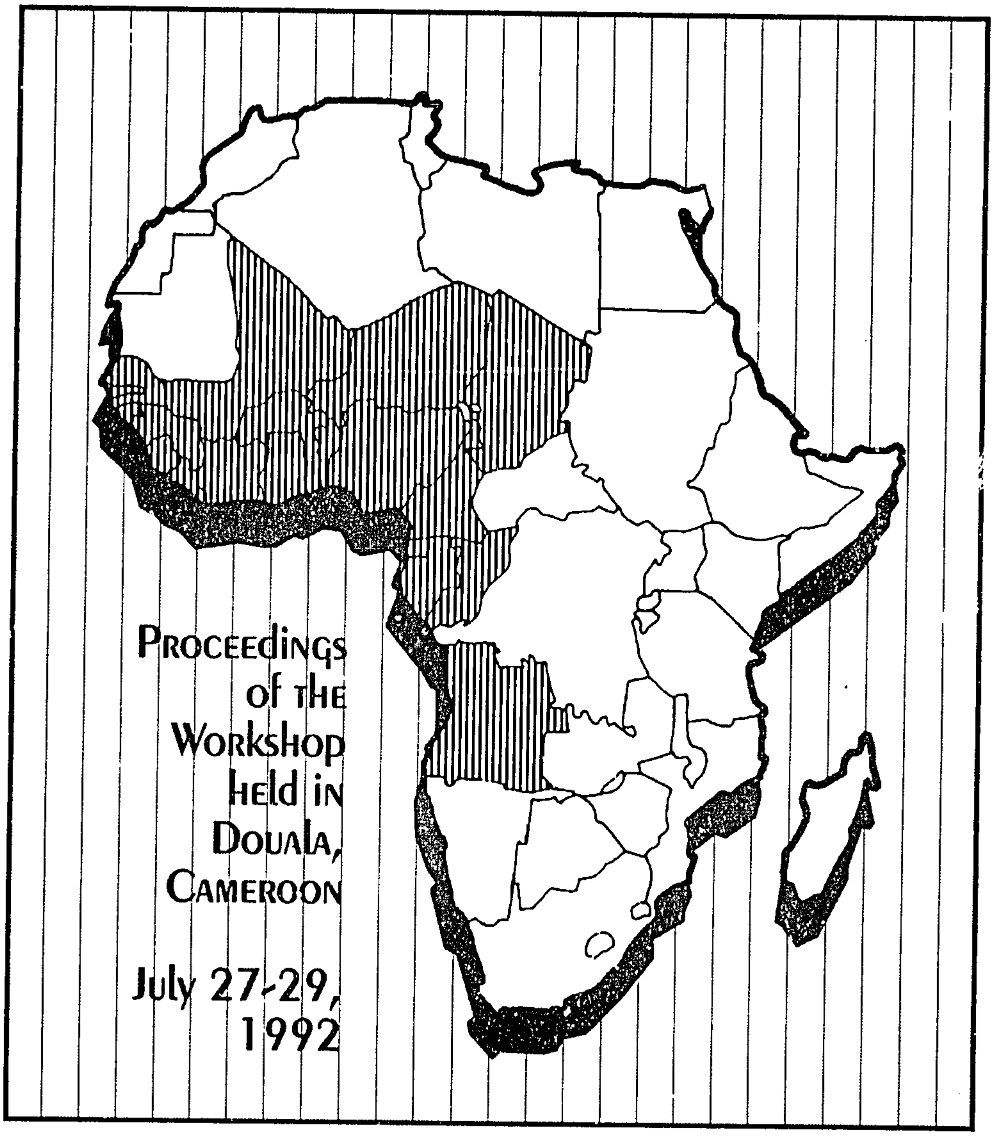

SWEETPOTATO SITUATION AND PRIORITY RESEARCH IN WEST AND CENTRAL AFRICA

INTERNATIONAL POTATO CENTER (CIP)

1994

SWEETPOTATO SITUATION AND PRIORITY RESEARCH IN WEST AND CENTRAL AFRICA

Proceedings of the Workshop
held at Douala, Cameroon
July 27-29, 1992

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PRESENTATION

On October 12, 1987 an agreement was signed at Yaoundé, Cameroon, between the Ministry of Higher Education and Scientific Research of that country and the International Potato Center (CIP). By this agreement, CIP will collaborate on different scientific aspects to improve potato and sweetpotato production in Cameroon. Furthermore, the agreement allowed CIP to establish in Bamenda, Cameroon, its Regional Office for West and Central Africa.

The organization of a workshop on "Sweetpotato Production and Constraints in West and Central Africa" was a top priority during the first year of the Regional Office. This workshop finally took place on July 27-29, 1992 at Douala, Cameroon. Participants from agricultural institutions of six countries attended this activity.

Apart from the scientific aspects discussed during the meetings, interaction, collaboration, and friendship developed among the participants. Some of the principal aspects discussed during the workshop are covered in this publication.

Carlos Martin
CIP, Bamenda, Cameroon

WELCOME ADDRESS TO PARTICIPANTS

Carlos Martin

Dear colleagues and friends: Good morning to everyone and welcome to Cameroon.

I should start by saying that finally, after so many inconveniences we are able to meet. On two previous occasions circumstances beyond our control forced us to postpone this Workshop, one in 1990 and later in 1991. I am very glad you are able to attend this meeting and on behalf of the International Potato Center and myself I would like to welcome you to Douala and to our first official meeting on sweetpotato research in West and Central Africa. Your participation is highly appreciated and we expect your full support and collaboration during the next few days in order to make this meeting a success.

The main objectives of the Workshop are to learn about and review in detail the sweetpotato situation in your countries, as well as to discuss priority research areas in which CIP can collaborate with you in order to improve production, productivity and utilization of sweetpotatoes.

Until a few years ago, CIP's mandate included research on potatoes (*Solanum* spp) only. In 1986 with official endorsement by TAC-CGIAR, CIP's mandate was broadened to include research on the sweetpotato. This action was technically implemented in early 1988, when an agreement was developed between CIP and IITA whereby IITA's sweetpotato germplasm collection and breeding lines were given to CIP. At that time, IITA sent a letter to the Ministries of Agriculture of the African countries, informing them of the change in its mandate.

To date, through collaborative projects, donations and collecting expeditions in Latin America, CIP has accumulated the largest collection of sweetpotato germplasm in the world. Several areas of research are being undertaken such as the development of new, advanced clones, studies in post-harvest utilization, and disease and pest resistances, etc.

At this time I will not go in details regarding the importance of this root crop in Africa and the rest of the world, since these matters will be addressed during the week. However, I would like to point out that sweetpotato, *Ipomoea batatas* (L.), ranks second in world root and tuber crop production, after potatoes. About 80 % of the world's sweetpotatoes are grown in China and virtually all (98 %), are grown in developing countries. Asian countries account for about 6 % of production, Africa for 5 % and Latin America for 2 %. In Africa, among the root and tuber crops sweetpotato is probably second in importance after cassava. Although the roots are the main part of the plant being utilized, the use of the foliage as a source for animal feeding is increasing significantly. Young foliage shoots are an important source of human food in certain areas of Africa and Asia.

One of the most important topics we would like to discuss during our meetings is : Why are sweetpotatoes, despite the fact that they are affected by few pests and diseases, are easy to cultivate under different agroecological conditions, and require minimum fertilization and inputs, not cultivated as intensively other root and tuber crops? Although significant progress has been achieved in developing improved varieties, probably insufficient efforts have been made towards improving post-harvest technologies and better utilization of this root crop. Several researchers working on transformation and utilization of sweetpotatoes, as well as colleagues from our Social Sciences Department have been invited to this Workshop. We expect they will contribute valuable information and new ideas regarding a better use of sweetpotato in our diet.

Our knowledge about the actual sweetpotato situation in this part of Africa is weak and we are still in the process of learning. Although IITA worked for several years on sweetpotato research and collaborated with several African countries, there are still several areas of research which need to be discussed and improved. In this regard, we expect to improve our knowledge with the information that Heads of National Programs and researchers from several countries will share with us during the next three days.

Besides your direct contribution to our knowledge on sweetpotato production in this part of Africa, one of the main reasons for participating in this Workshop, is to help us identify research areas that need more and prompt attention by CIP, both in the short as well as in the long term. I am very positive that several areas in sweetpotato research will be identified as needing more attention in order to improve production and productivity. This is a crop with a great potential to feed the hungry in the tropics, and it is up to us to make it possible.

Once again, I want to express my appreciation for your participation in this Workshop. I expect that your participation will contribute to us being able to better visualize and evaluate the sweetpotato situation in this part of Africa. I hope you have a nice stay in Douala and that this first meeting will be the base for future and better collaboration, among each other and also with CIP.

SWEETPOTATO RESEARCH AT THE IRA-CIP PROJECT IN CAMEROON FROM 1988 TO 1992.

M. Tucker

Introduction

In late 1987, when the agreement was signed between the International Potato Center (CIP) and the Government of Cameroon, establishing collaborative research and the CIP Regional Office for West and Central Africa at Bamenda, sweetpotato research was not within CIP's mandate. At that time, the mandate for sweetpotato research and collaboration with developing countries was a responsability of the International Institute of Tropical Agriculture (IITA) with headquarters at Ibadan, Nigeria.

In early 1988, CIP and IITA signed an agreement transferring the world mandate for sweetpotato research from IITA to CIP. At almost the same time, the IITA/IRA/Gatsby Project on sweetpotato was beginning to be phased out in Cameroon. Therefore, the IRA-CIP Project at Bamenda started its research on sweetpotato in late 1988, with the following main priorities:

1. To obtain and maintain elite clones from the Gatsby Project before the genetic materials were lost due to the phasing out situation. In addition, to continue field evaluations of advanced materials at selected locations.

2. To rescue advanced clones at IRA-Ekona which could be lost due to the lack of continuity of IITA support to National Sweetpotato research in Cameroon. In addition, to further evaluate those selected materials at different locations.

3. To develop minimum *in-vitro* facilities for maintenance of selected clones from IRA as well as those maintained at IITA-Ibadan. To train local staff.

4. To introduce new genetic materials with attributes different from those selected by IITA-IRA.

5. To concentrate research in the following areas:
   a) Further field evaluation of clones available at IRA
   b) Explore possibilities of sweetpotato production at higher elevations
   c) Initiate studies on comsumption patterns and processing
   d) Improve agronomic practices on cultivation
   e) Continue research on weevil resistance
   f) Explore adaptation of sweetpotato utilization techniques already being used in other countries.

