonwealth Mycological Institute (CMI, Kew, Roayume-Uni) et au Laboratoire de Mycologie de l'Université Catholique de Louvain (Professeur G. Hennebert, Louvain-la-Neuve, Belgique).

2.4. Essai d'une Méthode de Criblage

Vingt-sept cultivars de patate douce destinés à des essais de comportement et de comparaison variétale sont plantés en pot à Bujumbura (3 pots de 41 par varieté, 6 boutures par pot). Vingt-cinq jours après la plantation, chaque bouture est inoculée d'une disque de mycélium d'une culture d'Alternaria, sp, incubée 4 jours à ± 27°C sur milieu moisissure, suivant la technique décrite ci-avant. Les lésions induite sont

mesurées 10, 20 et 30 jours aprés l'inoculation. Les trios pots inoculés par variété sont considérés comme trois répétitions et les calcules statistiques de comparaison sont effectués sur les longueurs moyennes des lésions par répétition.

3. RESULTATS ET DISCUSSION

Trois champignons sont communément isolés des lésions de l'anthracnose de la patate douce: Alternaria sp., Fusarium sp. et Colletotrichum sp.; Alternaria sp. s'avère être le seul organisme capable de reproduire les symptômes de la maladie, les lésions induites par les deux autres champignons se limitent au point d'inoculation. Des inoculations mixtes ont cependant montrés qu'un rôle synergique de Fusarium sp. dans l'extension des lésions n'était pas à exclure (Simbashizweko, 1986). Les lésions induites en inoculation artificielle par Alternaria sp. sont d'autre part significativement plus étendues en altitude, à des températures plus froides qu'à Bujumbura (Tableau 1).

Tableau 1. Longeur moyenne des lésions induites par Alternaria sp. inoculé au cultivar TIS 2498 DB dans 3 sites différents (mesures 31 jours après l'inoculation).

Site	T° moyenne[a]	Longueur des lésions (mm)[b]
Bujumbura (830 m)	26.6 ± 0.3°C	21.4 ± 4.4
Murongwe (1450 m)	19.5 ± 0.4°C	80.3 ± 4.6
Gisozi (2100 m)	16.7 ± 0.4°C	85.3 ± 8.9

[a]Moyenne des maxima et minima journaliers pour la période de l'essai

[b]Moyenne de 20 mesures ± intervalle de confiance, p = 0.05

La coloration des colonies d'Alternaria sp. isolé de la patate douce varie de blanc grisâtre à vert olive foncè, suivant le milieu de culture utilisé. Les colonies sont en partie immergées et recouvertes d'un mycélium aérien blanc, cotonneux, dont l'abondance varie aussi en fonction du type de milieu.

Les conidiophores sont droits ou flexueux, brun pâle, solitaires ou en groupes restrients, occasionnellement géniculés avec 1 à 3 cicatrices conidiennes et 3 à 16 septa. Les conidies naissent de façon sympodiale, solitaires ou occasionnellement en chaine de 2 conidies. Elles sont de couleur foncée, brun doré à brun-vert olive,

obclaviformes à ovoides, prolongées d'un bec généralement plus long que le corps de la conidie et parfois ramifié. Elles sont cloisonnées transversalement (3 à 8 septa) et parfois longitudinalement (0 à 3 septa). Les mesures des conidies et conidiophores sont données au tableau 2.

Tableau 2. Caractéristiques morphologiques en milieu de culture d'Alternaria sp. agent de l'anthracnose de la patate douce.

Conidies		
Longueur totale	184.4 ± 17.3[a]	(55-300)[b]
Longueur du bec	127.6 ± 16.8	(25-290)
Longueur du corps	53.8 ± 7.7	(10-210)
Largeur du corps	15.0 ± 1.0	(10-22.5)
Largeur du bec	2.6 ± 1.0	(1.3-5
Longueur	131.8 ± 13.3	(40-250)
Largeur	5.0 ± 0.1	(3-10)

[a]Moyenne de 50 mesures ± intervalle de confiance, p = 0.05

[b]Valeurs extrêmes

Le CMI identifie ce champignon à Alternaria bataticola Ikata ex Yamamoto et les échantillons envoyés ont été déposés sous les numérous d'herbier IMI 303646, 303647, 303648 (Francis 1986). Un certain doute subsiste néanmoins du fait d'une identification basée sur la seule description originale de cet organisme, les échantillons de référence n'étant pas disponibles au CMI. Le Laboratoire de Mycologie de l'UCL, qui a pu comparer l'isolat du Burundi à un spécimen d'A. bataticola de sa collection, l'identifie plutôt à Alternaria solani Sorauer, en notant cependant qu'il en diffère quelque peu de par l'aspect finement verruqueux de ses conidies.

Alternaria solani a déjà été décrit comme agent pathogène de la patate douce aux Etats-Unis (Roger 1952) et en Afrique centrale (Buyckx, 1962). Il est cependant décrit come initiant une nécrose limitée au collet de la plante, ce qui diffère des symptômes notés dans notre travail. Nous ne disposons pas à l'heure actuelle d'information sur les symptômes induits par A. bataticola originellement décrit au Japon. Une nécrose de la tige et des pétioles causée par Alternaria sp. a récemment été décrite en Ethiopie (Van Bruggen 1984 dans R. P. P., 1985). Le champignon est rapporté faiblement sur tomate mais n'a pas été identifié au niveau spécifique.

L'inoculation artificielle permet la mise en évidence de différences de susceptibilité parmi les 27 cultivars testés. Le tableau 3 présente les résultats

portant sur la longueur moyenne des lésions induites 30 jours après l'inoculation, qui permet la meilleure séparation des cultivars. L'analyse de la variance, effectuée après transformation logarithmique des données pour égaliser la variance des mesures, révèle une différence très hautement significative entre cultivars. La comparaison des moyennes (Newman-Keuls) définit 9 groupes homogènes de moyenne et permet le classement des cultivars suivant leur niveau de susceptibilité.

Tableau 3. Longueur moyenne des lésions observées sur 27 cultivars de patate douce 30 jours après leur inoculation par Alternaria sp. (3 répétitions, 6 boutures/rép.)

Cultivars	Longueur des lésions (mm)									
TIS 2498/14/m42	49.0	a[a]								
Mugorewaradonaraye	48.5	a								
Mohy 3101	47.5	a								
7168 Nyiramujuma VK1	41.0	a	b							
Rushingacumu	40.0	a	b	c						
TIS 2498/14/m 16	36.5	a	b	c	d					
Mohf 3037	35.0	a	b	c	d					
P20-8405	34.5	a	b	c	d					
Gahungezi 1435	33.5	a	b	c	d	e				
TIS 2498/8	32.0	a	b	c	d	e				
4496 Cordes vertes	31.0	a	b	c	d	e				
Kiby 3008	30.5	a	b	c	d	e				
Imba 3115	29.0		b	c	d	e				
Ruhy 304	28.5		b	c	d	e	f			
6464 Nyiramujuma	27.0		b	c	d	e	f			
M-J. Karama	27.0			c	d	e	f			
TIS 2498/14/m1	25.5			c	d	e	f			
Mohc 2022	24.5				d	e	f			
Mohy 3001	23.0				d	e	f			
6482 Nyiramujuma VK6	22.5				d	e	f			
5684 Nyiramujuma VK6	20.0					e	f	g		
Luba 3057	20.0						f	g		
TIS/2498/6	17.5						f	g		
Nyiramanebe	15.0							g	h	
2668 Senyakanega	12.0								h	
Luhy 3043	8.0									i

[a]Des indices identiques indiquent des moyennes ne différant pas significativement (p = 0.05, Newman-Keuls, après transformation log. des données)

4. CONCLUSIONS

Alternaria sp. a été confirmé comme l'agent responsable de l'anthracnose de la patate douce au Burundi. Si son identification spécifique n'est pas encore établie avec toutes les certitudes souhaitables, cet organisme apparait cependant très similaire, si pas identique à Alternaria solani Sorauer. La méthode de triage par inoculation artificielle mise au point donne satisfaction et met en évidence de trés nettes sources de résistance. Il est intéressant de relever que TIS 2498/6, descendant du cultivar sensible TIS 2498 DB, montre un niveau de résistance appréciable, ce qui laisse entrevoir une possible incorporation des gènes de résistance vers les cultivars susceptibles. Si, parmi les cultivars actuellement en diffusion, TIS 2498 DB s'avère particulièrement sensible, les cultivars Rusenya et Nsasagatebo sont eux particulièrement résistants (Simbashizweko, 1986).

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LA CULTURE DE LA PATATE DOUCE AU BURUNDI

1. IMPORTANCE DE LA PATATE DOUCE AU BURUNDI

Pour saissir l'importance de cet aliment de base au Burundi, it suffit de se reporter à la part des superficies emblavées en cultures vivrières, qu'elle occupe dans le pays. Les données fournies par le Ministère du Plan disent que les plantes à racines et tubercules occupent en 1979, 39% de la superficie occupée par les cultures vivrières, contre 33% pour les légumineuses à graines et 27% pour les céréales. Dans cette grande part réservée aux tubercules, le manioc occupe 60% de la superficie contre un peu plus que 30% pour la patate douce, 6% pour les colocases et 2% pour la pomme de terre. L'igname est trés peu représentée.

En définitive, la patate douce occupe plus de 10% de la superficie occupée par les cultures vivrières avec des productions dépassant 0,5 million de tonnes. Cela correspond à peu près à 0,3% kg/habitant/jour. Le rendement par hectare est autour de net/ha.

La patate douce est cultivé dans toutes les régions naturelles du Burundi, mais ses rendements sont marginaux dans les régions de haute altitude (plus de 1750 m) où la production est limitée par l'acidité et la faible fertilité de terres et dans une moindre mesure, par les températures trop basse qu'on enregistre dans les marais en saison sèche.

Quoique la production nationale soit assez importante, la patate douce est trés peu commercialisée. Cultivée et récoltée presque à longueur d'année, elle constitue, avec le manioc, l'aliment de sondure pendant les périodes difficiles qui suivent les semailles de première saison (Octobre) et de deuxième saison (Mars).

2. PRATIQUES AGRICOLES

Au niveau des pratiques agricoles, la rareté d'intrants extérieurs accordé à la culture de la patate douce est remarquable. On n'utilise pas de fumure minérale pour cette culture, l'utilisation de la fumure organique est aussi inexistant en culture pure.

Bien souvent, la patate douce est utilisée comme culture d'ouverture sur les nouvelles terres et les rendements s'en ressentent.

La patate douce est cultivée tant sur colline qu'en marais en saison sèche. Quoique peu séparées, les grandes périodes de plantation de la patate douce sont les mois de Novembre-Decembre et Fevrier-Mars-Avril pour la culture sur colline et Mai-Juin dans les marais.

La patate douce se cultive bien souvent en cultue pure, mais elle se rencontre aussi dans les association culturales, sous forme de buttes clairsemées dans une gamme d'association culturales, tel de maïs-haricot, le maïs-Sorgho. . . Parfois, elles est même associée à d'autres tubercules comme le manioc ou la colocase.

3. CONSERVATION

L'absence d'un système approprié de stockage constitue un goulot d'étranglement pour l'augmentation de la production, la commercialisation et ainsi la sécurité alimentaire. Le système courant de la conservation de la patate douce est la conservation dans le champ. La méthode est malheureusement sujetté à l'infestation des tubercules par le charançon de la patate douce (Cylas sp.). Les attaques de taupes, perdrix et prédateurs divers.

Une autre méthode utilisée par les fermiers pendant les périodes de famines des années 1940 était la conservation de la patate douce sous forme de pellettes séchées. Cette pratique a été depuis, oubliée par les agriculteurs.

4. MALADIES ET RAVAGEURS

4.1. Viroses

Les maladies virales, ou soupçonnées telles, constituent un probléme important pour la maintenance des collections de clones, la multiplication et la diffusion des clones améliorés. La totalité des 48 clones de patate douce issus du troisième cycle de sélection généologique montraient des symptômes de virose en parcelles de prémultiplication, sur 5 à 100% des plantes (Goethals, 1986). Leur évidente présence en milieu rural laisse supposser qu'elles y sont un facteur de limitation des rendements, sans qu'aucune donnée quantitative ne soit disponible sur le sujet.

Douze échantillons de cordes manifestement infectées, collectés dans 4 zones écologiques différentes, ont été analysées au Glasshouse Crop Research Institute (Royaume-Uni, Dr. A. A. Brunt) pour identification des agents pathogènes. Tous ce sont révélés infectés par le Sweet Potato Feathery Mottle Virus (SPFMV), en association avec le Sweet Potato Mild Mottle Virus) pour 3 d'entre eux. Il semble cependant que d'autres virus encore non identifiés contaminaient aussi ces échantillons.

De fortes infestations de mouches blanches vecteurs du SPMMV, sont parfois observées dans les champs de patate douce,mais les espèces présentés n'ont jamais fait l'object d'une identification précise. Macrosiphum euphorbiae est le puceron le plus communément trouvé sur la culture et le seul responsable de réelles pullulations. Myzus persicae, Aphis gassypii et Aulacorthum solani en sont des colonisateurs occasionnels (Remaudière et Autrique, 1985). A notre connaissance, seul M. persicae et A. gassypii sont connus comme vecteurs de virus de la patate douce.

L'assainissement des clones améliorés et la diffusion du matériel de plantation sain sont des objectifs prioritaires du Programme Patate Douce de l'ISABU. Ils présupposent une identification précise des virus les plus fréquents et les plus dommageables, puis la mise au point des méthodes d'indexage plus pratiques et plus rapides (Sérologie, test ELISA) que les méthodes par greffage communément employées. L'utilité d'une production à grande echelle de matériel de plantation sain devra être vérifié par l'étude du taux de réinfection des plants différentes écologies.

Les contrôle des maladies virales para la résistance génétique deme une solution idéale si cette résistance existe et peut être incorporée dans des cultivars adaptés. Cette pratique présuposse aussi l'identification préalable des virus concernés et la mise au point des méthologies appropriés pour un criblage efficace.

4.2. Anthracnose

L'anthracnose est la seule maladie fongique dommageable à la patate douce au Burundi. Elle se caractérise par des lésions nor sombre, ovaliformes, déprimées qui s'étendent longitudinalement sur la tige et progressent vers les pétioles qui noircissent et se dessèchent.

Un essai préliminaire a mis en évidence des pertes en poids des racines, de l'ordre de 60% pour la variété sensible T15 24 98 DB par rapport aux variétés résistantes RUSENYA et NSASAGATEBO. La variété T15 24 98 DB perdant 90% de ses feuilles entre le 2ème et le 3ème mois après la plantation.

Un champignon du genre Alternaria a été identifié comme agent pathogène responsable de cette maladie. Son identification au niveau specifique et controversée. Le Commonwealth Mycological Institute l'assimile à Alternaria bataticola Ihata ex Yamamoto (échantillons déposé sans les No. d'herbier IMI 303646, 303647, 303648), sans cependant avoir pu le comparer à une culture de référence, non disponible au CMI. De laboratoire de Mycologie de l'Université Catholique de Louvain (Belgique), qui a pu comparer l'isolat du Burundi à un spécimen d'A. bataticola de sa collection, l'identifie cependant plutôt à A. solani Sorouer, en notant cependant qu'il en diffère quelque peu de par l'aspect finement verruqueux de ses coniolies.

Une méthode de criblage par inoculation artificielle a été mise au point (Simbashizweho et Perreaux, 1987), et permet la mise en évidence de nette différence de susceptibilité entre cultivars.

Cette maladie n'est pas en soi un problème majeur en millieu rural, mais doit être prise en considération dans les programmes de sélection, beaucoup de clones importés y étant particulièrement sensibles. Pareille constatation a d'ailleurs été vérifiée en Ethiopie, pour une maladie de la patate douce caussée par Alternaria sp., et qui apparaît très similaire à l'anthracnose décrite au Burundi (Van Bruggen, 1984).

4.3. Chenilles Défoliantes (Acraea acerata)

Les chenilles défoliantes causent localement des dégâts considérables. Une méthode de lutte basée sur la récolte manuelle des nids avant le dispersion des chenilles,

éventuellement suppléeé par un poudiage d'insecticide (Folithion P.P 3%) en cas d'intervention trop tardive, a été largement diffusée dans le pays sous forme d'affiches en Burundi. Appliquée en milieu rural dans certaines communes encadrées, cette méthode a donné résultats remarquables (PMDSS, 1984).

4.4. Charançons (Cylas spp.)

Les charançons constituent un facteur limitant une conservation prolongée des tubercules dans le sol.

Le niveau d'attaque des tubercules est un critère évalué dans les programmes de sélection. Il est cependant hautement désirable d'élaborer une méthodologie plus rigoureuse pour l'évaluation de la résistance à ces ravageurs. Parallèlement, il semble indispensable de développer un programme de recherche permettant la mise au point d'une méthode de contrôle utilisable en milieu rural.