Procedures and Results Obtained

At the start of the activities on sweetpotato research by the IRA-CIP Project, it was decided that the best location to maintain genetic materials and initiate field research was at IRA-Babungo (1 150 m) in the North West Province. This was close to the IRA-CIP potato headquaters located at IRA-Bambui, and also represented good agroecological conditions for sweetpotato production. Simple *in-vitro* facilities were being developed at IRA-Bambui, which could also include maintenance and multiplication of selected sweetpotato clones.

Research Trials Carried Out in 1989 and 1990

Clones from the Gatsby/IITA/IRA Project

In late 1988 stem cuttings from 18 selected clones and one local cultivar were received from IRA-Nyombe and maintained during the dry season in a small irrigated nursery at Babungo. One of the clones was lost during the transfer and the remaining 18 are shown below :

Table 1. List of Clones Received by the IRA/CIP Project From the IITA/IRA/Gatsby Project. September 1988.

	Clone	Color	
	Identification	Skin	Flesh
1)	TIB-1	Cream	Cream
2)	TIB-2	Cream	Cream
3)	IRA-002	Dark pink	White
4)	IRA-048	Dark pink	Cream
5)	IRA-502	Dark pink	Yellow
6)	IRA-076	Dark pink	Cream
7)	IRA-1112	Dark pink	Cream
8)	IRA-1487	Dark cream	Dark pink
9)	IRA-1592	Dark cream	Cream
10)	IRA-1530	Purple	Dark cream
11)	IRA-1602	Red	Cream
12)	IRA-1611	Pink	Cream
13)	IRA-1639	Dark red	Cream
14)	IRA-1669	Pink	Cream
15)	IRA-1692	Purple	Cream
16)	TIS-2498	Dark red	White
17)	TIS-2544	Dark cream	Cream
18)	Loca Nyombe	Cream	Cream

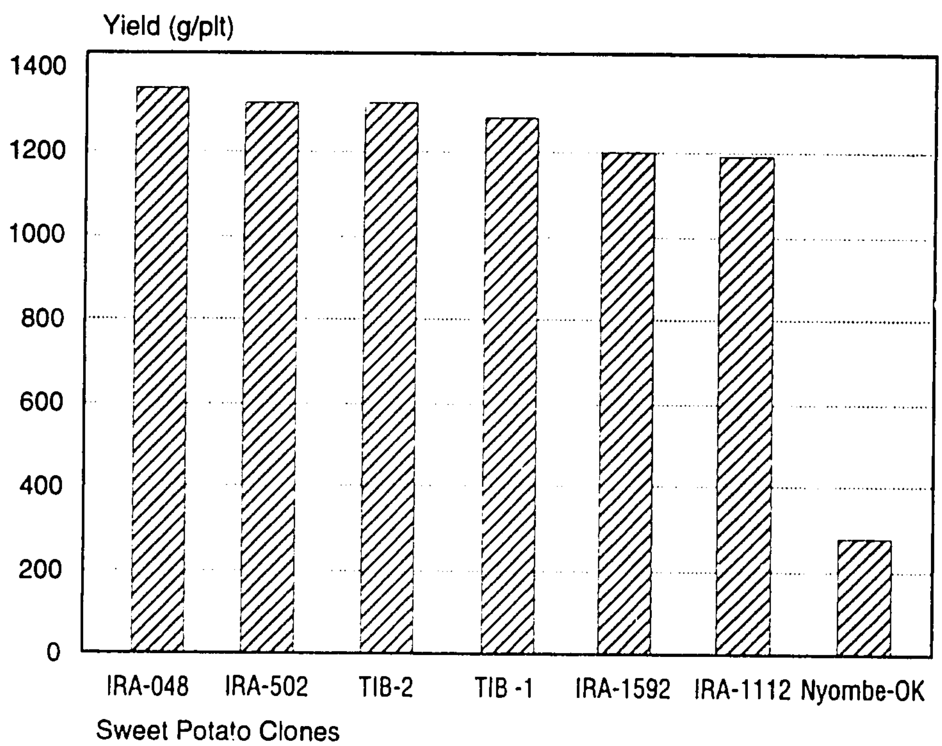
The genetic materials were kept in an irrigated nursery and evaluated for their yield potential at Babungo during the 1989 and 1990 rainy season. The field trials consisted of a RCBD with three replications and 15 plants per replication. The plants came from 20-25 cm stem cuttings collected in late April from the irrigated nursery and plants were harvested at 120 days after planting. No fertilizers were applied during the growing period. The yields obtained in both years at Babungo are summarized in Table 2, and combined data from the highest yielding clones are shown in Figure 1.

Table 2. Yield and Average Tuber Weight* of IITA/IRA/ Gastby Clones Evaluated at Babungo (1 150 m) During the First Half of 1989 and 1990 (rainy season), NW Province, Cameroon.

Clone	Root Wt. (g)		Yield (g/plt)	
	1989	1990	1989	1990
IRA-048	318	625	1 146	1 500
IRA-502	179	194	1 291	1 300
TIB-2	242	384	1 090	1 500
TIB-1	239	378	1 099	1 400
IRA-1592	260	363	1 195	1 200
IRA-1112	364	370	1 382	1 000
IRA-1639	292	435	1 140	1 000
TIS-2498	233	392	1 026	1 100
TIS-2544	214	297	897	1 100
IRA-002	175	207	771	1 100
IRA-1692	296	263	1 330	500
IRA-1530	174	164	715	1 000
IRA-1611	136	364	707	800
IRA-1487	125	125	438	700
IRA-076	53	157	292	800
IRA-1602	108	71	582	200
IRA-1669	74	77	310	400
Local Nyombe	104	120	270	300

*Average of three replications and 15 plants/replication.

Figure 1.
Highest Yielding Clones Average 1989 and 1990



Introduction of Genetic Materials

In mid-1989, one thousand seeds from 10 crosses were received from a research contract at North Carolina State University. Half of the seeds were planted in a nursery at Babungo and the other 500 seeds were planted at IRA-Mfonta (1 350 m), NW Province. Stem cuttings from 111 seedlings obtained at Mfonta and 337 seedlings obtained at Babungo were planted in a summer nursery at Babungo in late 1989. After the dry season, due to irrigation problems, only 114 clones survived.

In May 1990, the first 82 clones of the surviving 114, were planted for the first yield evaluation trial. Stem cuttings were planted in a RCBD with three replications and 15 plants per replication. Plants were harvested at 120 days after planting. A total of 24 clones were finally selected from this field trial. Yields from the top clones are shown in Table 3.

Table 3. Highest-yielding Sweetpotato Clones Selected from 82 Seedlings Evaluated in First Half of 1990, at Babungo (1 150 m), NW Province, Cameroon.

Clone	Root Weight (g)	Yield* (g/plt)	Color: Skin	Color: Flesh
NC 82-3.26	443	2 040	Cream	Cream
NC 87-4.7	249	1 840	Orange	Orange
NC 82-3.21	404	1 780	White	Cream
NC 87-4.1	232	1 760	Orange	Orange
NC 87-1.1	372	1 750	Cream	Cream
NC 87-6.18	335	1 740	Purple	Orange
NC 86-6.26	348	1 740	Cream	Cream
NC 82-3.28	296	1 600	Orange	Orange
NC 82-3.4	357	1 500	Orange	Orange
NC 87-2.3	411	1 480	Orange	Cream
NC 87-5.2	411	1 480	Orange	Orange
NC 196.4	173	1 480	Red	Orange
NC 87-5.3	292	1 460	Red	Orange
NC 87-1.24	362	1 450	Orange	Orange
NC 87-4.5	363	1 380	Cream	Cream
NC 87-1.4	409	1 350	Red	Orange
NC 87-1.23	268	1 340	Red	Orange
NC 82-3.24	191	1 340	Orange	Orange
NC 196.29	228	1 320	Orange	Orange
NC 82-2.24	332	1 233	Red	Orange
NC 196.2	157	1 110	Cream	Cream
NC 87-2.9	208	1 000	Orange	Orange
TIB-1 (Check)	562	1 800	Cream	Cream

*Average of three replications and 10 plt/replication.

The other 62 clones were also planted at Babungo in July in only one replication, with 10 plants per clone. Plants were harvested at 120 days after planting. After harvest, only 33 clones were selected from this group. The yields from the top clones are shown in Table 4.

Table 4. Highest-yielding Sweetpotato Clones of 62 Seedlings Evaluated During the Second Half of 1990, at Babungo (1 150 m), NW Province, Cameroon.

Clones	Root Weight (g)	Yield (g/plt)	Color	
			Skin	Flesh
NC 82-1.21	198	1 687	Red	Orange
NC 82-1.30	208	1 600	Orange	Orange
NC 87-1.20	151	1 570	Orange	Orange
NC 87-4.3	197	1 380	Cream	Cream
NC 82-2.27	121	1 310	Orange	Orange
NC 87-2.25	121	1 300	Cream	Cream
NC 82-2.31	112	1 260	Orange	Orange
NC 82-3.6	274	1 180	Red	Orange
NC 82-1.24	159	1 175	Red	Orange
NC 82-1.3	198	1 170	Pink	Cream
NC 82-1.23	227	1 156	Orange	Orange
NC 196.20	22.3	1 150	Pink	Orange
NC 196.1	230	1 060	Red	Orange
NC 87-2.24	194	1 050	Cream	White
NC 87-1.3	175	1 050	Orange	Orange
NC 87-5.23	212	1 040	Red	Orange
NC 87-6.30	92	1 022	Red	Orange
NC 87-3.30	103	980	Red	Orange
NC 87-1.25	313	971	Pink	Orange
NC 87-5.1	139	960	Red	Orange
NC 196.24	196	940	Cream	Yellow

Average of one replication of 10 plants/clone.

Genetic Materials from IRA-EKONA

In late 1989, 22 advanced clones from IRA-Ekona were received and planted at Babungo for maintenance, multiplication and further evaluation. Out of the 22 clones planted, only 10 survived the first dry season (Table 5).

Table 5. List of Clones Received From IRA-Ekona Which Survived the First Planting During the Dry Season at Babungo (1 150 m), NW Province, Cameroon.

Clone	Root color	
	Skin	Flesh
EK 8266	White	White
EK 8266.1	Pink	Pink
EK 80/723	Red	Cream
EK 84/0320	Cream	Cream
EK 82/0405	Red	Cream
EK 82/0405.1	Cream	Yellow
EK 84/04703	Cream	Cream
EK 84/0473.1	Red	Cream
EK 84/0473.2	Red	Cream
EK 820264	Pink	Cream

These clones were evaluated together with all other selected clones in an advanced yield trial in 1991 and 1992 at different locations.