5. LE PROGRAMME D'AMELIORATION DE LA PATATE DOUCE AU BURUNDI

Il s'agit d'un programme de recherche, intégré au sein de l'Institut des Sciences Agronomiques du Burundi. La recherche est axée sur trois domaines:

- l'amélioration variétale
- l'amélioration des techniques culturales
- la technologie post-récolte

En amélioration variétale, les thèmes développés sont les suivants:

1. Alimentation humaine qui c'est le thème de loin le plus important et le seul qui a déjà été développé jusqu'à présent. Les caractéres recherchés pour la patate douce sont - un haut rendement en tubercules avec une teneur élevée en matiéres sèches.

   Un bon développement du feuillage permettant une couverture rapide du sol (Réduction de l'érosion et du soudage).

   Une résistance ou tolérance aux maladies et pestes (viroses, Cylas, anthracnoses).

   Les caractères organoleptiques appréciés ainsi qu'une hautte qualité des tubercules: Forme, dimensions, conservation dans le sol, teneur un B carotèur.

2. Une option intéressante est également la production d'une patate douce à vocation fourragère, qui produirait une grande quantité de biomasse.

3. Nous envisageons de créer une patate douce à vocation industrielle, ayant une teneur élevée en sucres soluble, en une de sa transformation en ethanol.

L'amélioration variétale suit un schéma classique comportant:

1. Les introductions de nouveau matériel soit par croisement, soit par importation de clones à parti de différentes régions naturelles du Burundi, ou à parti de l'étranger (clones et semences).

2. Les épreuves de triage préliminaire et multilocaux.

3. Les essais définitifs variétaux

4. Les essais un champ d'agriculteur.

La recherche sur les techniques culturales porte le type de bontures à planter, la fertilisation, les association culturales.

La technologie post-récolte est un nouveau théme qui sera axé sur la conservation des tubercules et leur transformation en farine en vue de leur assurer une meilleure conservation.

La production d'éthanol à partir de la patate douce est un projet mis en veilleuse, inspiré par la nécessité de diversifier les sources d'energie. Sa réalisation doit passer par les étapes suivantes:

- Développement de patate douce à haute teneur en sucre

- Délimitation d'une zone d'action en fonction de sa potentialité de production.

- Identification de variétés adaptées à cette zone.

- Etude de l'utilisation des sous-produits d'usinage.

- Etude de faisabilité expérimental de l'hydrolyse de l'amidou et d'extraction du saccharose de la patate sucrière.

- Mise au point d'une technique de séparation de l'extrait riche en sucres fermentisaible de la pulpe de la patate douce sucrière.

- Etude de fermentisabilité aleodiquant de l'extrait riche en sucre

- Etude de faisabilité experimentale de la digestion methanique des residues semi-solide d'extraction et de fermentation.

6. ACQUIT DE LA RECHERCHE

Après 7 ans d'amélioration variétale, le programme a déjà identifié cinq variétés productives et donnant des tubercules de bonne qualité. Trois d'entre elles sont déjà

diffusés auprés de projets de développement rural intégré qui assurent la production de matériel de plantation à une plus grande échelle qu'en station de recherche et assurent la diffusion. Deux autres variétés sont en passe d'être diffussées.

7. PERSPECTIVES D'AVENIR

Nous envisageons continuer la sélection pour la productivité et la qualité et continuer à enrichir notre collection par importation de nouveau matériel génétique.

Un accent particulier sera mis sur l'amélioration de l'état sanitaire du matériel de plantation vis à vis des viroses essentiellement.

La technologie post-récolte sera également imitée et poursuivie.

OSutefois une assistance scientifique est très nécessaire pour la réalisation de ce programme ambitieux. Les domaines en souffrance sont essentiellement l'état sanitaire du matériel de plantation (viroses, alternariose), la technologie post-récolte la production de matériel de plantation. Nous souhaiterions une assistance dans les domaines suivants:

1. La production de matériel de plantation sain qui procéderait:

   - De l'identification des virus qui s'attaquent à la patate douce au Burundi.

   - De la mise au point d'un test ELISA pour le contrôle de l'état sanitaire de plants dans le but de réaliser une épuration efficace.

2. La technologie post-récolte.

3. La fourniture de nouveau matériel génétique adapté aux altitudes élevées du Burundi.

4. La formation des scientifiques, des techniciens et des vulgarisateurs.

COUNTRY REPORT ON SWEET POTATOES AND FUTURE PLAN IN EGYPT

Sherifa Fouda[1]

1. INTRODUCTION

Sweet potato is widely used in Egypt as a popular human food. Green foliage and unmarketable roots are used for live-stoks. It is also used as a raw material in many industries such as starch and alcohol. Despite its importance to satisfy the increase in populations, it has not been developed to its fullest extent.

2. PRODUCTION

Area, productivity and production of sweet potatoes during the period 1980 to 1986 are listed in the following table:

Year	Area	Ton/feddan[a]	Total production
1980	8574	10.47	89770
1981	5862	9.75	57155
1982	12929	9.67	125023
1983	7774	10.66	82870
1984	9365	10.60	99269
1985	5416	9.93	53780

[a]Feddan = 4200 m^2

3. IMPORTANCE OF SWEET POTATOES IN EGYPT

Sweet potatoes is a summer vegetable crop. It is planted all over the country in small areas. Since it needs temperature between 25-30ºC for growth, it does best in lower Egypt governorates i.e., Kalubiya, Sharkiya, Monofiya, Garbiya, Dakahliya, and Alexandria. It is also planted in smaller areas in middle Egypt governorates i.e., Giza, Bei Sweef and Minia.

[1]Vegetable Research Department, Horticulture Institute.

Most of the production is mainly used for human consumption, the edible part (root tuber) is eaten by majority of people. It is not considered as one of the basic food meals, but it is eaten between meals.

Some of the production goes for industrial purposes i.e., flour and starch. The foliage is used as a green fodder having a relatively high protein content.

Sweet potatoes are also cultivated in newly reclaimed land and sandy soil. Small farmers and new inhabitants in new reclaimed land use sweet potato to feed their animals during summer and autumn. The green foliage will participate in solving animal feeding problems.

4. SEED PRODUCTION

The propagation of sweet potato for commercial planting involves several practices. In general, there are seed stock selection, seed stock production and maintenance.

Sweet potato is propagated mainly by cuttings or by transplantings. Propagation by seed is used for breeding new cultivars.

5. PROPAGATION BY VEGETATIVE GROWTH

200-300 m^2 of the previous plantation is used for producing both cuttings or transplantings as follows:

5.1. For Production of Cuttings

The previous area is kept without irrigation during winter time, from end of November to end of February. It is covered with some straw to prevent chilling injury. At the end of February, it is irrigated and fertilized with farmyard manure. It grows and gives satisfactory vegetative growth. The foliage is divided to cuttings which are 15-20 cm and contain 3-5 buds. Then these cuttings are used directly for planting.

Another method in preparing seed stock is practiced in warm winter regions. After harvesting the crop, during November, a small nursery is planted by the vines. Cuttings are planted in rows 50-60 cm apart, and withing row spacing 10 cm. During April-May, the foliage of these plantations is re-cut.

5.2. Production of Transplantings

Small and unmarketable tubers which should be true to type are planted in nursery. The tubers are planted at the bottom of row one by one, covered with soil and irrigated. The transplants which are 15-20 cm long are removed and used for planting. The mother tuber is kept in the nursery for further production of transplants.

6. QUANTITY OF SEED (Planting material)

One Feddan (4200 m^2) needs 25,000-30,000 cuttings produced from 200-300 m^2 from the previous plantation, or 25,000 transplants produced from 300 kg tubers.

7. VARIETIES

7.1. Mabrouka

It is an old variety bred in Egypt 40 years ago. It is red skinned with creamy flesh and now showing deterioration owing to some virus diseases. Yield is about 6-8 tons/Feddan. It is utilized for human consumption and for starch industry.

7.2. Abeese

It was found as a mutant during a long period of growing sweet potato variety. It is red skinned with orange flesh. It matures after three months and yields 10-13 tons/Feddan. It is well known in the northern part of the country (Alexandria). It is utilized for flour and flakes.

7.3. Hepa

It is an Egyptian cultivar introduced eight years ago. It is characterized by golden skin with golden orange flesh. It gives good yield in saline soils.

7.4. Georgia get

It is an American cultivar introduced five years ago. It is sensitive to salinity. It has a red skin with orange flesh. It gives high yield ranging from 10-15 tons/Feddan.

Newly introduced cultivars:

TI 1892:	Drought resistant
II 130:	Drought resistant
Jewel:	Highly productive
Centenial 14	

8. PLANTING DATES

Middle Egypt: Early March - April
Lower Egypt: April - middle of May
Planting time affects yield, earlier plantation gives higher yield.

9. SOIL

It grows best in sand loamy and silt loamy soils. It can grow in sandy soil with some modifications of irrigation and fertilization.

10. PLANTING METHODS

On rows, 7 rows/7 m. The cuttings are inserted on the northern or western part of the row at 20-25 cm apart, two third of the cutting is inserted in soil with one third exposed, leaving one or two buds. In case of transplants, all are inserted leaving part of stem exposed.

10.1. Hand Hoeing

Is used to get rid of weeds, sometimes herbicides are used before planting or after planting "suitable weed killer."

10.2. Irrigation

Should be done as the plant needs. Sweet potato can resist drought during the first period of growth but not in later periods, since it decreases yield and yield quality. Generally, sweet potato needs 4-5 irrigations which is stopped 3-4 weeks before harvesting.

10.3. Fertilization

Sweet potato can grow in poor soil and newly reclaimed lands. Excessive farm manure may cause huge vegetative growth on account of tubers. However, fertilization depends on the previous crop before sweet potato. If the previous crop is alfalfa in loamy sand soil, the recommended rates are: 100 kg calcium nitrate + 200 kg superphosphate + 100 kg potassium chloride/Feddan.

In sand soils, about 20 m^2 of farm manure + 100 kg calcium nitrate + 300 kg superphosphate + 150 kg potassium chloride/Feddan.

10.4. Harvesting

It matures 5-6 months after planting. Some growers leave their crop stored in the ground, others harvest it early.

10.5. Curing

Root tubers are kept in stores at temperature ranging from 25-30ºC and relative humidity of 85% for two weeks.

Tubers are arranged in layers of 30 cm high or packed in mesh bags for curing. Curing process helps in the formation of periderm layers which strengthen the skin for handling and marketing.

10.6. Pests and Diseases

The major insect and disease problems are the cotton leaf worm, the clack cutworm, white flies, the mole cricket, mosaic virus, soft rot and dry rot. Strict quarantine regulations are followed for imported plant materials. Tissue cultures and seeds are more safe for introduction of new materials.

11. FUTURE PLAN FOR SWEET POTATO IMPROVEMENT

11.1. Breeding Program

- Introduction of new cultivars suitable for human food, that possess high sugar content and other constituents related to nutritional value; smooth surface of root with no veining.
- Introduction of cultivars suitable for industry, characterized by high starch content and white flesh.
- Use of true seeds, induction of flowering and crossing to produce desirable clonal hybrids.
- Production of certififed seed stock under cover.

11.2. Agronomy and Physiology

- Studies on plant densities.
- Studies on irrigation and fertilizer levels.
- Studies on the effect of growth regulators and fertilizers on yielding potential.
- The best methods for controlling insects, diseases and weeds.
- Studies on the causes of deterioration of some varieties.

11.3. Post Harvest and Processing

- Method of curing, storage and type of containers.

- Study of dormancy and rest period, and components of storage quality.
- Study of processing sweet potato for starch and other products.

SWEET POTATO PRODUCTION, RESEARCH AND FUTURE PROSPECTS IN ETHIOPIA

Terefe Belehu[1]

1. INTRODUCTION

Ethiopia has a population of about 42 million with a total land area of over 122 million hectares. About 84 million hectares of the land are considered fit for agricultural production. The cultivated (crop) land estimate totals 13 million hectares. The country lies mostly between 9° and 18° North and between 34° and 48° East.

The economy of Ethiopia is primarily based on agriculture, and over 85 percent of its population is dependant on agriculture.

Ethiopia has a wide range of climatic zones and soil types, which can provide suitable ecological conditions to the cultivation of many crops. Though cereals are the most important field crops in the country, root and tuber crops are also among the widely cultivated crops of Ethiopia. Although there is no available data, a considerable portion of the country's population is dependent on these crops as a source of food. The most important among the widely cultivated root and tuber crops are: enset (*Ensete ventricosum*), potato (*Solanum tuberosum*), sweet potato (*Ipomoea batatas*), godere (*Colocasia esculenta*) and yams (*Dioscorea* spp.) in the order of their importance. Among the most important root and tuber crops, this paper will focus on sweet potato.

Ipomoea batatas (L) Lam, has been cultivated as food crop in Ethiopia for the last several years and over 95% of the crop produced in the country is grown in the south, south western and eastern parts, where it has remained for centuries an important co-staple for the people.

The general agricultural survey (1982/83) and (1983/84) Ministry of Agriculture indicated that root and tuber crops cultivation was estimated to cover an area of about 97,107 hectares and 92,816 hectares, respectively in the southern regions, Sidamo, Gamo-Gofa and Bale (Table 1). Most root and tuber crops are produced in the main season, except in the Sidamo Administrative Region where they produced in both main and belg seasons (Belg is the short rainy season in Ethiopia).

The introduction of sweet potato to the northern part of Ethiopia is very recent. Apparently it has been introduced into Eritrea, Tigray, and Nello during the drought. Today, sweet potato is considered as an important food crop even in areas where it has never been cultivated and utilized before.

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[1]Sweet Potato Research National Team Leader, Institute of Agricultural Research, P.O. Box 2003, Addis Ababa.

In areas where sweet potato has been cultivated for several years the fresh tubers is consumed just after boiling. But in areas where this crop is introduced very recently the fresh tubers are consumed after boiling and baking. The tubers are also used in the distillation of the local liqueur "arekie."

Table 1. Area under root crops in southern regions (in hectares).

Root & Tuber Crop Type	Regions					
	Sidamo		Gamo-Gofa		Bale	
	1982/83	1983/84	1982/83	1983/84	1982/83	1983/84
Enset	79,616	76,532	5,856	5,780	1,300	1,288
Sweet Potato	6,337[a]	4,189	1,525	2,230	93	93
Potato	386[a]	239	639	1,315	-	-
Godere (C. esculenta)	709[a]	828	-	149	-	-
Yam	646[a]	82	-	91	-	-
	87,694	81,870	8,020	9,565	1,393	1,381

[a]The sum of main and belg season crops.

Source: Ministry of Agriculture, General Agriculture Survey, Vol. II, 1984, Addis Ababa.

2. REVIEW OF PAST RESEARCH WORK AND ITS OUTPUT

Research work on sweet potato was initiated by the Institute of Agricultural Research (IAR) at Nazret Station in the early 1970's with a few introductions from USA and Nigeria. The major emphasis of the research was on agronomic trials. Organized research on root and tuber crops started with the advent of the team approach. The institute of Agricultural Research has devised a new approach in 1980 to solve problems in the field of research by aggregating the thinly spread manpower into a team. The main objective of the root and tuber crops team which focused on sweet potato and potato at that time was to develop high yielding stable variety with necessary package of practices, and resistant or tolerant varieties to major diseases and pests. To solve these problems, the Root and Tuber Crops Research Team Members were assigned from different relevant disciplines (Breeding/Agronomy, Pathology, Entomology, Soil Fertility, Weed Science & Food Science).

The research program executed by the team includes:

2.1. Varietal Improvement

Characterization and evaluation of local and introduced materials, adaptability studies, high yielding varieties, evaluation in multilocation variety trials and seed increase and maintenance are routine type of activities which mostly support the varietal improvement program. Through years of continuous experimentation across locations the white skinned and white fleshed "Koka 6" and the cream colour skinned and the carrot red fleshed "Koka 12" cultivars out yielded most varieties and has been nationally released to farmers for production (Table 2). Other variety trials conducted recently at Nazret and Bako brought other high yielding cultivars into the picture. These were: "Koka 9A", "Koka 9", and "Koka 18" which yielded over 500 Q/ha at Nazret and cultivar Cemsa an introduction from Cuba yielded 407.5 Q/ha at Bako.

Table 2. Yield performance of six best sweet potato cultivars across three locations.

	Location			
	Awasa	Melka Merer	Nazret	
Variety	Mean Yield in Q/ha 1980/81 to 1983/84	Mean Yield in Q/ha 1980/81 to 1983/84	Mean Yield in Q/ha 1980/81 to 1983/84	Across Location Mean
Koka 6	294	266	392	137
Koka 12	337	253	263	284
Wondo Guenet	173	150	121	148
Koka 9	191	67	122	148
Koka 26	165	153	79	132
Arba Ninch III	151	111	95	119

2.2. Cultural Practice

Agronomic aspects of sweet potato production have been investigated in a number of stations in the Institute of Agricultural Research. Years of continuous experimentations allowed some improved cultural practices to be recommended:

a. The optimum plant population is 25,000 plants/ha, but the population can be decreased to a minimum 15,000 plants/ha with certain environmental conditions.

b. Timely planting of sweet potato is very important. Therefore, the optimum planting time for sweet potato in Ethiopia is that when the rainy season is well under way, that is to say after well-defined rains to insure satisfactory establishment of the vine cuttings.

c. The use of disease-free planting material gives good establishment minimizes disease problems.

d. Weeding sweet potato particularly during the first eight weeks is very critical.