Advanced Yield Trials 1991-1992

With the initiation of the 1991 rainy season, advanced yield trials were established at Babungo (1 150 m), Befang (700 m), and Upper Farm (2 000 m). Trials included a total of 85 clones: 28 clones from IRA-Ekona and Gatsby, and 57 advanced clones from seed received from NCSU, USA. Trials at Babungo and Befang were harvested at 120 days and at Upper Farm at 150 days after planting.

Data collected from the highest-yielding clones at Babungo and Befang are shown in Table 6. Combined data obtained at both locations from highest clones is summarized in Figure 2.

Table 6. Highest-yielding Sweetpotato Clones Evaluated in Babungo (1 150 m) and Befang (750 m), NW Province, Cameroon During First Half of 1991 (rainy season).

Clone	Root Wt.(g)		Yield (g/plt)	
	Babungo	Befang	Babungo	Befang
EK 84/0473.2	189	248	1 070	1 500
EK 82/0405	265	234	1 293	1 174
IRA 1112	276	239	1 330	1 025
NC 87-6.26	196	251	983	1 370
NC 82-3.21	210	190	937	1 379
EK 8266	222	235	1 273	1 016
NC 87-2.25	195	164	1 403	817
NC 87-4.5	194	197	920	1 064
NC 196.1	194	136	1 153	1 045
IRA 502	103	118	953	1 028
IRA 002	110	135	958	996
TIS 2544	203	133	1 118	764
EK 82/0405.1	194	151	1 207	707
NC 82-3.26	227	136	1 027	850
TIB-1	239	176	1 100	776
EK 820264	159	152	1 030	844
NC 196.25	125	241	1 043	692
NC 196.6	129	142	1 061	611
EK 80/723	162	214	923	694
NC 196.20	147	117	930	662
NC 87-6.30	132	143	867	475
TIB-2	245	188	896	391
Babungo (CK)	147	152	537	884
Nyombe (CK)	116	102	613	362
C.V.(%)	28	32	27	39
LSD.05	85	95	471	669

At Upper Farm, yields were very low despite the fact that plants were harvested one month later than those at Babungo. Only a few clones produced more than 150 g/plant. The highest-yielding clones at this elevation are shown in Table 7.

Figure 2.
Highest Yielding Clones
Average Two Years-two Location

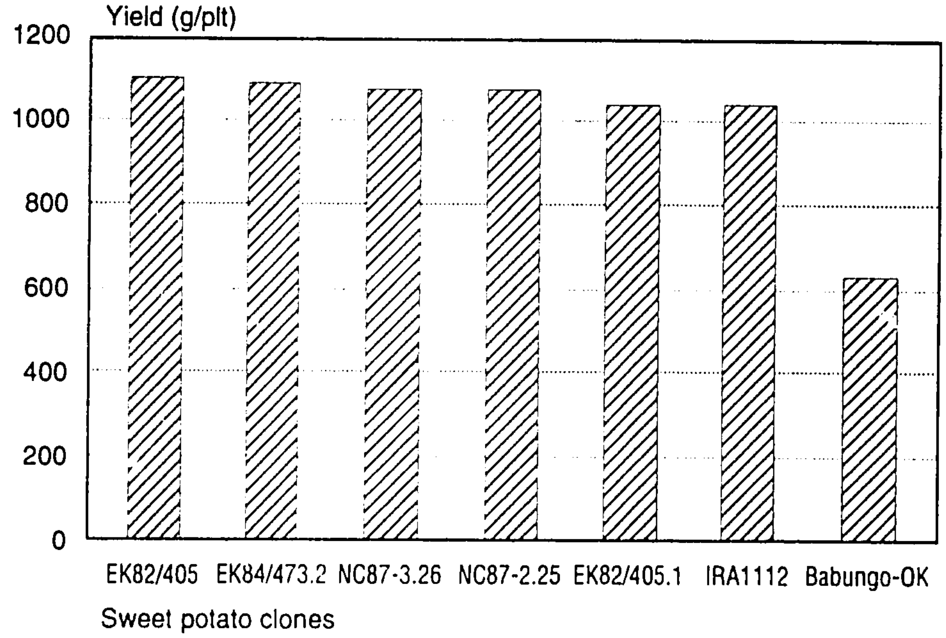


Table 7. Highest-yielding Clones Evaluated at Upper Farm (2 000 m), NW Province, Cameroon During the 1991 Rainy Season.

Clone	Root Wt.(g)	Yield (g/plt)
NC 87-5.3	80.6	250.0
NC 87-2.25	54.1	218.0
NC 82-1.2	63.0	214.3
TIB-2	50.8	195.0
NC 196.6	22.8	194.5
NC 82-3.26	55.9	190.4
IRA 820264	42.0	181.8
NC 87-6.26	56.3	181.6
NC 87-4.7	32.4	181.3
IRA 502	27.4	178.7
NC 82-3.21	50.3	175.3
NC 87-4.5	47.6	173.3
IRA 1592	49.0	170.8
NC 87-1.3	42.3	166.0
IRA 82/0405	47.4	151.9
TIB-1 (CK)	42.9	100.0

Of the initial 57 NCSU clones evaluated at the three locations, only 26 clones have been retained for further field evaluations. These, together with the other selected clones make a total of 53 advanced clones still kept in our germplasm collection at Babungo. These 53 clones were planted again in late August, 1991 at Babungo in a RCBD with three replications and 20 plants/replication. They were harvested in mid-January, 1992. Yields were not as high as those reported during the rainy season, since very few rains ocurred after late November. The yields of the top clones are shown in Table 8.

Table 8. Highest-yielding Clones Out of 53 Evaluated at Babungo (1 150 m) NW Province, Cameroon During the Second Half of 1991.

Clone	Root Wt. (g)	Yield (g/plt)
IRA 82/0405.1	195.7	1 198
TIB-1	174.1	1 001
NC 87-2.25	151.7	976
NC 82-3.6	169.4	923
IRA 502	100.7	891
NC 87-4.5	181.3	891
NC 82-3.26	167.0	881
TIS 2544	138.7	870
NC 87-6.26	152.9	842
IRA 80/723	144.5	826
IRA 82/0405	188.7	811
IRA 002	79.8	773
NC 87-5.2	131.2	771
IRA 8266	133.8	770
IRA 1112	230.2	749
IRA 84/0473.2	145.9	687
IRA 8266.1	106.5	627
NC 196.6	75.1	625
IRA 1639	134.8	608
TIS 2498	145.5	600
Local Nyombe	60.7	378
Local Babungo	131.8	460
C.V. (%)	25.6	27.7
LSD.05	42.6	250

After combining the yield data obtained from the 1991 field trials at Babungo, Befang (rainy season) and Babungo (dry season), the following are the highest-yielding clones (Table 9).

Table 9. Yields of Top Clones Evaluated at Babungo, and Befang During 1991.

Clone	Yield (g/plant)			
	Babungo 1991-A	Befang 1991-A	Babungo 1991-B	Average
EK 82/0405	1 293	1 174	811	1 093
EK 84/0473.2	1 070	1 500	687	1 086
NC 87-6.26	983	1 370	842	1 065
NC 87-2.25	1 403	817	976	1 065
EK 82/0405.1	1 207	707	1 199	1 038
IRA 1112	1 330	1 025	749	1 035
IRA 8266	1 273	1 016	770	1 020
TIB-1	1 100	776	1 001	959
TIS 2544	1 180	764	870	938
NC 82-3.26	1 027	850	881	919
IRA 002	958	996	773	909
NC 196.1	1 153	936	479	856
EK 820264	1 030	844	509	794
NC 196.6	1 061	611	625	766
NC 196.25	1 043	692	555	763
Local Babungo	537	884	460	627
Local Nyombe	613	362	378	451

In mid-March 1992, with the initiation of the rainy season, field trials were established in Babungo, Mfonta and Upper Farm. In addition, duplicated cuttings from the highest-yielding clones are being sent to Dschang University and IRA-Nkolbisson for evaluation. On-farm trials will also be established at several locations in the NW and West Provinces.

On-Farm Trials

Stem cuttings from the best clones have been distributed to several farmers, cooperatives and Training and Demonstration Centers (TDC-MINAGRI) for their evaluation. The distribution started in late 1991 and included 20 stem cuttings from each advanced clone. So far, data have been collected from only a few of the trials. Table 10 shows results from TDC Nyen (400 m) and TDC Widikum (600 m).

Table 10. Yield and Average* Tuber Weight of Advanced Clones Evaluated at Two Training and Demonstration Centers in the NW Province, Cameroon, During the Second Half of 1992.

Clone	Root wt. (g)		Yield (g/plt)	
	Nyen	Widikum	Nyen	Widikum
NC 82-3.26	237	181	1 500	595
TIB-1	278	200	1 500	471
IRA 1112	270	120	1 425	850
NC 196.25	144	238	1 389	707
NC 87-4.7	146	270	1 339	965
NC 87-6.26	232	123	1 200	595
IRA 048	91	184	469	527
IRA 1592	201	221	683	935
TIS 2498	205	78	700	515
LOCAL	238	114	1 367	510

*Average of two replications and 10 plt/replication

In-vitro Clones from IITA

As mentioned at the beginning of this presentation, one of the sources of genetic materials at the IRA-CIP Project was the introduction from IITA of a part of its *in-vitro* germplasm collection. Originally, when *in-vitro* facilities were not yet available at the IRA-CIP Project, clones were sent and maintained at ROTREP-Ekona. Close to 500 *in-vitro* clones were received. However, due to several factors affecting the maintenance of these genetic materials at Ekona, only 157 clones survived. In late 1991 *in-vitro* facilities were developed at the IRA-CIP Project in Bambui and the 157 clones are presently being maintained there. This year, the clones are being multiplied and a duplicate planted in the field in order to start evaluating them under local conditions in Cameroon. It is expected that by the end of August (1993) the first yield trial will be planted at Babungo.

Additional Research Activities

Several other research activities have been initiated within the past two years. These mainly include the adaptation of agronomic techniques to improve productivity in farmer's fields, e.g. weed control, use of stem cuttings with different numbers of nodes, association with other crops in the same field, etc. Results are not yet available as most trials are still ongoing.

Marketing, Utilization and Processing

These research activities are mainly the responsibility of Dr. Adhiambo Odaga, a CIP staff member posted at Bamenda. They will be discussed in more detail in another paper. It is important, however, to point out that the post-harvest activities of marketing, utilization and processing, have beer identified by CIP as some of the most important constraints increasing sweetpotato production and expanding the importance of this root crop as a human food in developing countries.