2.3. Pathology

Seven diseases have been identified on sweet potato, the most important among these are: stem blight (Alternaria spp.), leaf blight (Ascochyta hortorum), stem lesion (Colletotrichum spp.), tuber rot (Helicobasidium purpureum) (A review of crop protection research in Ethiopia, 1985). The widely occurring among these is stem blight. Biological studies, varietal screening and chemical control studies have been done on this problem. The chance of survival of the fungus under field condition was found to be nine months. The host range of the pathogen was also determined (Crop Protection Ann. Progress Report, 1979/80). Differences in susceptibility among the cultivars were observed. It was found that "Koka 12" was found less infected by the pathogen.

2.4. Entomology

Survey work carried out so far indicated that over twelve species of insects have been recorded on sweet potato in Ethiopia. The most important among these are: the sweet potato leaf miner (Bedellia somnulentella), sweet potato weevil (Cylas spp.), sweet potato tortoise beetle (Aspidomorpha tecta), sweet potato butterfly (Acraea acerata) (A review of Crop Protection Research in Ethiopia, 1985, Crowe and Shitaye, 1977 and Crop Protection Department Ann. Progress Report 1985/86 in press). The widely occurring among these is the sweet potato weevil. The Entomology section at Nazret and Melka Merer completed their study on the yield loss of sweet potato weevil and recorded a yield loss of 21% to 78%. Biological studies and chemical control studies have been done on this problem. Its life cycle is completed in 26-30 days, six to eight generations were observed per year and 151 adults were counted per moderately infested tuber. DDT (dipping) and foliar spray of endosulfan has been found effective in the control of sweet potato weevil (Crop Protection Department Ann. Progress Report 1984/85).

3. FUTURE PROSPECTS

The status of sweet potato in most parts of Ethiopia is that of a minor crop. However, the probability is that the importance of the crop will increase in the years to come. The future prospects look good for several reasons. Firstly, those parts of Ethiopia where the root and tuber crops are important in the diet are the densely populated areas, and the threat of large-scale starvation is ever present. The drought striken areas of northern Ethiopia (Eritrea, Tigray, and Wello) where sweet potato is introduced recently is vulnerable to starvation if the general weather conditions affected the crops. It has therefore become of urgent importance, to improve the crop

which can provide part of the food supply of the respective regions. Secondly, the increasing political awareness in Ethiopia has caused a diversion of emphasis in order to improve the production of root crops like sweet potato which have until recently been grown by crude method on limited areas, to meet the aim of self sufficiency in food supply.

4. FUTURE NEEDS FOR INTERFACE WITH CIP TECHNOLOGY

Most international institutions have had a policy of collaborative research with national and regional institutions around the world. The main objectives of the collaborative research with the national and regional program is to undertake research which will make the region or the nation capable of increasing food production and transfer new technologies and skills, through training. More than what is said the sharing of responsibility between institutions like IITA and CIP will be more advantageous in allowing them to reach their research objectives more rapidly. Therefore, the need for interface of these institutions to work on common development research is highly beneficial for the national and regional programs.

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IMPROVEMENT OF ROOT AND TUBER CROPS IN KENYA

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1. ABSTRACT

In Kenya cassava and sweet potato are grown on an area of 90,000 ha annually. About 63% area lie in Western Kenya, 30% in the coast while the eastern part contributes 5% to the national production. About 90% of sweet potato is produced in Nyaza, Western, Central and Eastern provinces, while the other parts of the country accounts for the other 10%.

About 250 accessions of cassava and 200 of sweet potatoes collected locally and introductions from other countries are being maintained in National collections at various stations.

Major production constraints are non availability of improved varieties, lack of production technology and susceptibility to diseases and pests. The national Research Programme is carried out by the national coordinator based at CARS Mtwapa. Research work carried out in the recent past has resulted in the development of improved varieties of both Cassava (in the Kibandameno and Serere) and Sweet potatoes (KSP 20, Mwezi tatua and Toilo).

In cassava, CMV is the major disease prevalent throughout the country, followed by cassava Bacterial Blight which is localized in Western Kenya, while Cassava greenmite has in the recent past become a major pest in some areas and losses by Red spidermite and scales are not of economic importance at present.

In sweet potato, the sweet potato virus complex is the major disease present throughout the country. A number of insect pests have been reported to damage sweet potato but sweet potato weevil is the most serious which can cause heavy loses in tuber yield particularly during dry season.

Breeding objectives for each crop and the salient research findings are mentioned in this paper.

2. INTRODUCTION

Although cassava and sweet potatoes are grown throughout the country, the major areas of production lie in Nyanza, Western, and Coast provinces.

About 63% of the area under cassava are in Western Kenya, 30% in the Coast and 5% Eastern. The area under cassava during 1985 was approximately 60,000 ha (FAO production Year Book 1986). The area under cassava has reduced by 26% since 1982.

Sweet potatoes are mainly grown in Western, Nyanza, Central and Eastern provinces. Sweet potato is also grown in Rift Valley and Coast provinces. The area under sweet potato during 1985 was approximately 30,000 ha (FAO Production Year Book 1986).

Cassava is utilized in various ways i.e. dried cassava can be ground into flour in combination with various cereals, to make "Ugali" which is eaten with meat or vegetables. It can also be boiled or fried and eaten as a snack with beverages such as tea. However, some regional variations in utilization do exist: in Eastern Province, the Kamba people chew it raw, while in the Coast cassava is mainly cooked in coconut milk extract. In Busia district of Western Province, cassava leaves are soaked in water for a night or two, boiled and fried. Milk or groundnut paste is added to give better taste and is served with "Ugali." Cassava is also used in starch production.

3. RESEARCH SET UP

In Kenya Agricultural Research has been put under Kenya Agricultural Research Institute (KARI) and is responsible to the Ministry of Research, Science and Technology. In the new set up research programme on Traditional crops including root and tuber crops have been given much emphasis, as these crops are important famine crops, require less agronomic husbandry practices, widely adaptable and have a higher production potential per unit area. A post of a National Coordinator has been created whose work will be to organize and execute the National programme and is based at Coat Agricultural Research Station (CARS) Mtwapa. The N. D. F. R. S. (Katumani) has the regional mandate with particular emphasis on dry area. The other regional research stations will cater for areas in their respective localities for instance W. A. R. S. (Kakamega) and Kisii Research Stations will cater for high to medium potential areas and CARS for the Coastal areas including hinterlands. Muguga deals with disease control aspects particularly viral diseases on cassava and sweet potato. Kibos Cotton Research is also doing research work on Cassava Greenmite.

The National Germplasm for both cassava and sweet potato will be maintained at the CARS Mtwapa. The National Programme will generate the breeding material and introduce the exotic material to pass on to various regional stations. However, regional Research Stations will maintain their own germplasm.

4. PRODUCTION CONSTRAINTS

4.1. Non Availability of Planting Material

Planting material is normally not available during planting time (on the onset of the rains) to most farmers. In the dry areas sweet potato planting material is particularly a problem to obtain after a long dry spell. Only farmers who live near rivers may be lucky as they can multiply the planting material along river banks during dry periods. Most farmers may not plant or they may plant late in the season.

While for cassava the farmers mainly r' on borrowing from each other, in which case the material is not even enough for all. There is also a risk of using infected material both by the CMV and pests, which results in poor establishment, growth and stand.

4.2. Late Maturity

Traditional landraces in both sweet potato and cassava are late maturing and low yielding, which are generally susceptible to diseases and insect pests.

4.3. Lack of Production Knowhow

Traditionally cassava and sweet potatoes are grown along with other crops such as cereals and grain legumes, except for sweet potatoes which in some areas is grown as a monocrop on ridges or mounds. In the traditional mixed cropping system, one finds cassava plants of different ages which encourage pest and disease build up. In the mixed cropping, spacing is irregular, in some cases leading to competition from other crops. The farmers are ignorant of the spacing and other agronomic practices which result in poor yields.

4.4. Marketing

Marketing is unreliable as the root and tuber crops are not staple food crops in Kenya. In dry areas root and tuber crops are still treated as famine crops during draught years demand increases. In Coast Province demand for cassava is highest during the Ramadhan period.

5. RESEARCH WORK DONE

5.1. Cassava

5.1.1. Germplasm

There are about 250 accessions of cassava, collected locally and obtained from IITA, CIAT, USA and Amani (Tanzania). They are being maintained at Plant Quarantine Station (Muguga), CARS (Msabaha), N. D. F. R. S. (Katumani) and W. A. R. S. (Kakamega).

Some of the germplasm has been properly described and catalogued, while part of it still remains to be studied. As a result of screening and evaluation a number of lines have been selected on the basis of earliness, yield, root character and resistance to diseases and pests. In Katumani KME 31, KME 1, KME 51, KME 16, KME 24 (TMS 30786), KME 25 (TMS 30555) have been selected on these basis, while in the Coat Agricultural Research 46106/27, 5543/156 and Kibandameno have been selected and at WARS (Kakamega)

the following have been selected 4763 (Brazil), 12200 (Nigeria), Tereke, Adhiambo Lera, and Serere. Some of these lines are on the approved list of improved varieties while others are being utilized as parents in the breeding programmes.

5.1.2. Varietal Improvement

Varietal improvement work in East Africa dates back to 1937 when inter-varietal and inter specific crosses were made by Dr. H. H. Storey. The improved lines showing tolerance/resistance to CMV were released to farmers in the Coast Province. From time to time, most of these hybrids were not accepted by farmers mainly due to their root character.

Recent work carried out at the Coast, Kakamega and Katumani has resulted in the development of some promising lines like KME 1, Mucericeri, Kibandameno, 46106/27 and 5543/156, 4763 (Brazil), 12200 (Nigeria), Tereka, Adhiambo Lera and Serere. These varieties have been selected on the basis of earliness, high yields, resistance to diseases and pests and adaptability.

The open pollinated/hybrid seed received from IITA was grown and studied in Katumani. As at present 10 selections IYT-B-38, 30555-22, 30395-23, 30474-35, IYT-B-37, 30395-29, and 30555-18) were selected on these basis and are in preliminary yield trial. These selections are highly resistant to CMV but some of them are susceptible to the CGM and scales.

5.1.3. Disease and Pests

5.1.3.1. Cassava mosaic disease (CMY)

This is the most serious disease prevalent throughout the country. The extent of the disease may vary and yield losses of 20-90% (Beck and Chant, 1958), Brant and Johns, 1940) have been reported. Although rate of secondary spread is only 2% annually (Bock, 1982) which could be controlled through use of healthy planting material and timely rogueing but in practice it does not appear to be very effective approach either due to farmers ignorance or farmers reluctance to rogue out the diseased plants for some reasons. Most of the new varieties coming out of IITA program have shown resistance against CMV.

5.1.3.2. Cassava Bacterial Blight

The disease is caused by a bacterium, Xanthomonas manihotis. The disease is mainly confined to Western Kenya. Varieties showing resistance against CBB have been identified in Western and Nyanza Provinces.

5.1.3.3. Cassava Greem Mite (Mononychellus tenajoa)

The CGM may have entered the country first to Western Kenya from neighbouring Uganda and was first noticed at Katumani in 1984. But in recent years it has spread to other parts of the country. CARS Mtwapa has identified resistance line; Commonwealth Institute of Biological Control (Muguga) is actively involved in monitoring the movement of these insects as well as its biological control measures through released predators.

5.1.3.4. Cassava Redspider Mite (Tetranychus telanious)

This pest can be serious throughout Eastern Province during the dry spell after the long rains. A local variety KME 1 is resistant to the scales and some IITA varieties also appear to have resistance against this pest.

5.1.3.5. Termites

Termites damage can be serious during dry season. Termites attack the stem and damage the plant resulting into wilting and lodging.

5.1.3.6. Mammals

These include rodents, porcupines, wild pig and monkeys which eat the roots when the crop is standing in the field. Sweet varieties are more prone to the damage by these group of pests. In Western Kenya some farmers deliberately plant bitter varieties to contain the problem.

5.1.4. Agronomic work

5.1.4.1. Fertilizer trials

Cassava fertilizer trials carried out in 1971 and 1972 for 3 different types of fertilizers: Farm Yard Manure, Double Super Phosphate and Sulphate of ammonium indicated response for SA and FYM, while work done in 1974 indicated positive response to all.

5.2. Sweet Potatoes Research Work Achieved

5.2.1. Germplasm

There are about 200 sweet potato accessions in the live germplasm maintained at NDFRS Katumani, Kakamega (WARS), Kisii Agricultural Research Station and CARS Mtwapa. The live germplasm consists of 154 local collections, 31 lines from IITA, 6 lines from AVRDC (Taiwan), 3 lines from U.S.A. and 1 line from Puerto Rico.

Preliminary evaluation of this germplasm has shown a wide range of genetic variability; plant type, skin colour, flesh colour, maturity, reaction to the virus, flowering and draught tolerance. A number of promising lines originating from local and exotic germplasm have been selected on the basis of yield, maturity, tuber character and disease tolerance. The most promising lines are KSP 20 (TIS 2534), KSP 21 (TIS 2544) KSP 17 (TIS 2498), KSP 97 AND KSP 11 (both local) Mwezi tatu, KSP 109, Nyalwoyo - 2, Mania. Forage and dual purpose Toilo, Musinyama and Mafuta.

The American lines are early, draught tolerant and high yielding but are susceptible to sweet potato virus complex and to sweet potato weevil. They are sweet and non-fibrous but are not acceptable because of their orange flesh colour and wateriness. They are however being used in making crosses to introduce earliness and draught tolerance to the locally adapted but late maturing and draught susceptible land races. Of the 6 lines introduced from AVRDC (Taiwan) only one is surviving, KSP 102 (CN 913-7). This variety is very prolific but the tuber character is not much desirable because of its wateriness and the flesh colour changes with age, after cooking there is a distinct purple tinge and the flesh colour which is generally very white turns creamish. This variety is now being used as parent material to make crosses. Studies show that introductions from IITA are the most suitable in nearly all parts of the country; except for very high altitude areas.

5.2.2. Varietal improvement

5.2.2.1. Breeding objectives

In Kenya sweet potato improvement work is focused on development of both dualpurpose and food types.

The major breeding objectives for sweet potatoes include breeding for early maturing, high yielding with good tuber character, tolerance to diseases and pests and wide adaptation.

In Katumani three high yielding lines have been identified, they include KSP 20 (2534), KSP 17 (2498), and KSP 11 which is a local collection. KSP 20 is well adapted to most parts of the country except in places above 1800 m. However, this variety is a poor establisher particularly in dry areas.

Open pollinated and hybrid seed from IITA have not produced any promising lines. Some of these hybrid lines are under preliminary evaluation.

Work on genotype x environmental interaction has been started using 10 varieties in 5 locations. Preliminary observation indicated that none of the varieties under test has wide adaptation.

Experiments on pre-rooting have shown advantage in establishment, improved growth rate and higher yield. Pre-rooting vines in polythene bags using rain or boiled water for about 10 days before the onset of the rains is convenient to the farmers.

5.2.3. Disease and Pests

5.2.3.1. Sweet Potato virus complex

This is the most important sweet potato disease in Kenya.

Other fungal and leaf spot diseases have been observed but have not yet reached economic thresh hold levels.

5.2.3.2. Sweet potato weevils (Cylas spp.)

This is the most important insect pest in the dry areas. So far no resistant variety has been identified in the dry areas though KSP 20 (2534) is quite tolerant. The damage in some varieties is very high and tuber damage of 4-5 points have been recorded in the variety trials.

5.2.3.3. Nematodes

Nematodes can be a problem in fields under continuous sweet potato production.

5.2.4. Agronomic work

In Kenya not much agronomic work has been done on sweet potatoes since improvement work started late compared to other crops.

Some work on Phosphorous and Nitrogen reactions were done in Western Kenya (Karachi, 1982). The results indicated that yields for both tubers and vines improved with P and N application.

6. ACKNOWLEDGEMENTS

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Table 1. Sweet potato yield, yield potentials and disposal Eastern and Coast Provinces of Kenya.