PRODUCTIVITY ANALYSIS OF SWEETPOTATO IN THE NORTH WEST PROVINCE OF CAMEROON

E.W. NGANJE AND E.T. ACQUAH

Abstract

Sweetpotato is one of the most important root crops in Cameroon and is widely produced and consumed. A major problem encountered by small farmers is the low productivity of this crop at the farm level. This study documents the various factors accounting for the low productivity at the farm level and suggests how farmers can more efficiently utilize their opportunities to increase sweetpotato production and productivity.

Cross sectional data were collected from 98 sweetpotato farmers in the North West Province, using a random, systematic sampling technique. The conventional Cobb-Douglas production function was used to estimate a production function for the data. A profit function was used to estimate net returns. Major findings revealed that:

- Sweetpotato production was not economically viable, with negative returns of 57 496.71 FCFA.

- The coefficient of labour and capital significantly influenced yields at the .001 and .05 levels, respectively.

- The coefficient of land was negative and not significant.

- The estimated production function was highly significant with a significant F value of 0.0035.

The above results indicate the importance of finding alternatives to make sweetpotato less labour intensive and suggest that greater research and extension efforts are needed to advise farmers on plant spacing and planting techniques that increase the efficiency of land use.

Introduction

Sweetpotato is one of the most important root crops in Cameroon and is widely produced and consumed. Lyonga and Ayuk-Takem (1984) reported that sweetpotato is grown in most administrative Provinces of Cameroon and in some localities such as Bambili in Mezam Division of North West Province it is occasionally grown alone during the dry season (August to January). Several authors

[Nzamage, 1984; Olaguwon, 1985; Foncho, 1989; Gass and Lekunze, 1990], have documented that the major constraints to increased sweetpotato production are; the high incidence of disease, inappropriate agronomic practices, progressive degeneration of older varieties without regular replacements, high prices of inputs coupled with low output prices, shortage of planting materials for early season production and the low productivity of the crop in farmers' fields.

'Much has been done to forester links between research and technology transfer through on-farm trials (Pfeiffer, 1984). Also, IITA has developed high-yielding stable clones like TIb 1, TIs 2544 and others, but little work has been accomplished on getting feedback from the farmers on the performances of improved clones and their major problems. The focus of this paper is to assess the economic viability of sweetpotato production, document the various factors accounting for low productivity of sweetpotato at the farm level, and suggest how the opportunities of the farmers can be more efficiently utilized to increase production and productivity.

Methodology

Model Specification and Measurement of Variables

Two models are use to back the empirical investigation in this study; the Cobb-Douglas production function model is complemented with the profit function model.

The Production Function Model

KENNETH (1966) defined a production function as a feasible set of quantities of inputs and outputs which show what quantities of input (factors) can be transformed into quantities of output (products). For a group of homogenous firms a general production function can be specified as:

$$Q = f(X_1, X_2, \ldots, X_n) \qquad \text{(i)}$$

Where Q is the output of the firms having different sets of inputs $X_1, X_2, \ldots X_n$.

In production analysis, parameters of factors of production are estimated. They generally show the magnitude of the influence of various inputs (factors) on the output of a product. There are various forms of production functions and the Cobb-Douglas production function has been very popular for research analyses of agricultural firms and is utilized for this study.

A conventional form of the Cobb-Douglas production function utilized for the study was:

$$Q = AX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} \ldots \qquad \text{(ii)}$$

Where: Q	=	Gross output
X_1	=	Land
X_2	=	Labour
X_3	=	Capital items
X_4	=	The Experience or years of farming
X_5	=	Hours of visit of extension workers.
$A, b_1, b_2, b_3, \ldots$	=	Parameters to be estimated.

The statistical form of the equation estimated in its natural logarithmic form for the regression analysis is:

$$LnQ = LnA + b_1LnX_1 + b_2LnX_2 + b_3LnX_3 + b_4LnX_4 + b_5lnX_5 + et \qquad \text{(iii)}$$

Where *et* is the error term.

The Profit Function Model

Economic efficiency is attained when the profit (II=TR-TC) is maximum. The profit is maximum when the marginal revenue is equal to marginal cost (MR = MC).

II = Profits
TR = Total revenue and
TC = Total cost.
In this study TC comprises explicit and implicit costs.

Measurement of Variables

The Dependent Variable (gross output)

Output in this study is measured in terms of its value. The gross output of sweetpotato was measured by the total units produced (unit was the basin) and then multiplied by their respective market prices to get the gross value of the output.

In cases where the total unit produced was for home consumption, the average market price for that unit was used to calculate its value. The value for the gross output was in FCFA.

The Independent Variables

Land

Land was measured in terms of its value. After the area allocated for sweetpotato was determined, the number of hectares was multiplied by the cost of renting the land, or the opportunity cost of renting land in the study area. This gave the value of land in FCFA.

Labour

Labour was measured in person-days (1 person-day was equivalent to 8 hours). To standardize the measurement of person-day, children under 16 years and adults over 60 years were equated to 0.75 of that of males and females between 17 and 59 years. Labour was classified into five different forms:

- Self Labour: The number of days the farmer worked on his or her own farm;

- Family male labour: The number of days the male children and relatives worked on the farm;

- Family female labour: The number of days the wife and female children worked on the farm;
- Communal labour: Mass labour from work groups that worked on the farm; and
- Hired labour: Paid labour for farm work.

Capital

Capital was disaggregated into tools, equipment, sacks, sticks and planting materials. All these were valued in FCFA. The straight line depreciation method and the number of days a farm tool or machine was used for a particular activity was used to compute the specific cost of that farm tool or equipment, used for that activity. With this technique the value of actual flow of service of capital farm tools and equipment for all farm activities was estimated. For other inputs and the cost of planting materials, the average costs specified by the respondents were utilized.

Data Collection and Limitation

Cross sectional primary data collected through a formal questionnaire/interview were used to generate the data for the study. Data were collected from the 1990/91 cropping season from 98 sweetpotato farmers. They did not keep formal accounting records for their businesses. Subsequently, they had to respond to the questionnaire/interview by memory recall. This data collected from memory may have some accuracy limitations.

Results and Discussion

Multiple regression analysis was used to estimate the production function for sweetpotato in the study area.

Table 1 presents the estimated function for sweetpotato production in the study area. The overall significance of the regression equation was tested using the F-ratio. The model specified for sweetpotato production was highly significant with an F value of .0034 and an R^2 value of 0.56.

The estimated output elasticity of labour (b_2) was positive and significant at .001 level and that of capital (b_3) was positive and significant at .05 level. However, the output elasticities of land, experience and extension were not significant. The elasticity of land (b_1) was negative and not significant. In general, all the independent variables specified in the production function for sweetpotato in the study area accounted for 56.2 % of the variation in the dependent variable (output).

From economic theory, if summation of output elasticities (b_i) >1, then an increase by one unit of all inputs (X_i) will cause a proportionally greater increase in output. If the sum of b_i <1, this will result in a proportionally smaller increase in output when all inputs are increased by one unit. In this study the combined effects of the elasticities showed a constant return to scale (sum of b_i = 0.90, was not significantly different from one). Therefore, one percent increase in all inputs will lead to one percent increase in the outputs.

The value of labour accounted for 113.9 % variation of the output when all other independent variables are held constant. The coefficient of capital was also positive and significant, influencing the gross output by 17.6 % when all other variables are held constant. The coefficient of land and the years of farming (experience) were negative and not significant. The number of hours spent by extension workers with farmers caused a 15 % variation in the output, even though it did not significantly influence the gross output.

The error term (et) which accounts for almost 44 % of the variation of the output can be attributed to environmental effects and other undetermined factors.

Even though extension had no significant influence on the output, there is a need for extension workers to increase their links with farmers and to advise them on new innovations such as appropriate plant spacing and planting techniques. This may be a good step towards increasing land productivity and the efficiency of other inputs used.

Results of the profit function are presented in table 2. The average cost of inputs per hectare(151 489 FCFA) for the study area shows that the value of labour accounted for 93.4 % (141 463 FCFA) of this total cost of production. A net negative profit of 57 497 FCFA was registered in the study area.

Land and capital accounted for 5.9 % and 0.7 % respectively of the total cost of production. The study also indicates that low yields coupled with low prices per unit of sweetpotato, result in a revenue of only 93.992 FCFA per hectare. This low revenue makes sweetpotato production in the study area uneconomical.

Constraints and Opportunities Revealed by the Study

Labour

Reducing labour would result in reduced cost of sweetpotato production. This could be accomplished by improved cultural methods, mechanization and the use of herbicides to reduce labour requirements.

One of the opportunities for expanded sweetpotato production therefore, is to devise labour saving or capital intensive techniques for critical activities such as land clearing, ploughing and ridging. Ironically, these solution have been proposed by other root crop researchers, notably Onwuene in 1982 (cited in Acquah and Nganje, 1991). His suggestions for mechanical land preparation and planting and the use of pre- emergence herbicides and close plant spacing (Onweme, 1982) need to be given more priority in root crop research programs in West Africa.

Land

Land, which is a critical production factor shows a negative returns to scale for sweetpotato production. This indicates that efficient plant spacing and planting techniques are not being used by sweetpotato producers. Lyonga and Ayuk-Takem (1984) recommended a spacing of 1 meter between ridges and 0.5 meter between plants (20.000 plants/ha) for sole cropped sweetpotato and for more efficient use of land and labour. IITA (1982) recommended 1.80 meter between maize rows with sweetpotato on 50 cm high ridges, between the maize rows.

Conclusion

The estimated Cobb-Douglas production function was highly significant (with a significant F-value of 0.0035), and revealed that:

- The independent variables significantly influenced the yields of sweetpotato accounting for 5t6.2 % of the yield variation.
- The coefficient of labour and capital were positive and significantly influenced the gross output.
- The coefficient of land was negative and not significant.
- The combined effects of elasticities showed a constant return to scale (sum of bi = 0.90 was not significantly different from one).

The economic profit analysis also revealed that sweetpotato production is not economically viable, with a net negative economic profit of 57 496.71 FCFA per hectare.

Examination of the factors of production shows that, labour constitutes a major component of the cost of production, accounting for 93.4 % of the total cost of production. Land has a negative return to scale in the study area. This implies that research in mechanization of the major land preparation operations should be pursued to address the labour constraint issue. Also, appropriate plant spacing and planting techniques should be define and extended to farmers. The available high-yielding varieties should also be more widely distributed for planting.

Table 1. Elasticity Coefficents and Related Statistics of the Estimated Regression Equation.

$$LnQ = LnA + b_1LnX_1 + b_2LnX_2 + b_3LnX_3 + b_4LnX_4 + b_5LnX_5 + et$$

Constant (LnA)	LnX_1	LnX_2	LnX_3	LnX_4	LnX_5	R^2	F	Signif F
0.459	-0.290	1.139	0.176	-0.275	0.150	0.562	5.12	0.0035
	-(1.287)	(4.685)***	(0.647)*	-(1.287)	(0.496)			

Values in parenthesis are t-values; *Significant at the .05 level; **Significant at the .01 level; *** Significant at the .001 level; Number of valid observations = 98; The standard error = 0.78; Returns to scale (sum of bi) = 0.90

Table 2. Implicit and Explicit Cost per Hectare In Sweetpotato Production.

Input factors	Input Cost (CFA)	Total Cost
Land	9 049.72	5.9
Labour*	141 462.92	93.4
Capital	976.29	0.7
Total	151 488.64	100.0

* 155.34 person-days were used to produce one hectare of sweetpotato at 910.67 FCFA/person/day. Total revenue = 93 991.93 FCFA Economic Profit = -57 496.71 FCFA.

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SITUATION DE LA PRODUCTION DE PATATE DOUCE AU MALI

Adama Traore

Introduction

Le Mali, avec une superficie de 1.204.000 km^2 compte environ 8.000.000 d'habitants. Les céréales constituent la base de l'alimentation, cependant les plantes à racines et a'tubercules jouent un rôle important dans l'alimentation des populations. En effet, le Mali produit environ 10.000 tonnes d'ignames, 20.000 tonnes de manioc et 50.000 tonnes de patate douce (M. Traore 1980).

Suite aux anneés de secheresse, pendant lesquelles l'acquisition des céréales était devenue difficile, la consommation de tubercules a augmenté dans les menages. La consommation de tubercules en 1989 est estimée à 16,8 kg/hab./an et en l'an 2005, elle devrait s'élever à 21,4 kg/hab./an (cf. rapport du projet MLI/84/005). Cette augmentation de la consommation correspond à une augmentation de la demande de 109.400 tonnes.

Toute la production de patate douce est autoconsommée. Elle est consommée soit à l'état frais, soit après préparation. Ainsi la patate douce se consomme au Mali sous forme de ragoût, bouillie à l'eau, frite, purée, cous-cous etc.

Production de la Patate Douce

La production de la patate douce est traditionnelle au Mali. Il n'existe pas de données statistiques précisant le niveau de productivité pour chaque zone, mais le rendement moyen dépasse rarement 10t/ha alors qu'avec des techniques modernes de production, on peut atteindre 50t/ha (LYONGA et AYUR TAKEM, 1985)

Zones Agro-climatiques

La Zone Sud-Soudanienne:

Qui n'occupe que 6 % du territoire dans l'extrême sud du pays entre les 11° et 12° de latitude nord est la plus arrosée. Elle reçoit 1.300 à 1.500 mm. de pluie par an en 90 jours en moyenne. La saison des pluies dure en moyenne 6 mois. L'amplitude thermique annuelle est faible (5° à 6°C)

La Zone Nord Soudanienne

Environ 3 fois plus étendue que la précédente est limitée par les isohyetes 1300 et 700 mm. La saison des pluies dure de 4 à 6 mois et les précipitations se concentrent sur 70 à 80 jours.

La Zone Sahélienne

Va de l'isohyete 700 à 200 mm englobant une zone de transition à nuance soudano-sahélienne entre 700 et 500 mm. Elle a une saison pluivieuse plus courte de 3 à 4 mois (Juin-Septembre) avec une moyenne de 30 jours de pluie par an. L'amplitude thermique annuelle y est plus forte (12°C).

Zone Sud-Saharienne

Qui est caractérisée para des précipitations très irréguliéres, accidentelles, inférieures à 200 mm/ an. L'amplitude thermique annuelle est plus forte (16°C). Les nuits sont froides (moyenne des minima de janvier 11.3°C à Tombouctou).

Les tempèratures sont élevées avec des moyennes annuelles comprises entre 26° et 30°C. A l'exception du Nord, l'évolution de la courbe des températures moyennes annuelles fait ressortir deux maxima (la principale en Avril-Mai et la secondaire en Septembre-Octobre) et deux minima (la principale en Décembre-Janvier et la secondaire en Août).

La patate douce est cultivée dans toutes ces zones agro-écologiques du Mali, mais dans la zone sud-saharienne il faut nécéssairement arroser les plantes ou les cultiver si possible en condition de décrue.

Contraintes à la Production de la Patate Douce

En déhors de la pluviométrie qui varie selon les zones, il n'existe pas de contrainte majeure spécifique à chacune des zones de production. La faible production de la patate douce est principalement dûe à:

- La faible performance des variétés cultivées
- L'insuffisance des techniques culturales
- L'insuffisance de la technologie post-récolte de conservation et de transformation.

Analyse des Contraintes

Variétés peu Performantes

Sensibilité des variétés aux nuisibles. Les variétés cultivées sont sensibles aux maladies (virales, bactériennes et fongiques), et aux insectes (surtout le charançon de la patate douce). Le coléoptère (*Cylas puncticollis*) est le plus redoutable de la patate douce au Mali. La femmelle adulte pond ses oeufs dans les tiges et les tubercules. Les dégâts les plus importants sont dûs à leurs larves, blanches et sans pattes qui creusent des galéries dans les tiges en dessous ou dessus du niveau du sol entraînant la mort des jeunes plantes, ou qui creusent les tubercules qu'elles peuvent dévorer entièrement (Collingwood *et al*, 1984).

Faiblesse des rendements des variétés disponibles. Les variétés de ces différentes espèces n'expriment pas toutes leurs potentialités. En effet les rendements de nos meilleures variétés ne representent que le tiers ou la moitié des possibilités estimée (DOKU, 1985)

Parmi les facteurs limitant on peut citer:

La Sensibilité de la Photopériode

La patate est très sensible à la photopériode. Dans certaines zones, les plantations de mars ne donnent pratiquement pas de tubercules alors que le développement végétatif est très important.

Le Manque de Matériel de Plantation Sain (boutures)

Plusieurs cultivars sont infectés par des maladies, notamment des maladies à virus. Les boutures déjà contaminées ne peuvent pas donner un bon rendement.

Maîtrise Insuffisante des Techniques Culturales

Elle se caractérise par:

La non-maîtrise des nuisibles. Les techniques et méthodes de lutte contre les nuisibles ne sont pas maîtrisées. Il s'agit des insectes, acariens, animaux, maladies, adventices, etc.

La non-maîtrise des systèmes de culture. Elle est dûe à la méconnaissance des rotations culturales et des densités optimales. La faible connaissance des associations culturales et la concurrence des autres cultures en sont les causes.

La prédominance des techniques de culture manuelles. Presque toutes les opérations se font à la main, ce qui limite considérablement le développement de la culture et augmente le coût de production. Les techniques de préparation du sol et d'entretien ne sont pas maitrisées et la récolte est très difficile.

Des fumures non determinées. Une fumure adaptée n'a pas été mise au point et on ne connaît pas très bien l'effet des précédents culturaux sur les rendements.

Insuffisance de la Technologie Post-récolte

Les connaissances sont insuffisantes en ce qui concerne l'utilisation des tubercules en alimentation humaine. La diversification est faible, qu'il s'agisse de la consommation des tubercules ou des feuilles.

Quant aux techniques de conservation des produits frais et transformés, elles sont faiblement développées.

Bilan de la Recherche

Peu de travaux de recherche ont été effectués dans le domaine de la patate douce.

Amélioration du Matériel Végétal

La patate douce constitue un terrain presque vierge où la connaissance du matériel végétal est très faible.

Il existe quelques cultivars de patate douce au Mali (4), mais il n'y a pas eu d'expérimentation pour déterminer leurs potentialité, par zone agro-écologique.

Objectifs de Recherche

L'objectif principal est d'accroître la contribution de la patate douce à la diversification de l'alimentation humaine. Pour atteindre cet objectif, il faut connaître les systèmes de production, rechercher des variétés performantes, mieux maîtriser les techniques culturales et la technologie post-récolte.

Projets et Opérations de Recherche à Long Terme

Sélection des Variétés Adaptées

-Sélection des variétés résistantes aux nématodes
-Sélection des variétés résistantes aux maladies virales, bactériennes et fongiques
-Rechercher des variétés tolérantes à la sécheresse
-Rechercher des variétés à chair jaune ou orange riches en vitamine A
-Rechercher des variétés non photosensibles
-Rechercher des variétés panures en sucre

Mise au Point des Techniques Culturales

-Détermination des doses de fumure organo-minérales adaptées
-Détermination des dates et des modes d'apport des engrais
-Etude des effets des précédents culturaux sur les rendements des tubercules
-Etude des systèmes d'association des cultures
-Détermination des densités optimales
-Inventaire des nuisibles
-Recherche des moyens de lutte efficaces et rentables
-Etude de la concurrence des adventices
-Tests d'utilisation des herbicides

Techniques de Conservation et de Transformation

-Etude des différents procédés de conservation des produits frais
-Détermination des qualités organo-technologiques
-Mise au point des techniques de transformation (tranche, cossettes, farines, etc.)
-Diversification de la consommation des feuilles

Projets à Court Terme

Dans le projet du programme de recherche de la patate douce on prévoit immédiatement de recenser, collecter et évaluer tous les cultivars locaux à fin de sélectionner les meilleurs. Dans le cadre de la réalisation de ce projet nous nous interreserons à la recherche de:

- Variétés riches en vitamine A (chair jaune ou orange)
- Variétés résistantes à la sécheresse et à la chaleur
- Variétés non photosensibles
- Variétés pauvres en sucre

Conclusion

Le programme de recherche de la patate douce est très énorme, et pour le réaliser il nous est indispensable d'établir une collaboration constante avec des institutions internationales tel que le CIP, et aussi avec les autres programmes nationaux pour échanger, d'expérience et de matériels améliorés de plantation. L'accent est à mettre également sur la formation du personnel qui s'occupera de ce programme.

STATUS OF SWEETPOTATO PRODUCTION AND RESEARCH IN NIGERIA

F.M.O. Agbo and L.S.O. Ene

Introduction

Sweetpotato (*Ipomoea batatas*) (L.) Lam. is an important staple food crop, particularly in northern Nigeria where most of it is produced. It is one of the six important root and tuber crops grown in Nigeria for which the National Root Crops Research Institute, Umudike, has developed a research programme. The others are cassava, yam, Irish potato, cocoyam and ginger. Nigeria produces about 0.2 % of the world's sweetpotato. Estimated production is about 0.26 million tonnes per year on about 20,000 hectares (Horton, 1988). These estimates are apparently low, yet Nigeria is one of the ten most important sweetpotato producing countries in Africa (see Table 1).