Districts	Yield kg/ha				Disposal %		
	Without Fert.	Level I	Level II	Level III	Market-ing Board	Local Market	Home Consumption
EMBU							
AEZ: UM2: Main coffee	8,000	8,000	18,000	25,000	0%	74%	26%
AEZ: LM 3: Lower mid cotton	3,800	-	6,000	10,000	0%	58%	42%
AEZ: LM4: Marginal cotton	4,000	3,000	5,000	8,000	0%	80%	18%
MERU							
AEZ: UM1: Coffee, Tea	8,000	7,000	18,000	3,500	0%	58%	42%
AEZ: LM3 Cotton zone	3,800	6,000	8,000	12,000	-	-	-
AEZ: UM2: Main coffee	6,000	5,000	16,000	25,000	0%	80%	18%
AEZ: LM5 L/Stock-Millet	3,500	2,000	4,000	8,000	-	-	-
MACHAKOS							
	-	-	-	-	-	-	-
KITWI							
AEZ: UM3 Marginal coffee	3,500	2,000	8,000	14,000	-	-	-
AEZ: UM4: Sunflower, maize	3,500	2,000	8,000	10,000	-	-	-
TAITA-TAVETA							
AEZ: UM3: Marginal coffee	5,000	3,000	8,000	16,000	-	-	-
AEZ: UM4: Sunflower, maize	4,000	3,000	7,000	14,000	-	-	-

Table 1. (continuation)

Districts	Yield kg/ha				Disposal %		
	Without Fert.	Level I	Level II	Level III	Market-ing Board	Local Market	Home Consumption
AEZ: LM4: Marginal cotton	3,000	3,000	7,000	10,000	-	-	-
KWALE							
AEZ: L3 Coconut, cassava zone	6,000	-	12,000	10,000	0%	81%	19%
AEZ: L4 Cashewnut, cassava zone	5,000	-	8,000	12,000	-	-	-
AEZ: L5 Lowland L/stock Millet	-	-	-	-	-	-	-
KILIFI							
AEZ: L3 Coconut, maize zone	3,500	-	8,000	16,000	-	-	-
AEZ: L4 Cashewnut, cassava zone	3,500	-	5,000	9,000	-	-	-
LAMU							
AEZ: L3 Coconut, cassava zone	4,500	-	10,000	18,000	-	-	-
AEZ: L4 Cashewnut, cassava zones	3,000	-	5,000	9,000	-	-	-

Table 2. Sweet potato yields, yield potentials and disposal for Western and Nyanza Provinces of Kenya.

Districts	Yield kg/ha				Disposal %		
	Without Fertil-izer	Level I	Level II	Level III	Market-ing Board	Local Market	Home Consumption
KAKAMEGA							
AEZ: UM1: Coffee, Tea zone	7,500	6,000	8,000	20,000	0%	52%	48%
AEZ: LM1: L. midland sugarcane zone	4,000	4,000	11,000	25,000	0%	2%	98%
AEZ: LM2: Marginal sugarcane zone	3,500	3,500	8,000	25,000	0%	0%	100%
BUSIA							
AEZ: LM1: Sugarcane zone	5,000	5,000	12,000	28,000	0%	0%	100%
AEZ: LM2: Marginal sugarcane zone	4,500	5,000	9,000	28,000	-	-	-
AEZ: LM2: Cotton zone	3,500	4,000	8,000	17,000	-	-	-
BUNGOMA							
AEZ: LM1: Sugarcane zone	6,500	6,000	10,000	28,000	0%	6%	94%
AEZ: LM2: Marginal sugarcane zone	7,000	8,000	12,000	28,000	-	-	-
AEZ: LM3: Cotton zone	4,500	6,000	10,000	18,000	-	-	-
KISUMU							
AEZ: LM2: Marginal sugarcane zone	6,000	5,000	12,000	30,000	0%	54%	46%

Table 2. (continuation).

Districts	Yield kg/ha				Disposal %		
	Without Fertil-izer	Level I	Level II	Level III	Market-ing Board	Local Market	Home Consumption
AEZ: LM3: Cotton zone	5,000	5,000	8,000	16,000	-	-	-
KISII							
AEZ: UM1: Coffee, Tea zone	9,000	8,000	16,000	35,000	0% 0%	67% 11%	33% 89%
SIAYA							
AEZ: LM1: Sugarcane zone	5,000	5,000	12,000	25,000	0%	0%	100%
AEZ: LM2: Marginal sugarcane zone	7,000	6,000	8,000	25,000	-	-	-
AEZ: LM3: Cotton zone	5,000	5,000	8,000	16,000	-	-	-
S. NYANZA							
AEZ: LM1: Sugarcane zone	5,000	6,000	10,000	26,000	0%	19%	81%
AEZ: LM2: Marginal sugarcane zone	6,000	6,000	10,000	30,000	-	-	-
AEZ: UM2-3: Coffee zone	8,500	4,000	8,000	2,000	-	-	-

Table 3. Sweet potato yields, yield potentials and disposal for Rift Valley, Province of Kenya.

Districts	Yield kg/ha				Disposal %		
	Without Fertil-izer	Level I	Level II	Level III	Market-ing Board	Local Market	Home Consumption
BARINGO							
AEZ: UM3: Marginal coffee zone	7,000	8,000	10,000	22,000	-	-	-
AEZ: UM4: Sunflower, maize zone	4,000	4,000	7,000	16,000	-	-	-
MARAKWET							
AEZ: UM4: Sunflower, maize zone	6,500	5,000	7,000	16,000	-	-	-
WEST POKOT							
AEZ: UH1: Sheep Dairy zone	5,000	-	6,000	10,000	0%	50%	50%
TRANSNZOIA							
AEZ: UM2: Coffee zone	5,000	-	8,000	20,000	-	-	-
AEZ: UM3: Marginal coffee zone	4,000	-	5,000	16,000	-	-	-
KERICHO							
AEZ: UM1: Coffee, Tea zone	8,000	5,000	10,000	30,000	0%	41%	59%
AEZ: UM2: Coffee zone	7,000	2,500	8,000	25,000	-	-	-
AEZ: UM3: Marginal coffee zone	5,000	2,000	6,000	18,000	-	-	-

Table 4. Sweet potato yields, yield potentials and disposal for Central Province of Kenya.

Districts	Yield kg/ha				Disposal %		
	Without Fertil-izer	Level I	Level II	Level III	Market-ing Board	Local Market	Home Consumption
KIRINYAGA							
UM1: Coffee, Tea zone	8,500	8,000	20,000	40,000	0%	50%	50%
AEZ: UM2: Main coffee zone	7,000	8,000	18,000	35,000	0%	50%	50%
UM4: Sunflower, maize zone	4,000	3,000	6,000	10,000	-	-	-
UM3: Marginal coffee zone	5,000	-	6,000	12,000	-	-	-
UM4: Sunflower, maize zone	5,000	4,000	6,000	8,000	-	-	-
AEZ: LM3: Lower Midland cotton zone	3,600	4,000	8,000	12,000	-	-	-
LM4: Marginal cotton zone	4,000	3,000	6,000	7,000	-	-	-
NYERI							
AEZ: UM4: Sunflower, maize zone	4,000	2,500	5,000	7,000	0%	45%	55%
AEZ: UM1: Coffee, Tea zone	7,500	6,000	15,000	35,000	0%	100%	0%

Table 4. (continuation)

Districts	Yield kg/ha				Disposal %		
	Without Fertil-izer	Level I	Level II	Level III	Market-ing Board	Local Market	Home Consumption
UM2: Main coffee	6,000	6,000	15,000	32,000	-	-	-
MURANGA							
AEZ: UM4: Sunflower, maize zone	4,000	2,500	5,000	8,000	-	-	-
AEZ: UM1: coffee, tea zone	7,000	8,000	14,000	35,000	-	-	-
UM2: Main coffee	7,000	8,000	15,000	30,000	-	-	-
KIAMBU							
AEZ: UM1: Coffee tea zone	5,000	7,000	14,000	30,000	40%	50%	10%
AEZ: UM2: main coffee zone	8,000	8,000	16,000	30,000	-	-	-

RECENT RESEARCH ON SWEET POTATO IN MOZAMBIQUE

H. Jimenex, W. Helmskenk, E. Nunes[1]

1. SUMMARY

A general description of Sweet Potato production in Mozambique is presented relating to the principal constraints affecting yield production; a research program with the objective to improve yield production is delined, and the results discussed.

2. BACKGROUND

In Mozambique, Sweet Potato is a crop of the small scale farmers; it is grown throughout the country in small plots of 150-200 m^2.

The area actually occupied by sweet potato represents only 2% of that covered by cereals; in comparison to cereals production root and tuber production is about 10-15h.

Sweet potato is a security source of energy for the peasant, because when the maize from the first harvest finishes and that one from the second crop is not yet available, sweet potato is utilized. However, the foliage is eaten all over the year as a vegetable.

Nowadays because of the increasing of small animals production the foliage has been utilized also for feeding.

Seldom sweet potato is grown for marketing in the urban areas, being prices quite expensive; usually it is grown for self-sufficiency.

3. SWEET POTATO RESEARCH PROGRAM

Since sweet potato is an important source of energy and it can produce carbohydrates easier than the cereals, the government has been making efforts to increase root and tuber production in Mozambique.

In 1982 it was started our cooperation with IITA which has provided germplasm as well as training facilities.

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In 1983 the Farming System Research team from IITA, started working in Chokwe region mainly on rice, maize, sweet potato, cowpeas, and cassava.

This region has an irrigation scheme for 20,000 ha mainly for rice production in the hot season and maize on cold season: 9500 ha belong to the smallholders (0.5 ha per family), 3500 ha to the private and cooperative farms and 7000 to the State Farms. 20% of this area is not suitable for rice production but for maize which is grown twice a year intercropped with cowpea in summer and Phaseolus neulgario in winter.

With the purpose to study the main constraints on production in the region a procedure was established:

1st stage - Diagnosis
2nd stage - Collection of local and introduced germplasm on station trials.
3rd stage - On farm trials
4th stage - On farm demonstration
5th stage - Multiplication and distribution of planting material

3.1. 1st Stage - Diagnosis

Based on an informal enquiry 30 peasants were enquired in the region. Later on a formal enquiry was done for 150 peasants: 80% in the first year and 70 in the second year. A 5 x 5 m square was instaled in every farm in order to get information about the production.

This system provides information on:

- soil preparation
- plant density
- methods of planting
- pests and disease attack
- intercropping
- planting time
- harvesting time
- flooding
- weed control
- yield production
- maturity

Only the most important aspects will be analyzed in this paper.

The peasants know very well the germplasm they use to grow even when it is mixed with each other in the field; its eating quality both the foliage and the tubers as well as its susceptibility to the environmental conditions.

Usually 4000-55000 holes/ha are used, planting 5 branches per hole in order to get a high standability.

The maturity ranges from six to eight months with two planting dates per year: August and February.

The average yield is about 4t/ha with the local germplasm, however some varieties are grown just for the vegetable green type being the yield production scarce or nule.

Flooding and excess of moisture during the rainy season decrease yield production.

Relating to Plant Protection aspects not enough work has been done because of lack of expertize people, however it seems that pests are not a major constraint, even weevil attack be present. Virus infestation is highly spread affecting mainly local germplasm and recently also an IITA variety-TIB 2532. A tentative visual screening was done in some varieties and a trial has been planted to compare the effect on the yield, on plots with and without symptoms.

3.2. 2nd Stage - On Station Trials

Three sets of trials were carried out in the research station:

- One with 8 local varieties (Annex 1)
- Two with 19 varieties from IITA and local variety (Annex 2)
- Four with 20 IITA varieties and 5 local varieties (Annex 3)

The first two sets of trials (Annex 1 and 2) in the period March 84 - April 85, 4 replications, 4 rows 5 m long per plot, 2 branches per hole on a Randomized Plots design (4).

The last four trials on a lattice 5 x 5 design, 3 replications, 4 rows 5 m long per plot; 2 branches per hole, evaluated during May 85 up to July 87.

A field genebank of 60 accessions was established, it is being characterized and maintained. (Annex 4).

The experimental trials were conducted in the same way as the smallholder's, i.e. with neither fertilizer non pesticide application and with irrigation.

The selection criteria utilized were based not only on yield production but also on eating quality, resistance to pests and diseases and acceptance by the peasants.

Two local varieties were identified: Mudrenca 10.8 t/ha and Thuluthulu 7.0 t/ha (Annex 1).

Four IITA varieties were also identified with superior yields - from 19.25 up to 27.53 t/ha, however only one was selected - INIA 39 (with red skin, white flesh, low fiber content) (Annex 2).

Twelve IITA varieties have yields from 29.9 up to 38.3 t/ha, having been selected four. This was a new material received from IITA and very much interesting for our collection: higher yields, big diversity with respect to leaves shape, size shape and color of the tubers. Also 2 each varieties were selected (Annex 3).

Variety	Yield t/ha	Skin colour	Flesh colour
INIA 4	38.3	Pink	White
INIA 3	38.2	Red	White
INIA 14	35.3	Red	Orange
INIA 18	34.9	Red	White
INIA 10	29.9	White	White
Chiandzelate	13.5	Red	Cream
Thulunthulo	12.4	White	White

Field a germplasm collection:

Within the 60 accessions, 25 are local varieties and 34 from IITA (Annex 4). Fertilizer has been applied for planting material production. Some varieties from IITA have reached 60, 70, and 90t/ha with the application of 30 kg/ha of N.

3.3. 3rd Stage - On Farm Trials

On the basis of the results we have got from the previous trials 37 on farm trials were conducted, with 6 superior varieties, two of which locals: 12 in 1985, 15 in 1986, and 10 in 1987. (Annex 5).

Four rows of each variety were planted with two branches per hole, on rows 4-6 m long depending on the area of the farmers. The trial management was done by the farmers, representing each farmer one replication.

Differences were found when compared yields on trials carried out on stations and on farm, because a better water and weed control was done.

3.4. 4th Stage - On Farm Demonstration

After 3 years of on farm trials, with the collaboration of the extension services 40 demonstration plots have been installed.

In every demonstration about 50 farmers have collaborated on planting and harvesting. At harvesting time the tubers were placed in front of its foliage. The superiority of the varieties was so evident that it was not necessary to weight. Instead of that the farmer started fighting to get planting material from the selected materials.

INIA 3, 18, and 10 have been selected by the farmers.

3.5. 5th Stage - Multiplication and Distribution of Planting Material

A program for multiplication of planting material has been started on 2 locations (Chokwe and Umleluzi) for later distribution.

Recently the selected material has been evaluated also in other location of the country, however just a few data are available at the moment (Annex 6).

4. HUMAN RESOURCES

Actually four technicians have been trained by IITA on Root and tubers production: one diploma working on Cassava and 3 of 6th class on Sweet Potato.

An agronomist has been requested to join the program to work on plant protection aspects.

5. FUTURE LINES OF WORK

The program will be expanded around the country including also sandy soils. Agronomic aspects related to pests and disease evaluation, fertilizer effect and post harvest losses will be studied.

The planting material multiplication program will be financed by FAO for later distribution on different areas of the country.

6. INTERNATIONAL COOPERATION

We have to regret the support received from IITA on providing germplasm and on training facilities.

However, virus incidence studies have to be covered; an appeal to the organizers is made in order to support our national program.

7. QUARANTINE

A project for reabilitation of our Quarantine facilities is being financed by DANIDA. In the meanwhile no special Quarantine work has been done in the country.

Annex 1

8/84 Variety	4/85 yield t/ha
Mudranca	10.8
Thulothulo	7.0
Branca	6.6
Chiandzadlala	4.2
Manhica	4.2
Nwadzubzuane	4.1
Kuasimono	4.0
Mukolonhi	3.5

Annex 2. Average yield of 19 varieties

Variety Name	Trial 1 t/ha	Trial 2 t/ha	x t/ha	Green matter t/ha	Dry matter t/ha
INIA 39	27.0	28.0	27.5	25.6	3.2
INIA 41	25.1	29.0	27.0	23.3	2.4
INIA 40	20.0	19.8	24.4	28.8	3.7
INIA 44	17.9	20.6	19.2	28.2	3.5
INIA 36	7.9	6.0	6.9	24.3	4.5
INIA 45	11.9	1.6	6.7	32.5	3.3
INIA 46	2.3	11.0	6.6	27.6	3.8
INIA 33	10.3	2.8	6.5	37.6	5.3
INIA 35	8.3	3.7	6.0	26.9	3.8
INIA 42	6.5	4.5	5.5	31.3	4.8
INIA 43	2.4	7.8	5.1	36.6	5.0
INIA 38	4.1	4.0	5.0	28.7	4.0
INIA 31	8.5	0.8	5.5	34.8	4.6
INIA 29	5.4	3.3	4.3	26.3	3.6
INIA 32	5.3	2.9	4.1	47.4	4.0
INIA 37	4.9	2.3	3.0	22.9	2.6
INIA 27	1.8	4.1	2.9	33.7	4.8
INIA 28	2.9	1.4	2.1	45.5	4.7
INIA 34	3.1	0.9	2.0	28.2	4.0
THULOTHULO		13.0	13.0		

Trial 9.4 - 11/84
Trial 2 - 11/84 - 5/85

Annex 3.

Variety name	Trial 1 (t/ha)	Trial 2 (t/ha)	Trial 3 (t/ha)	Trial 4 (t/ha)	X (t/ha)
INIA 4-TIS 1487		43.8	40.2	30.9	38.3
INIA 3	32.8	37.2	52.1	30.7	38.2
INIA 14	27.9	31.9	44.0	17.4	35.3
INIA 18	34.9	31.0	50.5	23.4	34.9
INIA 5-TIS 2498	31.0	27.6	57.6	23.5	34.9
INIA 16	32.5	24.8	57.8	21.9	34.2
INIA 13	25.6	29.6	51.5	22.3	32.2
INIA 1-TIB9	23.3	16.6	60.2	27.5	31.9
INIA 6-TIS 2534	25.9	35.8	41.6	20.5	30.9
INIA 41	26.6	38.2	37.1	20.2	30.5
INIA 2-TIB 10	19.1	27.3	43.0	31.0	30.1
INIA 10-TIS 9262	28.5	41.8	22.5	27.0	29.9
INIA 7-TIS 2544	24.7	14.3	47.5	24.5	28.2
INIA 9-TIS 3290	21.5	41.1	34.8	13.1	27.6
INIA 12	15.6	31.1	35.6	24.3	26.6
INIA 15	23.4	19.5	43.8	16.8	25.8
INIA 11	23.9	24.0	35.0	20.1	25.7
INIA 8-TIS 3017	19.3	27.2	33.9	19.0	24.8
INIA 39	25.9	11.1	23.6	18.9	19.8
MUKOLONHI	-	3.2	29.4	13.4	15.3
CHIANDZADLALA	16.0	6.1	18.5	13.5	13.5
INIA 44	17.4	7.6	17.7	9.8	13.1
THULOTHULO	17.0	6.4	22.7	3.7	12.4
MWAZUBZUANE	-	2.0	28.7	6.0	12.2
MUDRENCA	13.2	2.1	20.0	5.9	10.3

Trial 9: 5/85; Trial 2: 11/85; Trial 3: 5/86; Trial 4: 12/86
9/85 5/86 11/86 7/86

Annex 4. Germplasm Collection

	Variety Name	Yield (t/ha)		Variety Name	Yield (t/ha)
1.	INIA 18	61.2	30.	THULOTHULO	13.3
2.	INIA 14	60.9	31.	MUKOLONHI	12.9
3.	INIA 5-TIS 2498	56.5	32.	NWADZUBZUANE	12.8
4.	INIA 10-TIS 9265	55.9	33.	KWAXIMOWO	12.5
5.	INIA 3-TIB 2532	50.2	34.	LOCAL CKOKWE 2	10.5
6.	INIA 7-TIS 2544	47.9	35.	INIA 32	9.0
7.	INIA 13	47.5	36.	CHIPONI	8.6
8.	INIA 17	45.0	37.	LOCAL CHOKWE 3	7.9
9.	INIA 6-TIS 2534	44.2	38.	MHARACO	7.5
10.	INIA 12	43.4	39.	INIA 33	7.4
11.	INIA 14	39.5	40.	INIA 31	6.7
12.	INIA 2	36.9	41.	VIRGINIA	6.6
13.	INIA 4	35.5	42.	INIA 42	6.4
14.	INIA 44	34.7	43.	BSWABA	6.1
15.	INIA 37	31.8	44.	LIDLELO	6.0
16.	INIA 15	30.8	45.	CHIANDZADLALA	6.0
17.	INIA 41	29.9	46.	TECA	5.3
18.	INIA 9-TIS 3290	29.0	47.	INIA 38	5.3
19.	INIA 39	27.9	48.	BASSA	5.2
20.	INIA 1-TIB 9	27.7	49.	MATUBA 3	4.1
21.	INIA 11	27.5	50.	INIA 46	4.0
22.	INIA 8-TIS 3017	25.0	51.	MANCHICA	2.9
23.	INIA 34	22.1	52.	LOCAL CHOKWE 4	2.8
24.	THULO THULO	19.2	53.	LOCAL CHOKWE 5	2.5
25.	CHIANDZADLALA	18.5	54.	MATUBA 1	2.0
26.	MUDRENCA	18.1	55.	MATUBA 2	2.0
27.	LOCAL CHOKWE	17.3	56.	INIA 45	2.0
28.	INIA 43	17.2	57.	LOCAL CHOKWE 6	1.5
29.	INIA 35	13.4	58.	LOCAL CHOKWE 7	1.4

Annex 5. On Farm Trials - 12 trials (3.85-9-85)

Variety	Yield (t/ha)
INIA 39	14
INIA 41	9.8
INIA 40	8.3
CHIANDZADLALA	7.5
THULOTHULO	6.9
INIA 44	6.8

Variety	Yield[1] (t/ha)	Yield[2] (t/ha)	X (t/ha)
INIA 3	27.4	18.3	22.8
INIA 10	20.2	20.3	20.2
INIA 18	26.7	17.3	20.0
INIA 39	21.8	14.3	18.0
THULOTHULO	12.1	4.6	8.3
CHIANDZADLALA	10.8	3.6	7.2

[1] 3-9/86 - 15 Trials

[2] 1-7/86 - 10 Trials

Annex 6. Variety trial - Umbeluzi (12.85-6.86)

Variety Name	Yield (t/ha)
INIA 10 - TIS 9265	25.6
INIA 5 - TIS 2498	24.0
INIA 1 - TIB 9	23.3
INIA 2 - TIB 10	23.3
INIA 7 - TIS 2544	22.0
INIA 3 - TIS 2532	20.7
INIA 4 - TIS 1487	19.9
INIA 8 - TIS 3017	19.8
INIA 9 - TIS 3290	19.5
INIA 6 - TIS 2534	18.9
PIERRE	13.3
UMBELUZI 2	12.5
UMBELUZI 1	12.3

DEVELOPPEMENT ET AMELIORATION DE LA PRODUCTION DE LA PATATE DOUCE AU RWANDA

Ndamage, G.[1]

1. IMPORTANCE DE LA PATATE DOUCE

Le Rwanda, petit pays d'une étendue de 26,100 km^2 (230 hab./km^2) avait au début de 1987 une population de 6,5 millions d'habitants dont 95% s'occupe de l'agriculture. Aussi la priorité du développement national est-elle accordée au secteur agricole.

Au cours de la dernière décade l'agriculture vivrière rwandaise est dominée par 6 cultures (tableau 1) dont la patate douce et le haricot constituent la base du régime alimentaire. La patate est cultivée presque exclusivement pour l'alimentation humaine.

La ration alimentaire quotidienne en milieu rural comprend une composante à base de tubercule le plus fréquent étant la patate douce surtout en moyenne et basse altitude.

Cultures	1984	1985	Energie % du total	Protéines % du total
Bananes	1,982,287	2,193,841	19.2	5.9
Haricots	256,504	278,287	19.8	48.6
Pois	16,905	19,039	1.3	3.3
Arachide	14,716	16,260	1.0	1.7
Soja	4,458	4,926	0.4	1.3
Sorgho	171,057	158,878	16.9	15.1
Maïs	111,475	135,803	9.3	9.4
Froment	3,148	3,834	0.2	0.3
Patate douces	730,927	861,904	19.9	10.0
Pomme de terre	251,372	241,466	3.6	2.9
Manioc	324,208	361,899	8.4	1.6
Total	3,867,057	4,250,617	100.0	100.0

Source: MINAGRI: ENA: 1984 et 1986.

[1]ISAR, Rubona.

Selon le Miniplan, l'importance de la patate douce a pris un développement remarquable au Rwanda entre 1965-1983, avec une augmentation annuelle de 7% en superficie cultivée et de 9% en production.

Relativement aux autres cultures vivrières, sa production s'élevait à 8% en 1966, à 14% entre 1968-1973 et à 20% entre 1974-1983. Au cours de cette dernière décade, la superficie et passée de 81.667 ha à 112,080 ha et la production de 612,230 T à 923,000 T. La tendance observée au cours de cette dernière décade se confirme en 1986 où la patate douce reste le premier fournisseur d'énergie; elle est suivie de près par le haricot, la banane et puis le sorgho. Malgré sa teneur en protéines faible (1.6%) le volume total élevé de la patate douce lui permet de produire 10% du total des protéines fournies à la population par les cultures vivrières. D'après le Minagri, sur un total de 1.5 million de tonnes produites en 1986 par les plantes à racines et tubercules amylacés, la patate douce a fourni 59% de la production, 62% d'énergie et 49% de la valeur monétaire agricole (tableau 2).

Tableau 2. Production (en Tonnes) de la patate douce par Préfecture en 1986.

	Patate douce	% du total	Manioc	% du total	Pomme de terre	% du total
Butare	152,320	17.7	81,321	22.5	4,893	2.0
Byumba	89,224	10.4	8,839	2.4	12,668	5.2
Cyangugu	37,215	4.3	27,210	7.5	4,515	1.9
Gikongoro	103,853	12.0	21,276	5.9	4,034	1.7
Gisenyi	62,079	7.2	14,676	4.1	54,133	22.4
Gitarama	98,608	11.4	99,323	27.4	6,148	2.5
Kibungo	52,575	6.1	22,168	6.1	1,586	0.7
Kibuye	67,524	7.8	10,657	2.9	22,372	9.3
Kigali	91,019	10.6	70,919	19.6	3,277	1.4
Ruhengeri	107,487	12.5	5,510	1.5	127,839	53.0
Total	861,904	100	361,899	100	241,466	100

Ce tableau qui compare la production des tubercules montre que la patate douce, le manioc, et la pome de terre fournissent respectivement 59%, 25% et 16% de la production totale des tubercules.

Au cours de la décade 1973-1983 le rendement moyen national était d'environ 8T/ha et la consommation annuelle par habitant de 122 kg. En 1986, la patate douce a eu une énorme contribution à l'alimentation de la population par un apport énergétique, protéique, lipidique évalué respectivement a 20%, 10% et 13.6% de la valeur nutritive totale.

2. SYSTEMES DE CULTURES

La patate douce vraissemblablement introduite au Rwanda au 18ème. siécle s'est largement répandue dans le pays et s'est bien adaptée au système de production du paysan. Beaucoup d'introductions variétales eurent lieu à partir des pays limitrophes principalement à partir de l'Uganda; une collecte des variétés locale effectuée récemment en 1983 à pu rassember 270 variétés locales.

En ce qui concerne le systéme de culture, d'après une enquête menée en 1984 (Alvarez, Ndamage) la patate douce est généralement plantée sur des friches ou après une courte jaachère d'une seule saison. La majorité des agriculteurs préparent en marais de gros billons de 1 à 3 m de large et sur colline des buttes ou des billons d'environ 50 cm de hauteur. Certains plantent à plat sur les grosses pentes des collines argileuses (ferrisols) surtout dans les préfectures Kibuye et Ruhengeri.

La saison de plantation s'étend en général d'octobre à mars sur colline. Les agriculteurs ayant accès à des parcelles hydromorphes en marais peuvent cultiver la patate douce dans la vallée au cours des mois de mai et juin. La méthode de plantation largement répandue consiste à couper les cordes en boutures de 30-40 cm qui sont plantées deux par poquet à tres forte densité. Le paquet est fait à la houe et les boutures y sont placées de façon à ce que un petit bout dépasse de chaque côté une fois les boutures recouvertes de sol. On pense que la plantation traditionelle dense (17 boutures/m^2) de boutures de plusieurs clones (de 2 à 6) en mélange sert de mesure de réduction de risques et de prévention contre les contraintes biophysiques.

Seuls les paysans de l'Est du pays en préfecture Kibungo utilisent des boutures apicales à une densite moins élevée Plus de 97% des agriculteurs n'utilisent pas de engrais sur la patate douce. Seulement 26% des agriculteurs sarclent le champ une seule fois, la majorité ne sarclent jamais. La patate douce est plantée en culture pure ou en association avec d'autre cultures.

Gashumba (1982) rapporte que les associations avec la patate douce dans les régions agricoles de l'Imbo, Crête Zaïre-Nil, Dorsale granitique varient entre 10-12% de toutes les associations. Des associations sont beaucoup plus élevées en marais dans certains régions. Elles atteignent 40% pour les associations patate douce - haricot et 53% pour les associations patate douce - colocasse. En général 30% de la patate douce est cultivée en association avec le haricot, maïs et sorgho sur colline. Délepierre confirme les associations de patate douce à 35%.

Parmi 270 variétés locales collectées en 1983, Nsasagatebo, Gahungezi et Wadada sont les plus populaires.

La plupart des agriculteurs font leur première récolte après 4 mois mais il y en a qui n'hésitent pas à récolter après 3 mois en période de disette. Vu la différence entre les cycles de croissance de divers clones cultivées en mélange, seules quelques variétés précoces peuvent donner un bon rendement lors de récolte prématurée. Parfois la récolté s'échelonne jusqu'a 6 ou 8 mois. La patate douce est une plante vivrière de subsistance, cultivée essentiellement pour nourrir le ménage; elle se conserve dans le sol et se récolte au fur et à mesure des besoins de la famille. Environ 12% de la récolte sont commercialisées.

Les rendements obtenus en milieu rural sont variables surtout en fonction de la nature du sol, des variétés et du climat. Le rendement moyen obtenu en 1984 était de 12T/ha en champ d'agriculteurs dans une fourchette variant de 4 T à 32 T/ha (Alvarez et Ndamage, 1984).

3. ZONES DE PRODUCTION

Bien qu'une visite sur le terrain montre que la patate douce est largement cultivée au Rwanda, jusqu'à une altitude de 2300 m, certaines régions agricoles produisent beaucoup plus que d'autres surtout en raison des conditions écologiques de la région principalement la température, la pluviométrie et la nature du sol.

Le tableau ci-après donne pour l'année 1984 la situation des superficies et des productions de la patate douce dans les différentes régions agricoles du Rwanda.

Tableau 3. Caractéristiques des régions agricoles du Rwanda, situation des superficies et production de la patate douce en 1984.

Région	Altitude	Pluviosité (mm)	Sols	Valeur Agricole	Situation de la patate douce Anée 1984		
					Superficie (ha)	Productions (tonnes)	Rendement (T/ha)
1. IMBO	970-1100-1400	1050-1200-1600	Sols alluvionaires	Excellent	231	1,300	5.6
2. IMPIRA	1400-1700-1900	1300-1400-200	Sols rouges lourds dérivés de basaltes	Bonne	1,434	13,878	9.7
3. BORDS DU LAC KIVU	1460-1600-1900	1150-1200-1300	Sols limonoargileux superficiels	Excellent (Bugoji-Kanage) bonne ailleurs	2,904	33,841	11.7
4. TERRE DE LAVE	1600-2200-2500	1300-1500-1600	Sols volcaniques	Excellent	830	7,400	8.9
5. CRETE ZAIRE-NIL	1900-2100-2500	1300-1600-200	Sols humifières acides	Moyenne	20,663	131.820	6.4
6. BUBERUKA	1900-2000-2200	1100-1200-1300	Sols, latérisés d'artitude	Bonne	19,297	105,447	5.5
7. PLATEAU CENTRAL	1500-1700-1900	1100-1200-1300	Sols humifières divers	Bonne	26,269	214,285	8.2
8. DORSALE GRANITIQUE	1400-1600-1700	1050-1100-1200	Sols légers, graveleux	Moyenne	7,462	82,909	11.1
9. MAYAGA	1350-1450-1500	1000-1050-1200	Sols argileux derivés de shistes	Très bonne	2,351	32,268	13.7
10.BUGESERA	1300-1400-1500	850-900-1000	Sols argileux fortement altérés	Pauvre	2,218	17,657	8.0
11.PLATEAU DE L'EST	1400-1500-1800	900-950-1000	Sols latérisés	Moyenne au Nord bonne au Sud	9,586	76,036	7.9
12.SAVANE DE L'EST	1250-1400-1600	800-850-900	Vieux sols de texture variable	Très pauvre	1,138	14,084	12.4

Il ressort de ce tableau que les régions de moyenne-base altitude (Pleateau Central, Dorsale granitique, Mayaga, Busesera, Plateau de l'Est, Savanne de l'Est) c-a-d le Centre, une partie du Sud et l'Est du pays totalisaient 52% des superficies et 60% de la production en 1984.

Le rendement y est de 114% du rendement moyen général. Bien que la production totale soit relativement élevée, la patate douce est cultivée exclusivement pour l'alimentation humaine. Elle est bouillie dans l'eau dans les campagnes tandis que dans villes elle est bouillie ou parfois consommée sans forme de frites.

La transformation des tubercules en d'autres produits n'existe pas encore mais la chute des prix dans les périodes de suproduction fiat sentir les besoins de transformation.

Il a été souligné plus haut que la patate douce a une grande importance économique comme aliment de base de la population puisqu'elle constitue une grande source de calories. Des enquêtes effectuées montrent qu'environ 10% de la récolte sont commercialisées et constitue donc une source de revenue pour la population. La patate douce est commercialisée pratiquement sur place sauf dans la préfecture de Gitarama où commerçants, restaurateurs et gérants des établissements publics de Kigali surtout vinnent s'approvisionner par grandes quantités.