Sweetpotato has the highest solar energy fixing efficiency among the food crops, primarily because of its capacity to produce dry matter for a long time (Hahn, 1977). It is adaptable to tropical and sub-tropical climates and it grows under marginal conditions, being tolerant to drought, low fertility and low pH (Hahn 1977). The crop has a 4-months growth cycle, and two to three crops a year can be grown with supplementary irrigation. On a per hectare basis, average protein production is of the same order as cereals and beans (CIP, 1991 Annual Report).

The capacity for increasing sweetpotato production in Nigeria exists in terms of area under cultivation. Nigeria, a tropical country has an area of 923,768 sq. km. It is characterized by tropical rainforest in the south which stretches northwards into a forest-savanna transition belt beyond which lies the wide, and drier savanna region of the north. An important geographical feature in the northern savanna region is the central, cool, temperate Jos Plateau region (average height 606 m.).

Given the needed supports for research, development and production, sweetpotato could contribute more to the Gross National Product of Nigeria, with significant economic impact. The change could be dramatic. The ten most important sweetpotato producing countries in Africa are all in the sub-Saharan region. A comparison of the FAO production data between the three-year periods, 1961-1963 Vs 1986-1988, showed that both total production and area under cultivation in sub-Saharan Africa increased significantly by 83.1 % and 87.2 % respectively (CIP, 1991 Annual Report). This highlights the importance of international collaboration in programmes geared toward effective diagnostic survey, collection, conservation, development and utilization of sweetpotato germplasm in Nigeria.

Table 1. Sweetpotato Production/area (000t) and (000ha). 1985, World, Africa (Nigeria etc.) North and Central America, South America, Asia (China), Europe Oceania (Papua N. Guinea).

Country	Production of World	% Production	Area under of World	%
World	110,842		7,913	
Africa	6,305	5.7	1,100	13.9
Angola	180	0.2	19	0.2
Burundi	520	0.5	78	1.0
Cameroon	140	0.1	37	0.5
Kenya	280	0.3	30	0.4
Madagascar	450	0.4	91	1.2
Nigeria	260	0.2	20	0.3
Rwanda	900	0.8	100	1.3
Tanzania	530	0.5	84	1.1
Uganda	2,000	1.8	450	5.7
Zaire	360	0.3	72	0.9
N/C America	1,495	1.3	213	2.7
S. America	1,365	1.2	152	1.9
Asia	101,001	91.1	6,321	79.9
China	90,000	81.2	5,000	63.2
Europe	110	0.1	10	0.1
Oceania	586	0.5	117	1.5
Papua N. Guinea	469	0.4	103	1.3

Source: FAO, Basic Data Unit (unpublished) from Douglas Horton, Underground Crops, 1988

History, Production, Consumption and Economic Importance of Sweetpotato in Nigeria

Sweetpotato is not indigenous to Nigeria but originated in tropical Central or north-western South America (Onwueme, 1978; Hahn and Hozyo, 1984). It was probably brought to Nigeria by Spanish and Portuguese explorers. Today sweetpotato is systematically planted as the sole or mixed crop and is given proper crop management by farmers in Delta and Rivers States on the banks of the River Niger, as well as in all parts of northern Nigeria.

In terms of total production and consumption sweetpotato is presently considered a minor crop. In most localities it is intercropped with major crops such as sorghum, maize, cassava, yam, cocoyam, and millets. The average yield under local conditions is 4t/ha (Chinaka, 1983). But the national average has been estimated to be 13t/ha (Horton, 1988). Of the estimated 200 million tonnes of all roots and tubers produced annually in Nigeria between 1983-1985, sweetpotato contributed only 0.26 million (0.13 %) on 20,000 ha (Horton, 1988). About 90 % of production is locally consumed by humans and livestock and 10 % is wasted. At present sweetpotato does not earn foreign exchange for Nigeria.

Production and Utilization Constraints

Sweetpotato production, unlike yam and cassava production, can be mechanized, and the crop requires little attention. Labour and production costs are low, compared with other crops (Hahn, 1977). However, serious factors limit the production and utilization of the crop in Nigeria.

Food Habits

Nigerians in the south obtain their food energy mainly from cassava, yams, plantain, rice and cowpeas. The main sources of carbohydrate energy among the northerners are obtained from cassava, yam, sorghum, rice, millets and cowpeas.

Farm Inputs and Ineffective Extension Services

Inputs such as fertilizers, insecticides/other chemicals, and tractors/implements are not readily available. Extension agents pay minimal attention to farmers. In 1975/76 the average ratio of extension staff to farmers in Nigeria was 1:2321, compared to 1:191 for the Netherlands (Okereke, 1981). The situation has not changed much since then.

Pests and Diseases

Yield losses of sweetpotato caused by Cylas puncticolis can be as high as 80 % (Nwana, 1977). Weevil damage increases with decreasing soil moisture and timely harvesting is recommended. Selection for early maturity is needed.

Storage and Marketing Problems

Like all roots and tubers sweetpotato tubers have a short storage life. Bruising during transportation and marketing reduces the quality and predisposes the product to attack by pathogens.

Maintenance of Adequate Planting Materials

Sweetpotato is vegetatively propagated. The varieties have to be sustained through the dry season in Nigeria by expensive irrigation. Virus-free planting materials are obtained through costly *in vitro* tissue culture.

Consumption Pattern, Processing and Utilization

Food and Industrial Raw Materials

In Nigeria, most people consume boiled sweetpotato tubers as food. Fried slices or chips and roasted tubers are also eaten. Sometimes, the tubers are eaten in the form of pounded fufu (dough). Sweetpotato flour can be prepared from dried chips and the flour is usually reconstituted into fufu. Bakeries now blend 15-30 % sweetpotato flour with wheat flour for baking bread, and 20-30 % sweetpotato flour for pastries. Baby food has been formulated using sweetpotato flour. In northern Nigeria sweet varieties are used as sweeteners, taking the place of sugar. The tubers are also utilized in the brewing of local alcoholic beverages. The leaves are eaten as vegetables.

Except for sweetening food, most consumers do not distinguish between either the hard, mealy, more starchy types and the soft types which contain more sugar and protein and have a higher gel strength. The consumer just purchases what is available in the market.

Preparation of industrial starch from sweetpotato is limited in Nigeria. In Japan or China, sweetpotato starch is produced industrially for paper, textile and alcohol production as well as for producing adhesives (Lu *et al.*, 1988; Sakamoto, 1988). Selection for starch content and quality, and sugar and protein content is therefore necessary.

Canned or frozen sweetpotato, and sugar syrup from sweetpotato are not usually produced in Nigeria, as they are in the USA.

Livestock Feed

Unmarketable tubers, peels and leaves are fed to pigs, rabbits, poultry, cattle, sheep and goats in Nigeria. The potential exists for using peels and tubers in the feed industry (Tewe and Ologhobo, 1984). The leaves, which contain 24-34 % protein can be incorporated into feed formulations or for grazing.

Pharmaceuticals

The use of sweetpotato for pharmaceuticals is a possibility in Nigeria. Sweetpotato tubers contain high amounts of vitamins, such as riboflavin, and ascorbic acid (vitamin C). The yellow-fleshed varieties are good sources of carotenoids or vitamin A.

Prospects for the Future

It has been shown that the potential for increased sweetpotato production and utilization exists in Nigeria. A diagnostic research survey of these potentials should be conducted and documented. This would assist in the effective research, development and production of sweetpotato in Nigeria. Improved varieties and research findings available at the National Root Crops Research Institute, Umudike, and at the International Potato Centre (CIP), Lima, Peru could be harnessed to realize the useful role that sweetpotatoes can play in meeting the future food, feed, and industrial raw material needs of Nigeria. It would require well-funded, collaborative activities.

It has been suggested that, in order to successfully adopt this approach, the following organizations are needed (Ene *et al.*, 1986):

1. an effective group of research workers and technicians;
2. a seed certification organization;
3. a seed growers association to supply adequate pest/virus free planting materials over the dry season;
4. an organization for seed distribution; and
5. an organization for root tuber growers.

Highlights of Achievements 1972-1992

Germplasm Collection, Conservation and Evaluation

The NRCRI, Umudike, was established in 1972. Between 1972 and 1991 a total of 661 sweetpotato germplasm accessions were obtained from local sources in Nigeria and IITA, Ibadan, and screened. Top selections based on ecological adaptability, fresh tuber yield, dry matter, flour yield, starch yield, virus tolerance, Cylas spp tolerance, have varied over the years. Genetic erosion has been about 4 % annually, attributable to ineffective dry season conservation in the field.

Presently 208 accessions are being maintained under field conditions. In addition, 88, out of 99 original international *in vitro* entries collected from IITA in 1990 are still being maintained in the NRCRI tissue culture laboratory. Hardening of some of these *in vitro* accessions for field screening to increase the germplasm base for breeding work, is being carried out this year. Arrangements to prevent further losses of germplasm materials through effective irrigation during the coming dry season are underway.

The data in Tables 2-4 show screening results in 1990-1991. Table 5 shows the most popular selections and their origins. These have exhibited more consistent vigour, drought tolerance and high yield.

Table 2. Flour and Starch Yield in Five High Yielding Cultivars of Sweetpotato in 1990.

Cultivar	Boiled root tuber texture	% Flour	%Starch	% Peel Loss	Deserible Traits	
					Epiderm	Flesh
TIS 8441	Soft	26.70	25.04	28.30	Yellow	White
AK/83/7	Soft	33.04	23.08	28.76	Purple	Light Orange
TIS 2534	Mealy	28.27	24.34	26.18	Purple	Orange
TIS 8504	Non Sweet Soft	18.59	20.98	29.74	Purple	Orange
TIS 87/0087	Mealy	29.29	24.63	21.79	Pink	Cream

Table 3. Selected Accessions With Tuber Yields Above 10.0 t/ha. in 1990.