A l'horizon de l'an 2000, le Plan Quinquennal de Développement reconnaît l'importance de la patate douce comme aliment de base et prévoit une augmentation de la superficie de 10%, du rendement moyen de 50% et de la production nationale d'environ 70%. Cela suppose la conjuguaison des effort de la recherche, la vulgarisation et l'amélioration des facteurs de production.

4. PRODUCTION DE SEMENCES, GERMOPLASME ET VARIETES

Chaque année on dispose d'un champ de multiplication totalisant environ 4 ha aux stations de Rubona et de Karama où l'on trouve environ 5 ou 6 variétés proposées pour la diffusion, adaptées aux principales zones agro-écologiques du pays, 4 ha peuvent fournir environ 40 ha après 3 coupes réalisables au cours d'une année.

Cette quantité de boutures est généralement destinée aux projects agricoles qui établissent eux-mêmes leurs champs de multiplication avant la distribution aux paysans. Actuellement un petit project basé à Rubona s'occupe exclusivement de la multiplication de boutures à distribuer aux projets agricoles et aux agriculteurs.

Des variétés de patate douce à rendement élevé ont été identifiées parmi les variétés locales, exotiques ou parmi les nouvelles sélections. Ces variétés ont été vite multipliées et distribuées aux projets agricoles: en 1985 par example, 4,020 bottes de patate douce, contenant chacun 500 boutures apicales ont été distribuées aux projets agricoles pour multiplication. En 1987, plus de 500 bottes ont été distribuées aux projets agricoles.

Des clones de patate douce précoces à production stable ont été récemment identifiés, il s'agit de K 51/3261, Mugande, Karebe II, Muvatori I qui viennent compléter la liste des clones locaux ou exotiques de production stable connue (Rusenya, Nsasagatebo, TIS 2544 Rutambira, N. mujuna).

Ces variétés donnent de bons rendements et présentent une bonne tolérance à l'alternariose et à la virose de la patate douce. Des progrés substantiels ont été réalisés dans l'identification des sources de matériel de patate douce précoce, à haut rendement et résistantes aux maladies.

Cependant, malgre l'utilisation des insecticides pour réduire la population des vecteurs de virose, malgré les techniques d'indexage pour identifier les boutures saines, des cas de virose sont toujours observés après la première coupe de boutures.

Les boutures qui rejettent des souches montrent souvent des symptômes de virose qui sont parfois sévères.

Le germoplasme qui compte actuellement 230 clones se maintient difficilement en champ à cause des attaques d'alternariose et de viroses surtout en saison sèche.

Pour les techniques culturales, les boutures apicles de patate douce ont prouvé leur supériorité de production, tandis que le niveau de fumure de 35 T/ha de fumier seul ou complémenté de NPK 40-50-100 est considéré comme optimal en cas de faible fertilité du sol.

Les tests de dégustation et les essais en milieu rural ont permis de vérifier le refus ou l'acceptation des nouvelles variétés et nouvelles techniques culturales.

5. MALADIES ET PARASITES

Les maladies les plus importantes au Rwanda sont le complexe viral et l'alternariose tandis que les parasites les plus fréquents sont les charançcons et les chenilles défoliantes.

L'enquête effetuée en 1984 dans 8 régions agricoles à patate douce a montré que la pourcentage de champs montrant les symptôme de maladies est elevé: 68% pour l'alternariose, 57% pour la virose, 42% pour les chenilles (en début de saison sèche), 31% pour les charançons, 28% pour l'érinose et 4% pour la pourriture racinaire.

L'ampleur des dégâts dépend principalement de la nature du sol et de la sensibilité des variétés utilisées. Les nématodes ne semblent pas être connus dans le pays sur les plantes à racines et tubercules.

5.1. Complexe Viral

La virose, qui apparait sous forme de complexe, transmise principalement par la mouche blanche (*Bemisia tabaci*) et le puceron vert (*Aphis* sp.) est actuellement la maladie la plus importante de la patate douce au Rwanda.

Parfois le complexe viral reste masqué lorsque la plante pousse dans un sol très riche en matière organique alors que les symptômes sont bien accentuès dans des sols pauvres en éléments minéraux. La maladie réduit le développement végétatif des plants dont la production devient quasi nulle en cas d'atteinte grave.

On ignore quand ce complexe viral de la patate douce est apparu au Rwanda, probablement qu'il est arrivé avec l'introduction de celle-ci dans le pays, vraissemblablement au 18ème siecle.

Les dégâts les plus sévères sont observés dans les régions sèches du Nord-Est de l'Est du pays où la population de la mouche blanche est la plus abondante. La mouche blanche et le puceron vert sont également présents dans le reste du pays mais le facteur qui perpétue davantage la maladie et l'utilisation comme semence de boutures malades provenant souvent de clones susceptibles.

Plusieurs variétés populaires quant à leur goût et leur production collectées dans le pays et testées en station se sont montrées sensibles à la virose et commencent à disparaître. Parmi 270 clones locaux introduits en 1983, environ 25% d'entre eux étaient résistants à la virose mais ne l'étaient pas toujours pour l'alternariose ou avaient une faible production.

Après plusieurs criblages, les clones suivants ont été reconnus résistants au complexe viral: il s'agit de variétés locales, Mugande, Karebe, Kijanja II, Muvatoro, Rutambira, N. marebe, (Kalibunduki, N. gacakanyuzi), Rusenya, Nsenge, Gakoba, Rukubinkondo de l'hybride Caroline lee 1666-3-1049 et des variétés exotiques Caroline lee et TIS 2498.

Les clones résistants à la virose enrichissent continuellement les blocs de croisement. Les graines obtenus donnent naissance à des familles de demi-soeurs et des vrais soeurs qui sont observées et éliminées en cas de sensibilité à la virose. Le criblage pour la résistance aux maladies continue de saison en saison à partir du champ de sélection, des essais de rendement préliminaire, avancé ou uniforme jusqu'aux essais comparatifs multilocaux.

Quelques dégâts de virose sont observés aux premiers stades de sélection, mais à partir des essais de rendement avancé le nombre de clones susceptibles diminue à tel point que les clones composant les essais comparatifs multilocaux montrent généralement peu de symptômes de cette maladie. Néanmoins cela n'a pas empêché que quelques clones manifestent dans la suite une sensibilité graduelle au cours du temps. L'évaluation du comportement des descendants a fourni de meilleures informations sur le potentiel génétique en matière de résistance à la virose.

5.2. Alternariose

A part la virose, la seconde maladie qui fait le plus de dégâts à la patate douce est l'alternariose transmise par Alternaria solani à laquelle on a souvent donné le nom d'anthracnose en raison de ses symptômes qui le rappelent. L'enquête conduite au Rwanda en 1984 a montré que l'alternariose est la seconde maladie en importance car 68% des champs visités en milieu rural ont montré des dégâts d'alternariose.

Dans une collection de 270 variétés locales introduites en 1983, 19% d'entre elles se sont montrées résistantes à l'alternariose. Les variétés Rusenya, Rutambira, Myiramarebe, Nsenge et Gakoba sont révélées particulièrement résistantes à cette maladie.

Pour certaines variétés, il a été constaté que l'alternariose n'extériose les symptômes que lorsqu'elles sont plantées dans des sols pauvres tandis qu'en cas de bonne fertilité, les symptômes restent plutôt minimes. Des champs de patate douce installés dans des sols pauvres dégradés ont parfois accusé une telle gravité de symptômes d'alternariose qu'il n'y avait pas moyen d'y trouver une seule bouture saine utilisable comme matériel de plantation. Des études effectuées sur la collection locale ont montré que les variétés précoces sont plus sensibles que les variétés tardives.

Quand cette maladie intervient en pépinière de semenceaux en sélection, elle déssèche complètement les plantules et les familles susceptibles sont automatiquement éliminées. Les graines obtenues de 1983 à 1986 en provenance de Chine (AVRDC) et du Japon ont donné naissance à des familles de demi-soeurs qui se sont révélées toutes susceptibles à l'alternariose (dessèchement de tout le plant). Habituellement après la pépinière, les familles en champs de sélection ou en essai de rendement préliminaire qui montrent les symptômes sont vite extirpées.

5.3. Charançons

La sélection pour la résistance aux charançons de la patate douce est également importante. D'énormes pertes de tubercules occasionnées par les charançons pendant la saison sèche peuvent atteindre 50% pour les variétés sensibles et réduire ainsi la disponibilité de nourriture pour la population. Des pertes d'environ 10% seraient couramment enregistrées en milieu rural.

Bien que plusieurs espèces existent dans le pays, deux espèces, Cylas puncticollis et C. formicarius font le plus de dégâts. Des études sur le type de gènes impliqués dans la transmission de la résistance n'ont pas été faites. Cependant des tests de résistance variétale effectués dans les conditions sèches de la station de Karama ont indiqué 2 nouvelles sélections précoces Nsujira 1026 et Bukarasa 812, qui sont particulièrement résistantes aux charançons. Des variétés locales à cycle végétatif long (6 mois) possèdent également des gènes de résistance (Nsenge, Rusenya, Rukubinkondo, Gahungezi) tandis que d'autres manifestent une résistance moyenne (Nsasagatebo, Seruruseke, Rutambira).

Des introductions exotiques, qui ont une faible teneur en matière sèche et qui sont précoces, possèdent une grande susceptibilité aux charançons (TIS 2544, TIS 2498 et TIS 2534).

5.4. Chenilles Défoliantes

Les chenilles défoliantes (ou chenilles mineuses de feuilles) du papillon Acraea acerata causent de sérieux problèmes à la production de la patate douce en première saison sèche (fin décembre à mi-février) et en deuxième saison sèche (juin à mi-septembre). Ces chenilles répandues dans tout le pays, mangent complètement le limbe des feuilles à l'exception des nervures primaires et entravent ainsi le phénomène de la photosynthèse.

D'après les observations effectuées dans les essais variétaux multilocaux, la récolte d'un champ sérieuseent dévasté n'atteint même pas 1 tonne par hectare. Dans les conditions naturelles du champ, la variété Rutambira a semblé manifester une certaine tolérance.

Au début de cette année 1987, des chenilles défoliantes ont attaqué indistincttement environ 24,000 génotypes de patate douce composant le champ de sélection de la station Rubona. Il en fut de même d'un test de résistance effectué au laboratoire sur 6 variétés diffusées qui ont été toutes devorées de la même façon. Ceci laisse supposer qu'il sera probablement difficile de trouver un génotype naturellement résistant. La lutte mécanique et la lutte chimique seraient plus indiquées en attendant les résultats des criblages pour la résistance des nouveaux clones améliorés.

6. CONSERVATION, DISTRIBUTION, COMMERCIALISATION ET UTILISATION

Les tubercules de patate douce peuvent se conserver jusqu'à 12 mois dans le sol pourvu que la variété cultivée ne soit pas sensible aux charançons. Une fois la récolte effectuée, les tubercules se conservent dans les conditions du pays, pendant une semaine, puis commencent à pourrir, à germer ou à être attaqués par les charançons. La récolte est généralement consommée dans les 7 jours. L'agriculteur préfère conserver la patate douce dans le sol; il récolte au fur et à mesure de ses besoins. Presque tous les marchés locaux étalent des corbeilles pleines de tubercules de patates douces. Environs 10 à 12% de la production totale sont commercialisés mais la consommation est pratiquement locale, la patate douce faisant l'objet de faibles circuits de commercialisation sauf pour les marchés de la préfecture Gitarama qui approvisionnent la ville de Kigali ou les établissements publics. Les difficultés de conservation des tubercules limitent probablement les circuits de commercialisation, les commerçánts sachant qu'à partir du 3ème jour les tubercules ne seront plus appréciés par les consommateurs.

Jusqu'à présent, la patate douce ne connaît pas d'autre utilisation au Rwanda sinon qu'elle est mangée comme frite, bouillie dans l'eau parfois braisée par les enfants. Les tubercules farineux sont le plus appréciés.

Les tubercules sont rarement utilisés pour l'alimentation animale sauf s'il s'agit de déchets de tubercules ou des cordes de patate douce.

7. LEGISLATION PHYTOSANITAIRE

Les réglements de quarantaine sont d'une extrême importance si l'on veut limiter l'introduction de races de pathogènes ou de parasites qui font souvent plus de dégâts dans le nouveau milieu que dans leur milieu d'origine. L'importation ou l'exportation de denrées alimentaires dans le pays n'est soumise qu'au règlement douanier habituel d'importation ou d'exportation de marchandises. Quant à l'importation ou l'exportation de semences à des buts de recherche ou de production elle requiert un certificat

pytosanitaire qui prouve que la semence est indemne de maladies ou de parasites. Mais à proprement parler il n'existe pas encore de service phytosanitaire qui s'occupe de règlementation d'importation ou d'exportation de matériel végétal.

La libre circulation des personnes et des biens à la frontière et l'absence du service de quarantaine favorisent l'introduction dans le pays de semences contaminées.

8. PROGRAMME NATIONAL DE PATATE DOUCE INSTITUTIONS PUBLIQUES ET PRIVEES

8.1. Production

Il n'existe pas un programme national défini uniquement pour la production de la patate douce. Cependant le 3ème Plan Quinquennal Economique Social et Cultural avait défini come objectif d'atteindre pour la patate douce une superficie récoltée de 127,000 ha, un rendement de 10 T/ha et une production nationale de 1,270,000 T en 1986. A l'horizon de l'an 2000, on espère doubier ce dernier chiffre par une légère augmentation de la superficie cultivée et l'accroissement du rendement moyen à 15 T/ha.

Mais en dépit de cet objectif, la patate douce est en train de faire face à de nombreaux problèmes. La patate douce, en raison de sa rusticité, est souvent reléguée aux sols moins fertiles, le paysan étant loin de faire le moindre effort de fertilisation ou de sarclage sauf en cas de culture associées.

Les variétés cultivées en mélange par les agriculteurs possédent généralement un cycle végétatif long (6 mois) alors que la plupart des paysans commencent la récolte à 3 mois. La plantation est souvent tardive et dépasse parfois le mois de mai sur colline. Les épidémies de chenilles défoliantes surgissent en saison sèche. Les superficies des vallées réservées dans le temps à la culture de la patate douce diminuent progressivement parce qu'elles sont également utilisées pour d'autres cultures.

Suite à la saison sèche, le paysan manque du bon matériel de plantation au retour des pluies en octobre.

Compte tenu de tout ce qui précède et pour surmonter les difficultés susmentionnées, on compte mettre en vigueur le moyens suivants:

- Au niveau de la recherche, continuer à sélectionner des variétés précoces, résistantes aux maladies, à production stable.

- Multiplication rapide à superficie réduite (organiser des pépinières en début de saison sèche dans des marais, faire plusieurs coupes et jamais une seule) et distribution de variétés précoces au niveau de chaque secteur communal, a fin de fournir aux paysans du matériel de plantation au moment critique à la fin de la saison sèche.

- Respecter la date de plantation, éviter les plantation tardives sur colline au-delà du mois de mars.

- Epandre un peu de dumier ou du compost.

- En cas d'épidémie de chenilles défoliantes, revenir à la vieille pratique d'arrachage à la main de chenilles encore au stade grégaire pour freiner leur multiplication. Cette opération est facile et très rentable quand elle est synchronisée au niveau d'une région.

Par ailleurs, étant donné que la conservation est difficile, le paysan récolte au fur et à mesure des besoins. Aucune méthode de conservation n'est encore mise au point. La difficulté de conservation reste l'un des handicaps majeurs à la commercialisation.

9. VULGARISATION

Le Service Agricole chargé de vulgarisation a sa direction au Ministère de l'Agriculture, de l'Elevage et des Forêts. Ce service se subdivise, suivant les entités administratives existantes en 10 préfectures et en 141 communes ayant à sa tête un ou plusieurs agronomes chargés de l'organisation du service agricole et de la diffusion aux agriculteurs des informations et de leur formation dans le but d'améliorer leur production.

Le Service Agricole du Ministère d'Agriculture, de l'Elevage et des Forêts est aidé dans sa tache par des projets agricoles éparpillés sur tout le pays dont chacun a un objectif agricole bien précis.

Le pays compte environ une quarantaine de projets agricoles financés par des donateurs extérieurs; ils diffusent des intrants, procurent des services et des informations, assurent la formation des agriculteurs et organisent des concours agricoles pour récompenser les meilleurs producteurs. C'est dans ce cadre que rentre la diffusion des technologies concernant la patate douce. Il est entendu que un project agricole ne s'occupe pas d'une seule culture mais plutôt de toute une série de cultures majeures pratiquées dans la régions.

En ce qui concerne la production de boutures de plantation les projets agricoles s'en approvisionnent à l'ISAR, rarement au project "Service de Semences Selectionnées", service qui ne s'occupe pour le moment que de la production de semences de graines ainsi que de la pomme de terre. Les projets multiplient et fournissent à leur tour des boutures aux paysans.

En 1976, le Service de Semences Sélectionnées avait diffusé jusqu'alors 5,000 boutures de patate douce alors que les besoins du moment étaient estimés à 10 x 109 boutures (Nezehose, 1983).

Pour pallier à ce manque de matériel de plantation, un projet de multiplication de patate douce et de manioc est en place à l'ISAR Rubona depuis 1986, il multiplie et diffuse en grande quantité aux projets agricoles les boutures de patate douce et de manioc.

10. RECHERCHE SUR LA PATATE DOUCE

10.1. Objectifs

L'objectif global est d'assurer une meilleure sécurité alimentaire, une meilleure nutrition de la population et renforcer les capacités de recherche et de développement des technologies appropriées et la mise en place d'une équipe complète de scientifiques capables de faire face aux problèmes de production et de transformation des tubercules.

Les objectifs particuliers de la recherche de la patate douce sont constitués par:

- Développement de variétés précoces, de haut rendement en matière sèche et adaptées aux différentes zones agro-écologiques du Rwanda.
- Développement de variétés résistantes à l'alternariose (*Alternaria solani*), au complexe viral.
- Développement de variétés résistantes aux charançons.
- Amélioration des systèmes de production existants, étude des possibilités de conservation et de transformation et amélioration de la qualité alimentaire (technologie alimentaire).
- Transfert de technologies appropriées au système de production du paysan.
- Formation du personnel à intervalles réguliers pour renforcer les capacités de recherche du programme. Formation des techniciens de projets agricoles et formation de paysans par organisation des journées agricoles afin de mettre les producteurs au courant de nouvelles techniques de production du manioc et de la patate douce.

10.2. Activités Actuelles

10.2.1. Sélection

La majeure partie des travaux de recherche est consacrée à la sélection et à l'évaluation clonales.

10.2.1.1. Germoplasme

Maintien et enrichissement des collections de patate douce. Evaluation du germoplasme pour la résistance aux maladies et aux parasites.

10.2.1.2. Amélioration génétique

- Semenciers

Maintien et enrichissement de blocs de croisement contrôlé ou jardins semenciers à Rubona et Karama avec des clones précoces, résistants aux maladies et aux parasites, ayant du bon goût et adaptés aux différentes conditions écologiques.

De nouveaux blocs de croisement sont installés à Rubona et Karama au début de 1987 pour renforcer l'échange de graines de patate douce avec les pays du Réseau de Recherche sur les Tubercules en Afrique orientale et australe.

- Pépinière

Semis en pépinière à Rubona et Karama des graines récoltées dans le bloc de croisement ou importées.

- Triage des clones

Evaluation pour la résistance aux maladies et aux parasites des familles de clones issues de la pépinière.

Evaluation pour la précocité, caractéristiques de racines, résistance à la virose, alternariose, charançons.

Evaluation du le rendement au niveau des essais de rendement préliminaires, avancé ou uniforme.

- Essais comparatifs variétaux

Essais comparatifs variétaux à Rubona, Karama et à Base: Evaluation du goût et de la stabilité de production des variétés en essai de rendement uniforme.

Essai commparatif variétal multilocal en diverses localités du pays choisies en fonction de leurs diversités écologiques. Ces essais multilocaux sont conduits en collaboration avec les projets agricoles.

- Essais phytopathologiques

Test des variétés parentales et des sélections descendantes de patate douce pour leur résistance aux maladies et aux parasites. Inspection de l'état phytosanitaire des champs en station et en milieu rural.

10.2.1.3. Techniques culturales

- Effet de la densité de plantation sur le rendement et la taille des tubercules.
- Essais d'associations de la patate douce avec d'autres cultures.
- Essais de fertilisation.

10.2.1.4. Recherches en milieu rural

- Test d'acceptabilité de nouvelles variétés chez les agriculteurs dans des régions à patate douce.

- Démonstration des variétés et techniques améliorées en milieu rural.

- Multiplication rapide et diffusion des variétés améliorées avec l'appui des projets agricoles.

10.2.1.5. Multiplication et diffusion

Amélioration des techniques de multiplication et du système de diffusion, Patate douce: 2 ha à Rubona et 1 ha à Karama.

10.2.1.6. Formation

En novembre 1986, on a organisé le 3ème stage de formation sur la production et la multiplication rapide des tubercules à l'intention des agronomes oeuvrant dans les projets et services agricoles.

En janvier 1987, ont eu lieu les journées agricoles pour Paysans (2ème édition) à la station de Rubona et à la station de Karama.

En novembre 1987, on organisera à Rubona un stage de formation sur la production, la conservation, la transformation et l'utilisation des plantes à racines et tubercules en collaboration avec l'UNICEF et l'IITA.

Au cours des 6 dernières années, le programme s'est principalement occupé de l'amélioration de la patate douce et a recueilli des informations autorisant la redéfinition des objectifs et la réorientation du programme selon les priorités définies par les paysans.

Des variétés de patate douce à rendement élevé et stable ont été identifiées parmi les nouvelles sélections.

Il s'agit de K 51/3261, Mugande, Karebe II, Muvatoro I qui viennent compléter la liste des clones locaux ou exotiques de production stable connue (Rusenya, Nsasagatebo, TIS 2544, Rutambira, Nyiramujuna).

Pour les techniques culturales, les boutures apicales de patate douce ont prouvé leur supériorité de production, tandis que le niveau de fumure de 35 T/ha de fumier seul ou complémenté de NPK 40-50-100 est considéré comme optimal en cas de faible fertilité du sol.

Les tests de dégustation et les essais en milieu rural ont permis de vérifier le refus ou l'acceptabilité des nouvelles variétés et nouvelles techniques culturales.

La formation des agronomes de projets agricoles a également atteint de bons résultats et facilitent déjà l'installation et les observations des essais multilocaux. Des journées agricoles pour paysans consistent à leur montrer les maladies, les parasites de la patate douce, les techniques de multiplication rapide du matériel sain de plantation, les techniques de fertilisation, les nouvelles variétés et leur potentiel de production par la récolte, l'identification par eux-mêmes des différentes contrainte de production dans les champs des paysans.

Ces journées agricoles, qui constituent une rencontre entre chercheurs, vulgarisateurs (anciens stagiaires) et un grand nombre de paysans provenant de diverses régions du pays, sont appréciées par les paysans eux-mêmes et continueront à être organisés chaque année à la fin du stage de formation des techniciens agronomes des projets ou services agricoles.

10.2.2. Perspectives d'avenir

Les activités décrites plus haut continueront mais certaines d'entr'elles seront intensifiées en fonction des contraintes du moment.

Des tests en serre sont nécessaires pour tester la résistance aux charançons et aux chenilles défoliantes de la patate douce.

Des travaux de laboratoire et de serre doivent être envisagés pour confirmer les sources de résistance au complexe viral et à l'alternariose de la patate douce. La caractérisation de différents types de virose, par des techniques simples est nécessaire pour appuyer la sélection.

Bien qu'il n'existe pas pour le moment des données qui permettent de chiffrer les excédents de production de patate douce, cependant on observe régulièrement des chutes spectaculaires des prix de la patate douce sur le marché. La récolte pourrit parce qu'il n'existe pas de technique améliorée de conservation du produit brut ni de technique de transformation en produit fini. L'amélioration des techniques de conservation, de transformation et de technologie alimentaire auraient pour conséquence d'accroître les circuits de commercialisation, stabiliser le prix sur le marché et assurer un prix rémunérateur aux producteurs.

A l'heure actuelle, le programme de recherche continue de s'occuper des travaux de routine de sélection et d'expérimentation des techniques culturales, domaines dans lequel des résultats probants sont obtenus, mais on doit également essayer de résoudre les problèmes cruciaux rencontrés pour le moment: la surproduction, la difficulté de conservation, la transformation et la technologie alimentaire. Il est donc souhaitable de développer à présent des aspect de la recherche qui n'ont pas été suffisamment exploités à savoir:

- Lutte biologique contre la chenille défoliante, à combiner à la sélection de clones résistants.

- Entomologie: travaux en serre et en laboratoire pour tester la résistance variétale contre les charancons.

- Phytopathologie: travaux en serre et en laboratoire pour caractériser les différentes races de pathogènes (surtout viroses et alternariose) et tester la résistance variétale.

- Laboratoire de cultures de tissus pour contrôler les maladies virales surtout, assurer la conservation du germoplasme et l'échange variétal entre les pays du réseau de l'Afrique orientale et australe.

- Conservation des tubercules de patate douce.

- Transformation de la récolte: transposer sur place des modèles de transformation connues ailleurs mais acceptables par le paysan, ou étudier d'autres possibilités de transformation.

- Formation sur place (techniciens, paysans) et à l'extérieur (stages, cours académiques).

11. COLLABORATION SOUS-REGIONALE

11.1. Echanges de Graines de Patate Douce

Dans notre région, il existe des clones locaux qui, au cours des années, se sont adaptées aux conditions locales. Cependant l'introduction récente en Afrique de parasites nouveaux et de nouvelles races de pathogènes a prouvé que même les clones adaptés succombent aux attaques répétées de ces pathogènes.

Il est donc indispensable de collecter, conserver, évaluer et échanger le germoplasme local de l'épurer et de l'utiliser à des fins d'hybridation pour combiner les caractéristiques intéressantes et sélectionner des clones adaptées aux contraintes biologiques (maladies et parasites d'importance économique) ou environementales (sécheresse, haute altitude, pH acide ou basique).

A la demande du Coordinateur du Réseau de Recherche sur les Tubercules en Afrique orientale et australe, 4 blocs de croisement sont actuellement en place pour une durée de 2 ans afin de produire sous croisement contrôlé environ 100,000 graines de patate douce qui sont déjà partagés entre les différents programmes nationaux de l'Afrique orientale et australe.

11.2. Echange de Matériel Végétal de Patate Douce

Les maladies et particuliérement les viroses constituent une contraintes majeure d'échange de germoplasme et de variétés améliorées entre les pays de la région.

Il est donc indispensable de disposer d'un laboratoire de culture in vitro pour permettre la multiplication saine des plantes et faciliter les échanges du materiel sain sous forme de cultures méristématiques avec les autres pays de l'Afrique orientale et australes.

12. PERSONNEL CHARGE DE LA RECHERCHE - SITUATION EN 1987

Domaine	Responsable de Recherche	Techniciens Agronomes
1. Sélection de la patate douce	1 Ing. Agr.	1 A_2
2. Multiplication de semences	1 Ing. Agr.	-
3. Essais chez les paysans manioc - patate douce	-	A_2

* 3 chercheurs ont quitté le programme au cours de l'année.

* 2 consultants (en Phytopathologie, en Transformation) ont assisté le programme en 1987 pendant 3 mois.

Ce tableau montre bien que le programme ne dispose que d'un effectif réduit. Le renforcement du personnel s'avère d'autant plus urgent qu'il y a 3 chercheurs qui ont quité le programme au cours de l'année 1987.

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SWEET POTATO SITUATION IN THE SUDAN

Ahmed A. Geneif

1. INTRODUCTION

The Sudan, the largest country in Africa, has variable climate conditions from desert in the North to arid and semi-arid in the Center, to equatorial rainy climate in the South. Annual rainfall varies from almost zero in the far North to over 1500 mm in the far South.

The average temperatures are relatively high in most regions during summer. However, some areas in Western and Southern Sudan are of high altitude and thus have relatively low temperatures throughout the year. The country has vast areas of cultivable land. Irrigation water is available from the River Nile and its tributaries as well as river floods, ephemoral streams, and underground water. The country has a population of about 22 millions with an annual growth rate of 2.79 percent. About 80 percent of the populations depends for its subsistence on agriculture and related activities.

2. SWEET POTATO PRODUCTION

Among many vegetable crops, sweet potato is well known in Sudan and is produced and consumed in the different regions of the country. It is produced under irrigation in central and Northern Sudan and under rain in Southern and some parts of Western Sudan. The crop is produced by small farmers under conditions of traditional farming systems.

This is characterized by simple cultivation methods, the use of hand tools and almost no inputs like fertilizers, insecticides, etc. In the South the crop is mostly produced for subsistence, while in Central and Northern Sudan it is produced for market. In the South the crop is grown during the rainy season, while in some irrigated areas it is produced almost all year round. Production is dominated by the varieties of white flesh and relatively low yielding capacities compared to some introduced varieties. Crop, faces no major production constraints by virtue of its good adaptation.

The most important pest is the sweet potato weevil, whiteflies and aphid are commonly observed also. No proper survey was made to determine the important disease on the crop.

3. LOCAL RESEARCH ON SWEET POTATO

More important vegetables like onion, tomato, Irish potato and peppers, and Okra attracted research emphasis in the Sudan in the past. Research conducted on sweet

potatoes was confined to variety evaluations and very few nutritional and planting studies. Cultivars of orange flesh were introduced earlier and evaluated, and some showed high yields capacities. However, they could not go into production because they lacked the consumer preference. Recently some introductions from IITA showed very high yields compared to local cultivars in the South. Future research priorities will emphasize on:

- Introduction and improvement of cultivar.
- Improving cultural practices e.g. planting dates, plant population, fertilization, as well as propagation methods.
- Surveying pests and diseases, and developing methods of control.
- Exploring new utilization of the crop.

4. FUTURE TRENDS

The environmental conditions are favourable for successful sweet potato production in Sudan. Demand on this crop may increase considerably through improving the quality of the cultivars and diversifying the uses of the crop. Improvement in yield and quality can be rapidly attained by introducing superior cultivars. With more areas assigned for vegetable production in irrigated schemes e.g. Gezira scheme, expansion in sweet potato production can be secured if the demand for the crop increases.

5. INTERFACE WITH CIP

Since Sudan has all favourable conditions for sweet potato production, efforts are needed to enable this crop play an important role in social and economical development. Much can be gained in this direction by exposure to available achievements and technologies, and by exchange of experience with other countries. This can best be realized by establishing strong cooperation between the Agricultural Research Corporation and the International Potato Center (CIP). the Agricultural Research Corporation (ARC) is a semi-autonomous national research body entrusted with all applied agricultural research in the country. It is also adopting practical ways of interaction with the farmers in the different crops.

The Food Research Center, one of the ARC institutions can explore new utilization of sweet potato in the country, thus improving the market for the crop.

SWEET POTATO GROWING AND RESEARCH IN UGANDA

Robert O. M. Mwanga[1] and Nelson W. Wanyera[2]

1. INTRODUCTION

Uganda is a small landlocked country lying in the centre of Africa across the equator between latitutes 4° 12′ N and 1° 29′ S and longitudes 29° 34′ W 35° 0′ E. It is 236,040 km^2 but its land surface is only 208,759 km^2 and the area under permanent crop is about 120,000 ha (FAO 1980). Most of the country is a plateau, about 1050 m above sea level although there are peaks, Mt. Elgon (4,323 m) in the East and Mt. Ruwenzori (5113 m) in the West of the country.

Soils of Uganda include: 1) vertisols in the North East; 2) isolated patches of podsolic soils; 3) entrophic soils of tropical regions (on volcanic ash and alluvial deposits) in isolated locations in the West and East; 4) ferruginous tropical soils freely drained, block clays and lithosols in some places in North-Eastern Uganda; 5) ferrallitic soils (mainly sandy loam and sandy clay loams).

The mean annual rainfall varies from 510 mm in parts of Karamoja (N. E. Uganda) to about 216 mm in Sese Islands in Lake Victoria. The rainfall is bimodal with rainfall peaks in April-May and October-November. The Southern part of the country does not generally have a distinct dry season unlike the Northern region. More than 70% of the land area of the country receives between 750 mm and 1250 mm four years out of five as shown in Table 1.

Table 1. Percentage of land area receiving selected amount of precipitation four years of every five (Griffiths, 1962).

Rainfall (inches or mm)		%
Less than 20"	(500 mm)	12
20-30"	(500-750 mm)	10
30-50"	(750-1250 mm)	72
over 50"	(1250 mm)	6

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Mean annual minimum and maximum temperatures vary from 10° to $20^{o}C$, and between $22.5^{o}C$ and 32.5^{o}, respectively. Mean monthly radiation ranges from 356 to 564 gm cal cm^{-3} depending on location and time of the year (Jameson 1970).

The variation in environmental conditions is reflected in the variety of the main food crops which include cooking bananas, finger millet, cassava, sorghum and sweet potatoes.

2. IMPORTANCE AND DISTRIBUTION OF SWEET POTATOES IN UGANDA

Sweet Potatoes and cassava are the most important root crops in Uganda, the farmer being more widely distributed. Sweet potato is the most widely cultivated and most spread of all food crops in the country. In various parts of the country it is grown as a major or supplement to other staple food crops. Grown in almost all parts of the country its distribution relates quite closely to that of the population. The most marked concentration occurs in Southern, Eastern and Central Uganda. Before 1900 the crop was more important in Buganda, Bwamba and among the Bakonjo of Ruwenzori (MacMaster, 1962). The spread of the crop to the north has been more recent since the crop only reached Lango, about 1920. In the 1950's Sweet Potatoes occupied about 9% of the food crops area and ranked as the most important food crop, after Eleusine millet, bananas and cassava (Uganda Pro. Dept. Agr., 1958).