	Yields t/ha.		% Cylas	%	
	Tuber	Vine	Infestation	D.M.	Starch
TIS 2498*	40.9	21.0	0.0	37.5	16.4
TIS 87/0087*	23.1	9.9	0.0	38.3	14.4
TIS 8164	21.8	1.3	3.1	31.6	16.8
TIS 2534*	20.5	2.6	0.0	36.0	14.7
TIS 8504*	19.8	6.6	26.7	31.6	15.3
TIS 81/647	17.2	0.0	42.9	34.8	17.5
TIS 86/0228	17.2	0.0	0.0	39.2	16.5
TIS 80/019	16.5	16.5	33.3	36.3	16.5
TIS 8/637	15.3	15.8	5.2	34.4	14.3
TIS 87/0140	14.5	15.2	0.0	37.0	14.7
TIS 87/0255/2	14.2	11.9	5.6	33.5	16.3
TIS 87/015	13.9	1.9	0.0	37.2	28.4
TIS 8524	11.9	9.9	16.7	34.7	15.3
TIS 8441*	11.9	33.0	0.0	36.3	21.3
TIS 4	11.2	1.3	0.0	36.3	21.3
TIS 3259	10.6	3.3	40.7	32.4	15.2

* Selected in 1989 for high yield: AK/83/7 was also selected in 1989 but not as consistent as the other above.

Table 4. Sweetpotato Selections from 1991 National Root Crop Research Institute Umudike Germplasm.

S/No	Variety Accession	Av. Yield/ha	Std. Error	Root Epiders	Colour Tissue	Virus Score	Cylas	Flowering
1	TIS 87/0087	47.48	12.98	Pink	White	2	1	None
2	TIS 1170	36.85	12.65	Purple	White	1	3	None
3	TIS 87/0183	24.50	5.2	Yellow	White	2	1	Profuse
4	Ex-Duncan	23.98	5.18	Orange	Orange	1	2	Profuse
5	TIS 8337	21.60	19.94	Yellow	White	3	1	Profuse
6	TIS 80/047	19.75	2.34	Pink	White	2	1	None
7	PR 2	17.8	2.0	Purple	White	1	1	Scanty
8	BIS 31	16.75	6.85	Yellow	White	1	1	Scanty
9	TIS 87/0255/2	16.50	16.5	Purple	White	1	2	None
10	OCH/83/14	16.15	0.35	Yellow	Yellow	1	2	Profuse

Table 5. Top Six Potato Selections Exhibiting Consistant Good Vigour, Drought Tolerance and High Yield(t/ha), and Their Origin

Entry	1989-1991 Average Yield	Origin Trait	Distinct
1. AK/83/7	15.3	NRCRI Umudike	purplish petiole, purple stem
2. TIS 87/0087	31.9	IITA Ibadan	bunchy habit, less spreading smaller leaves
3. TIS 2498	30.7	-do-	older stem green
4. TIS 8504	2[illegible].2	-do-	palmately divided leaves, linear fingered
5. TIS 8441	20.3	-do-	non-flowering at Umudike
6. TIS 2534	17.5	-do-	Stem apex purple, immature apical leaves purple

Breeding

A breeding cycle, involving a half-sib family selection scheme (see Table 6) was initiated in 1991, using 15 selections for population improvement. The scheme aims at increasing population means, and retaining a high degree of genetic variability through continuous cyclic evaluation, selection and recombination. The 1992 cycle has been planned with 10 selections which in 1991 indicated high self-and/or cross-compatibility. Self/cross-incompatibility is a serious problem in sweetpotato breeding (Fehr and Hadley, 1980).

Agronomic Practices

Investigations to determine the causes of yield depression over time were initiated in 1991 at Umudike (rainforest) and at Otobi (savanna).

Collaboration with International Institutes

i) IITA, Ibadan, Nigeria

NRCRI/IITA collaboration in sweetpotato research has existed since 1972. It has involved germplasm exchange and clonal evaluation. In 1991, 169 new clones from IITA were screened at Umudike.

Table 6. Sweetpotato Hybrid Seed Production in 1991 at National Root Crops Research Institute Umudike.

S/N	Crossing Block No.	Parents In Crossing Block A Female	B Male	No. of Seed Collection From Parents A	B
1	No. 3	TIS 87/0087	TIS 2498	66	-
2	No. 4	AK/83/7	TIS 2498	20	10
3	No. 10	AK/83/7	AK/83/7	-	5
4	No. 11	GR-1-9-10	GR-1-9-10	-	257
5	No. 12	TIB 2	GR-1-9-10	138	26
6	No. 13	TIS 87/0057	GR-1-9-10	202	324
7	No. 14	TIS 8/637	GR-1-9-10	-	86
8	No. 16	TIS 2498	GR-1-9-10	-	86
9	No. 18	TIS 87/0087	GR-1-9-10	-	66
10	No. 19	AK/83/7	GR-1-9-10	5	45
11	No. 21	TIB 2	TIS 87/0057	150	-
12	No. 22	TIS 8/637	TIS 87/0057	16	-
13	No. 23	TIS 81/663	TIS 87/0057	76	56
14	No. 26	TIS 87/0087	TIS 87/0057		51
15	No. 27	AK/83/7	TIS 87/0057	-	40
16	No. 28	TIS 81/663	TIS 81/663	99	57
17	No. 29	TIB 2	TIS 81/663	11	23
18	No. 30	TIS 81/637	TIS 81/663	-	33
19	No. 32	TIS 2498	TIS 81/663	11	23
20	No. 34	TIS 87/0087	TIS 81/663	-	40
21	No. 35	AK/83/7	TIS 81/663	4	-
22	No. 37	TIB 2	TIS 87/0255/2	252	-
23	No. 38	TIS 87/0057	TIS 87/0255/2	50	-
24	No. 39	TIS 8/637	TIS 87/0255/2	31	38
25	No. 42	TIS 87/0087	TIS 2358	-	20
26	No. 44	OCH/83/16	TIS 2271	21	-
27	No. 46	TIS 81/188	TIS 2271	21	-
28	No. 47	OCH/83/16	GR-1-9-10	66	33
29	No. 48	TIS 2358	GR-1-9-10	14	48
30	No. 49	TIS 81/188	GR-1-9-10	43	115
31	No. 50	OCH/83/16	TIS 87/0057	88	61
32	No. 51	TIS 2358	TIS 87/0057	16	37
33	No. 52	TIS 81/188	TIS 87/0057	109	114

ii) CIP, Lima, Peru

NRCRI/CIP collaborative research and programmes for germplasm exchange were initiated in 1992. In July 1992 advanced yield trial and clonal multiplication to be sponsored by both institutions was set up at Umudike and at Vom, a cool, high altitude plateau. Four selections-TIS 87/0087, TIS 2498, TIS 8441 and AK/83/7, were used for the advanced yield trials. In addition to the above varieties, TIS 8504, TIS 2534 and 70314 are being multiplied in both locations for uniform trials next year in four or more locations across Nigeria, geared towards official release of recommended varieties. As TIS 8441 does not flower at Umudike, flowering/fruiting in Vom will be observed.

Other Services

Since 1991, the sweetpotato programme has met the needs of the NRCRI Farming Systems Research Programme for on-farm research with the ADPs of the south-eastern zone of Nigeria. This year, the Adamawa State (drier savanna) has collected 4000, 4-node cuttings for its trials, and to date the programme has supplied 13,610, 4-node cuttings to other private institutions and farmers in the south-eastern zone.

It is hoped that the interest of farmers and government agencies in the sweetpotato crop will be sustained to the extent of funding research on the crop. Commercial production and industrial utilization of sweetpotato products will raise the economic status of the crop and help to feed the 88.5 million people of Nigeria.

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HISTORY AND IMPORTANCE OF SWEETPOTATO IN CAMEROON

Ambe Tumanteh Jerome

Abstract

Sweetpotato is grown and eaten in all the agro-ecological zones of Cameroon. Until recently, it was not regarded as an important staple in the diet of Cameroonians. Constraints to production have been mostly solved through a concerted research approach. Three varieties, Tib 1, 1112 and Tis 2498, that are tolerant to prevalent pests and diseases, are higher yielding than existing local varieties, are well adapted to the environment and which satisfy consumers' taste preferences, have been selected. These are now found in the prepared dishes of rural and urban dwellers. The demand has been astronomical.

Improved cultural techniques have been developed, tested in farmers' fields and promoted. Basic seed material has been multiplied on-station and distributed to farmers. Some extension agents and model farmers have been trained in the production of sweetpotatoes. Educational materials have been developed and given to growers as a guide to crop production.

Sweetpotato production has increased. Major constraints are the lack of post-harvest technologies which can help preserve the fresh tubers or transform them into other products. The lack of organized markets is an important constraint. Sweetpotato has however, now provided employment to some growers in several areas of Cameroon. Research emphasis is now concentrated in areas of priority interests, of which the main priority is post-harvest technology development.

Introduction

Cameroon has varied agro-ecological zones; from rainforest to steppe; altitudes of 0-4000m and an annual rainfall of 400-12,000mm. Soil fertility varies from very poor, sandy, sedimentary soils to very rich, volcanic soils. This has led to the classification of Cameroon into five major agro-ecological zones (Fig.1) based on climate, phytogeographic factors and altitude, which principally determine the biotic production constraints of food crops (CNRCIP, 1982).

Root and tuber crops are a major energy source for more than 70 % of the population. They occupy 16 % of the total land area cultivated for food crops (Government of Cameroon, 1985). A preliminary survey carried out in Cameroon on root and tuber crops (CNRCIP 1981) showed that they are grown and eaten in all the five ecological zones (Table 1). Sweetpotato is one of the five major root and tuber crops grown and eaten in Cameroon; i.e. cassava, yams, cocoyams, sweetpotatoes and potatoes.

Table 1. Importance of the Different Root and Tuber Crops in the Five Agro-ecological Zones of Cameroon.

Root and tuber crops	Agro-ecological Areas						
	I	II	III		IV	V	
			A	B		A	B
Cassava	xx	xxx	xxx	xxx	xxx	xx	x
Macabo	xxx	xxx	xxx	xx	x	x	
Taro	xx	xxx	xx	xx	x	x	
Yam	xxx	xx	xx	xxx	x	xx	
Sweetpotato	xx	xx	xx	xx	xx	xx	x
Irish potato	xx				x		

The presence of the crops is indicated as follows:
x : sometimes; xx: quite frequent; xxx: abundant
(Adapted from E. Westphal *et al.* (1981): L'Agriculture autochtone au Cameroun).

Sweetpotato is grown over a wide range of environments between latitude 40° N and 40° S and from sea level to 2300 meters (Hahn, 1977). It has a tremendous potential to be an efficient and economic source of food and animal feed. It is a good source of provitamin A, vitamins B and C, calcium, iron, potassium and sodium (Alvarez, 1986). Sweetpotato has a high yield potential within a relatively short growing period and adaptability to wide agro-ecological zones.