Although there seemed to be a decline in the importance of sweet potato in banana growing areas in the early 1970's (Dunbar, 1975) production increased between 1975-1981 (Table 2). The increasing popularity of the crop may be partly due to the effect of population pressure on the land in various parts of the country. The population pressure dictates a trend towards replacement of the traditional staple cereal by a higher yielding crop. However a considerable acreage is grown for marketing in urban areas.

In banana areas where soils are eroded and exhausted couples with heavy banana weevil and nematode attack on bananas, sweet potato tends to be more tolerant to water stress, pests, diseases and infertile soils than other food crops except cassava.

Table 2. Production of Sweet Potatoes in Uganda 1975-1981 (FAO production Yearbooks)

Year	Area harvested 1000 ha	Annual Production 100 t
1975	140	650
1976	135	650
1977	137	660
1978	139	674
1979	139	693
1980	139	670
1981	140	680

3. PLANT TRAITS

Sweet potato is cultivated as an annual although it is a perennial. it is propagated vegetatively from cuttings, rarely from roots. The cuttings are generally left under humid conditions in shade for two or more days for root initiation and improvement of establishment. Without this treatment, however, fresh vines tend to exhibit more vegetative vigour when the moisture level is low in the soil (Aldrish, 1963). Most sweet potato cultivars flower freely and set fruit freely and seedlings are often observed in the field.

Most cultivars are self incompatible but will set seed when grown with other cultivars or when artificially crossed. There is great variation in root size shape, colour, quality, leaf shape, size and colour, and vine, root ratio.

Maturity period varies between four and six months depending on climate, variety and local customs.

4. FIELD OPERATIONS

In Uganda sweet potato are grown on mounds or ridges of varying sizes but rarely on the flat. Deep cultivation is required for ideal root growth, expansion and for higher yields.

4.1. Planting Material

Although propagation by seed is used by breeders vegetative propagation is the only method practiced by farmers in Uganda. Young tips of vines about 30 cm long are planted after being stored for about two or more days in a humid shaded place. In

areas with a pronounced dry season, swamps and swamp edges are often used as a means of providing planting material and some food at the end of the season.

4.2. Planting Time

Farmers rarely give sweet potatoes priority over cereals or important cash crops. Sweet potato is planted at any convenient time when there is sufficient moisture for establishment in the soil. Planting can be done throughout the year where rainfall is evenly distributed, as along the shores of lake Victoria. Where there is a pronounced dry season, as in Teso planting is usually concentrated at the start of the rains of high ground. At the end the rains and in the dry season planting in swamps is extensive.

4.3. Planting Methods

Throughout Uganda sweet potatoes are propagated vegetatively by cuttings of about 30 to 45 cm long.

Apical vines are used when planting material is abundant. Slips are planted in deeply worked soil and are drawn well into the soil, frequently leaving only the tip protruding supposedly to reduce insect damage.

Vines are commonly planted on mounds consisting of thoroughly cultivated soil made into a heap. The cuttings are commonly thrust into the mounds about one metre by hand but the use of a forked stick is common in northern Uganda. Usually 2 to 6 cuttings are inserted in each mound. Planting on the ridge is not common while planting on the flat is rarely used to avoid theft by monkeys but it produces a relatively very poor crop.

Most peasant farmers cultivate the crop frequently in small patches and usually as a pure stand but sometimes interplanting it with crops like beans and maize. Rarely does the farmer grow plots of sweet potatoes consisting one cultivar. A mixture of several cultivars is preferred and reasons for that are variable (MacDonald, 1967).

4.4. Spacing

McDonald (1967) did some work on methods of planting and spacing. No significant differences were detected between yields on hill 60, 90 and 120 cm apart or on ridges 70 and 90 cm apart. The farmers' planting rates vary from 25,000 vines/ha to 75,000 vines/ha; 2 to 4 vines being planted per hill or mound while on ridges they are usually planted 30 cm apart in 2 rows, one on each side of the ridge. However, altering the population from 25,000 to 100,000 vines/ha had no significant effect on yield but the components of yield changed. Plant density may be manipulated with advantage in areas where planting material is scarce (Aldrich, 1962).

4.5. Rotation

The sweet potato is usually grown outside the conventional erable rotation land. Sometimes it is used as a closing crop in the rotation or as an opening (clearing) crop after the rest period. Being perishable and harvesting the crop piecemeal, makes it difficult to fit it in the erable rotation (MacDonald, 1967).

4.6. Cultivars

A large number of cultivars exists varying in taste, food value, size, shape and color of root, consumer acceptance, maturity period, yield, resistance to pests and diseases and vine characteristics. There are only about 300 cultivars and about 40 introduced clones in the germplasm collection at Namulonge and Serere Research Stations. There are probably many more cultivars with farmers since new cultivars are frequently found, probably from self-sown seedlings resulting from cross-compatible cultivars. New cultivars come up almost every decade. Frequent cultivar degeneration over the years seems to be due to virus diseases.

4.7. Fertilizer and Manure

The small farmer in Uganda nearly always grows sweet potato without any fertilizer application. There are no specific fertilizer recommendations for the crop.

4.8. Weed control

Weeding is usually done 2 or 3 times in the first two months of crop growth. With full canopy closure most of the weeds are suppressed. The mounds are usually reshaped during the weeding. Farmers do not generally use herbicides because they are very expensive and they are usually unavailable.

4.9. Harvesting

In Uganda sweet potato maturity period varies between 4 to over 9 months depending on altitude and variety. Harvesting in most parts of the country involves two operations. The first tuberous roots to mature are dug out with a stick leaving the plant and its mound or ridges as intact as possible. The presence of cracks on mounds are used as indicators of the presence of sizeable storage roots and digging is carried out at that spot. Two or three months later the rest of the crop matures and is dug up completely using a hoe. Piecemeal harvesting maintains a continuous supply of food for 2 or more months from a perishable crop.

Late maturing cultivars like Kalebe are better adapted to this system of harvesting than early ones like Bitambi. In the former variety a high proportion of the tuberous roots are found from roots of the young plant at the nodes of the vines. However in Bitambi practically all the tuberous roots from roots originating from the pieces of parent vine originally planted. In rapid harvesting especially if mechanization is envisaged, the compact grouping of the roots in a cultivar like Bitambi is advantageous (Aldrich, 1963).

4.10. Yields

Yields in Uganda vary greatly between 2t/ha to about 9t/ha with an average of 3t/ha. Those yields are quite low compared to those of Japan where at least 20t/ha may be expected. Inferior cultivars, diseases, pests and lack fertilizer largely account for the low sweet potato yields in Uganda.

4.11. Storage

Sweet potatoes are seldom stored for 4 or more days in their fresh conditions, especially when damaged, as rotting quickly sets in. Consequently the crop is left in the ground and harvested only as needed. Weevils, however, infest the roots in the soil in dry weather. Although some cultivars keep better than other it is not a satisfactorily method of storage, hence the need for sun drying in areas with a dry season. In regions with a pronounced dry season part of the crop is peeled, sliced, sun dried and stored for a few months. Some people store fresh undamaged storage roots in underground pits covered with grass or soil for periods usually less than a week. Curing sweet potatoes to improve storage qualities and flavour seems to be unknown to peasant farmers in Uganda.

4.12. Cooking Quality

Dry, floury, with little fibre, sweet and distinctly flavoured cultivars when cooked are preferred. Orange fleshed or yellow fleshed varieties like Caroline Lea and Early Port are usually not so popular. Yield rather than quality is the overriding factor for purposes of sun-drying and storage.

4.13. Utilization

All the sweet potato crop is consumed locally, the fresh roots may be boiled, steamed, baked, roasted or fried and consumed directly without processing. Boiled potatoes may be mushed with beans and eaten. Sun dried potatoes are boiled, mushed, and consumed. The total calories supplied by sweet potatoes in Uganda ranked third after cassava and bananas (Jameson, 1970). Although the sweet potato slightly low in sulfur containing amino acids (lysine and tryptophan), this state is slightly alleviated by the wide spread occurrence of beans which are frequently consumed together with the crop. In some cases the storage roots are used in beer making and the leaves used as spinch. Surplus fresh roots and sweet potato vines may be fed to livestock and pigs. The leaves are sometimes used as food for *Tilapia* spp. in fish ponds.

4.14. Marketing

Distribution and marketing of the crop may be limiting sweet potato production in areas far away from Urban centers where transport is lacking.

5. DISEASES

5.1. Virus Diseases

The sweet potato virus disease (SPVD) is the most serious disease in Uganda (MacDonald, 1967a). Sheffield (1957) distinguished virus A, a mild disease transmitted by the aphid, Myzus persicae (Sulz.) from Virus B, a severe disease, common at altitudes 1200 to 1500 m above sea level and transmitted by the white fly, (Bemesia tabaci (Genn). Symptoms due to virus A vary with cultivars and include chlorotic spots, and mosaic may be latent, tending to be mild and can be transmitted through grafting. Virus B (with different strains) symptoms also vary with cultivars and may include stunting, mottling, and distortion and can be transmitted through sap.

Serious deterioration of the crop due to virus infection occurs with the possibility of some cultivars going out of cultivation (Aldrich, 1963), MacDonald 1963, 1967). Yield reduction may reach 66% (Aldrich, 1963). Mukiibi (1976 b) reported a 57% reduction in yield both in terms of weight and number of roots in the cultivar, Kyebandula. These reports indicate that the sweet potato virus diseases constitute a serious constraint to crop production in Uganda.

Roguing very young and mature plants at which stage disease symptoms are clearly visible, use of resistant cultivars and apparently virus free planting materials, and burning of infected plants have been advocated as control measures.

5.2. Fungal and Bacterial Diseases

Fungal diseases are of minor economic importance and their symptoms are described by Hansford (1945). They include stem disease, Plenodomus destruens Preuss; charcoal (dry) rot, Rhizoctonia bataticola Taub. Butl., Pseudocercospora timorensis, tuber rot due to Pythium sp. and Rhizopus stolonifer (Jameson, 1970) and post-harvest fungal and bacterial diseases. Moulds may develop on inefficiently dried sweet potatoes.

5.3. Pests

More than 60 insect pests of sweet potato have been listed from Uganda but only 4 are of economic importance (Jameson, 1970; Ingram, 1967; Maitai, 1958). The most serious pests of sweet potatoes in the country are weevil Cylas formicarious (F) and Cylas puncticollis Boh and they are widely distributed. The smaller, C. formicarious is the commoner and more serious pest. They attack storage roots, leaves and stems. The larvae tunnel through the pith system of the stem and sometimes destroy the shoots. Weevil damage may result in severe reduction market value of storage roots and leaves and quality of storage roots after harvest since the root can become rapidly infested during the life cycle of 29 to 30 days. Quantified yield loss due to the weevil seems not to have been reported.

Use of D. D. T. to control sweet potato weevils has been discouraged. In Uganda inputs are low, consequently the use of cultural control measures like earthing up to

prevent storage root exposure in the field, and planting weevil free material, rotating with other crops and the cultivation of resistant cultivars, seems to be the most economic way of controlling the weevils.

The stem weevil Peleropus batatae Mshl. (Curculionidae) is less common and causes much less damage than Cylas.

The spiny caterpillar of the sweet potato butterfly Acraea acerata Hew and the tailed caterpillar of the sweet potato moth Herse concoluvuli (L), cause considerable devastation to the crop. They may cause complete defoliation of the crop in the dry season if they are not controlled. Control of the caterpillars is effected by hand and insecticide sprays. Yield losses have not been determined. Incidental invasion of a high population of A. acerate by safari ants, (Anomma nigricans I Iliger) was observed by the senior author in a sweet potato plot of about 0.5 ha at Kawanda Research Station in 1980. This possibly important aspect of biological control could be investigated into.

5.4. Nematodes

Although the nematodes, Meloidogyne incognita and Radopholus similis have been reported associated with the crop in Uganda (MacDonald, 1963) the nature of damage and yield loss have not been characterized.

5.5. Storage Pests

Dried sweet potato products are attacked by a host of wood-boring and stored product pests, the most serious and widespread of which are Stophilus oryzae (L), Dinoderus minutus (F) Lyctus brunneus (Steph.), Rhyzopertha dominica (F), Araecerus fasciculatus (Deg.), Tribolium castaneum (Hbst.), Calandra oryzae (L), Lophocateres pursillus (Kug) and Lasioderma serricorne (F). The less common and very rare storage pests include Bostrycholplites cornutus (Oliv.), Heterobostrychus brunneus (Murr), and Thaneroclarus bugneti (Lef.).

In some instances these pests reduce the commodities to a useless pile of dust. The low commercial value of the stored products does not make treatment economic. More or less continuous, thorough and good sundrying is advocated as the control measure (Davies, 1960; Jameson, 1970).

5.6. Vertebrate Pests

Wild animals including rodents, monkeys and wild pigs are also a source of great loss. Monkey theft and damage has recently become a very serious problem in many parts of the country.

6. SWEET POTATO RESEARCH IN UGANDA

Although the sweet potato is one of the most important food crops in Uganda it has received little research attention in the past. Apart from a few yield trials, a few agronomic studies (MacDonald, 1967a) some work on virus diseases (Hansfard, 1945; Mukiibi, 1976a; 1976b) preliminary breeding work (MacDonald, 1965; 1967b) and some chemical control experiments (Ingram, 1967) not much work has been done on the crop in the country. Having less priority in research programs, lack of local trained personnel and political instability may have led to such little research activity on the crop. Rootcrops research is entirely government controlled.

6.1. Research, Production and Extension Services

It was only in 1980 that root and tuber crops came on the priority list of food crops in research programmes in Uganda. Root and tuber crop improvement programmes are centered at Serere and Namulonge Research Stations. Lack of inputs is however a major constraint to the progress of the programs.

Uganda had an excellent extension service with 45 variety trial covering all the important ecological zones of the country where extension staff were stationed. However, the service has broken down due to the effects of recent wars. Rehabilitation of the centres is now in progress.

6.2. Research Priorities

Research programs are geared towards identifying virus resistant, weevil resistant and high stable yielding varieties of wide adaptability and consumer acceptance in terms of storage root characteristics like storability and palatability. More extensive studies on sweet potato response to fertilizers and farmyard manure are essential.

7. COLLABORATION NEEDED FROM INTERNATIONAL COMMUNITY

A lot of support is needed from international and regional organizations like IITA, IDRC, IAEA; AVRDC, CIP, CIAT, etc. for supply of root and tuber crops germplasm material and literature. Support is also required from these organizations and the international community in training personnel, and financial support of the Uganda National Root and tuber Crops Improvement Program.

Currently the International Research Centre (IDRC) funds part of National Root and Tuber crops Improvement Program. Sweet potato tissue culture material from IITA is being evaluated at Serere and Namulonge Research Stations.

There is need to set up a tissue culture laboratory to enable exchange of germplasm with other countries, to clean up virus infected materials and to enable rapid multiplication of virus free materials to supply to the farmers.

8. QUARANTINE REGULATIONS

No quarantine facilities are available but import of root and tuber crops vegetative material into the country is prohibited. Only true seed treated against bacterial and fungal diseases may be imported. Use of the quarantine station at Muguga, Kenya has been with great difficulty.

9. REQUIRED INPUTS FOR PRODUCTION

Among the inputs that currently limit production are ridgers, fertilizers, herbicides, insecticides, spray pumps, Ox-ploughs, and simple implements like hoes and pangas. Availability of tractors would greatly alleviate farmer's problems.

10. SWEET POTATO STAFF AND TRAINING

The current status of sweet potato staff in Uganda is shown in Table 3.

Table 3. Current status of sweet potato staff in Uganda.

Staff on Program	Qualification	Current Discipline	Training Required
Otim Nape G. W.	B. Sc. (Agric.)	Pathology	M. Sc. (plant pathology)
Ocotti p'Obwoya C.	M. Sc. (Agronomy)	Agronomy	Ph. D. (Agronomy)
Wanyera Nelson W.	M. Sc. (Plant Breeding/Genetic Resources	Plant Breeding and Genetic Resources	Ph. D. (Plant Breeding and tissue culture laboratory technology)
Mwanga Robert O. M.	M. Sc. (Agronomy)	Plant Breeding	Ph. D. (Plant Breeding & tissue culture laboratory technology)
Odogola, V.	M. Sc. (Eng.)	Engineering	Specialized training
Wamajje S.	M. Sc. (Food Technology	Food Technology	Ph. D. (Food Technology)
Odong, B.	M. Sc. (Trainee)	Entomology	Ph. D. (Entomology)

Many supporting staff need training and training facilities some of which can only be obtained at Internatinal centers like IITA, CIAT or regional centers like AVRDC.

11. FUTURE PROSPECTS OF SWEET POTATO IN UGANDA

The sweet potato, ranking among the major food crops in Uganda represents an inadequately explored commodity for economic development. Since it is a popular crop in the farming systems and has high yield potential, it is likely that increases in population growth and increasing its use as a livestock feed or raw material for industrial purposes will enhance its demand, giving it a bright future

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