Sweetpotato was first regarded as food for children and dogs, probably because of its sweetness and soft texture. There exist local cultivars that vary in tuber skin colour ranging from white through pink to red. The tubers are the major economic portions of the plant but in some areas where vegetable production is low, the young leaves are eaten as vegetables, and the vines are sometimes fed to animals. Sweetpotato is generally grown on ridges or mounds, in association with other staples or on small patches of land in monoculture (Ambe, 1987). Cropping cycles vary with ecologies and varieties. The cycles get longer at higher altitudes and are also reflective of the culture of the people. Basically, sweetpotato has one cropping cycle in areas with short periods of rainfall and two in areas of rainfall lasting more than seven months.

Sweetpotato Production in Cameroon

Annual production of sweetpotato in Cameroon had been low due to lack of improved varieties, susceptibility of local cultivars to diseases and pests and the use of unimproved cultural practices. The unavailability of improved varieties adapted to local growing conditions, resulted in low yields. The realization of the nutritive value of sweetpotatoes and the availability of higher-yielding improved varieties, that are tolerant to prevalent pests and diseases and satisfy the consumer's taste preferences, have led to increased demand and production with an estimated growth rate of 5.8 % from 1984/85 to 1990/91 (Table 2).

Table 2. Production Estimates of Starchy Food in Cameroon (1 000 tons).

	1984/85	86/87	90/91	% Growth rate
Plantain	1001	1063	1224	3.4
Banana	703	739	815	2.5
Manioc	1375	1458	1660	3.2
Sweetpotato	50	56	70	5.8
Yams	96	107	132	5.4
Macabo/Taro	188	193	237	3.9
Solanum Potato	42	47	60	6.1

Source: Cameroon 6th. Fifth-Five Year Development Plan, 1986-1991.

Production Constraints in Cameroon

Sweetpotato production in Cameroon is constrained by the lack of improved varieties and cultural practices and by the susceptibility of varieties to pests and diseases. The severity of these constraints varied with ecologies and the priority given to the most important agro-ecological zone (Table 3). The most important disease was the sweetpotato virus disease (SPVD) while the weevil (*Cylas* spp) constituted the most important pest.

Table 3. Potato Constraints Level of Priority in the Five Agro-ecological Zones in Cameroon.

Crops	Zones				
	I	II	III	IV	V
Sweetpotato					
Diseases:					
SPV	xx	xxx	xx	xx	xx
Leaf spot		xx			
Pests:					
Weevil (*Cylas* spp.)	x	x	x	xx	xx
Solanum potato					
Diseases:					
Blights, fungal	xx	x		xx	xx
Bacterial	x	xx		x	
Improved varieties	x	x	xx	xx	xx
Lack of planting material	xx	xx		xxx	xx

Legend: x = low priority; xx = medium priority; xxx = high priority

In 1978 the Cameroon National Root Crops Improvement Programme (CNRCIP) started research on sweetpotatoes, looking for solutions to identified problems. Priority was given to problems of economic importance: superior clones with high stable yield performances, good root characteristics, acceptability and high level of tolerance to SPVD and weevil. Clone Tib 1, originating from IITA, performed very well under all agroecologies. Clone Tis 2498, imported from IITA as tissue culture material, showed excellent performances in lowland (zones II and III) while the

CNRCIP selected clone (1112) performed best in the mid and high altitudes (zones I, III and IV). With these achievements, regionally adapted cropping techniques to optimize the yield performances of the improved materials have been developed, with bulletins published for growers.

Improved cropping techniques have been verified, demonstrated and generated at the farmers' level. Training of extension agents and pilot farmers in sweetpotato production has been carried out in some zones (Table 4). On-station and on-farm multiplication and distribution of planting material has also been carried out with 4,436,000 cuttings provided. These are enough to plant 189 hectares (Table 5). This trend of increased planting material distribution and planted area is continuing, with a resulting increased production. This has led to a major production constraint which is a lack of post-harvest technology in sweetpotato.

Table 4. In-country Training for Extension Agents and Farmers (1986-1989).

Year	Zone	Courses	Extension agents	Farmers
1986	I	-	-	-
	II	1	25	-
1988	I	1	65	-
	II	15	51	564
	IV	5	30	215
1989	I	4	5	240
	II	27	319	891
	IV	4	5	155
Total		57	500	2065

Table 5. Number of (a) Sweetpotato Vines (x 1,000) Produced and Distributed and (b) Estimated Farm Area Planted (ha).

Research Station		1986/87	1987/88	1988/89	3 year total
EKONA	(a)	136.00	1102.00	-	1238.00
	(b)	6.80	55.10	-	61.90
NYOMBE	(a)	505.00	704.00	-	1209.00
	(b)	25.25	35.20	-	60.45
NGAOUNDERE	(a)	739.00	788.00	350.00	1877.00
	(b)	24.60	26.60	11.60	62.80
DSCHANG	(a)	50.00	63.00	-	113.00
	(b)	1.60	2.10	-	3.70
TOTAL	(a)	1430.00	2657.00	350.00	4437.00
	(b)	59.25	119.00	11.60	188.85

Source: Compiled from reports supplied by the Research Stations.
Note: The plant density in zone IV is 30,000/ha while in zones I and II, it is 20,000.

Sweetpotato is playing a vital role in the rural economies of Cameroon, especially in zone IV (Table 6). The sale of tubers supplies a substantial amount of money to the growers for their daily household needs (Ambe, 1991).

Table 6. Approximate Composition of Fresh Sweetpotato Tubers.

Factor	Percent of fresh weight
Moisture	50.00 - 80.00
Starch	8.00 - 29.00
Protein	0.95 - 2.40
Ether extract	1.80 - 6.40
Reducing sugars	0.50 - 2.50
Non-starch carbohydrates	0.70 - 7.50
Mineral matter	0.88 - 1.38
Vitamins	mg / 100 g fresh wt
Carotene	1.00 - 12.00
Nicotinic acid	0.90
B1 (Thiamine)	0.10
B2 (Riboflavin)	0.06
C (Ascorbic acid)	29.00 - 40.00

Source: Sweetpotato grower's bulletin Nº DUC/IRA/87/3 (1987).

Sweetpotato Consumption Patterns

Development of improved varieties with high consumer acceptance has resulted in increased consumption by all classes of people. Sweetpotatoes have high nutritional value . They are good sources of energy, supplying sugars and other carbohydrates. Calcium, iron and other minerals are found in sweetpotatoes. The popular orange-fleshed varieties, high in carotene, provide vitamins A and C (Table 6). The leaves are also a good source of energy and much richer in proteins, minerals and vitamins than the tubers (Table 7). Sweetpotato has become an important food crop in Cameroon and sweetpotato production has provided employment to many people in Adamaoua Province, where the crop is mostly grown for sale (Table 8).

Table 7. Approximate Composition of Fresh Sweet-potato Leaves on a Dry Matter Basis.

	%
Starch	8
Sugar	4
Real protein	27
Ash (mineral matter)	10
Carotene (mg/100 g)	56

Source: Sweetpotato Grower's Bulletin Nº DUC/IRA/87/3 (1987).

Table 8. Distribution of Farmers in Adamaoua Province According to Sales of Potatoes, Consumption, and Uses of Returns from Potatoes.

Variables and classes	Frequencies and cumulative frequencies [a]	
1. Sales		
Local markets	30	(30)
Urban markets	40	(70)
Road sides	27	(97)
In the field	3	(100)
2. Selling forms		
Sold as fresh storage roots	100	(100)
Sold in processed forms	0	(100)
3. Consumption		
10 % of produce	29	(29)
10 - 20 %	71	(100)
20 - 50 %	0	(100)
50 %	0	(100)
4. Uses of returns from produce		
Household necessities	10	(10)
Building houses	20	(30)
Purchase of livestock	25	(55)
School fees	3	(58)
Others	42	(100)

[a]Numbers in parenthesis are cumulative frequencies.

Sweetpotato Utilization in Cameroon

More than 80 % of the sweetpotatoes produced in Cameroon is used for human food, the rest is used for animal feed or industrial purposes. The fresh tubers are also processed into starch and other forms. Although sometimes consumed raw, the fresh tubers are usually boiled, baked, roasted or fried before being eaten.

Dried sweetpotato chips are a famine food security product common in the North-West, West and Adamaoua Provinces of Cameroon. Sweetpotato flour is used to make "fufu", which can be eaten with a sauce or mixed with other ingredients to make cake. A popular non-alcoholic beverage is made from sweetpotatoes in parts of the West, North-West and Adamaoua Provinces. The leaves are eaten boiled or incorporated into soup.

For Animal Feed

Limited quantities of sweetpotatoes are used as high- carbohydrate feed for cattle, poultry, goats and other domestic animals. They are mostly fed raw on farms where they are grown and most are offgrade and offsize roots not suitable for fresh market sale. The vines and foliage may be used as well, but not as widely. A satisfactory, nutritional silage can be prepared from vines, leaves and roots.

The extent to which sweetpotatoes can be fed raw to animals is restricted by the handling and storage problems resulting from the high water content, bulkiness and quick perishability of the fresh tubers. These limitations can be largely overcome by partly drying or dehydrating the material before storage.

For Industrial Purposes

Many industrial uses for sweetpotatoes exist. Sweetpotato starch is not yet produced in Cameroon. Although many processed products of sweetpotato are known, their production in Cameroon is limited. However, a few processed products do exist.

Sweetpotato Chips

The tubers are peeled, sliced, parboiled and dried in the sun. They can be stored for more than a year and eaten directly. This form, often used by travellers, is common in North-West, Adamaoua and the Northern provinces.

Other kinds of chips are prepared by cooking the peeled, washed, and sliced raw tubers in oil. They are drained, salted and eaten as desired.

Sweetpotato Cake

The fresh tubers are peeled, washed, grated and pressed to remove most of the liquid. The pulp is then pounded or ground to produce a paste which can be mixed with other ingredients, wrapped in leaves and steamed for an hour.

Sweetpotato Flour

The fresh tubers are peeled, washed, chipped and dried in the sun. The dried chips are pounded into a fine flour which can be used alone or mixed with other flours to produce "fufu".

Dolo

A non-alcoholic beverage which is popular in the North-West, West and Adamaoua provinces. Fresh tubers are peeled, sliced and dried for two days in the sun. They are then boiled with a limited quantity of water. The cooking water is filtered, cooled and consumed as a fresh drink.

Outlok of Sweetpotatoes in Cameroon

CNRCIP has selected sweetpotato varieties that have met the consumer's preference. They are also adaptated across growing zones, yield higher than local varieties and tolerate prevalent pests and diseases. Researchers are multiplying and distributing basic seed material. Farmer to farmer dissemination of the material is in progress. Planters' bulletins have been produced and distributed.

The major clones (IRA 1112 and Tib 1) have reached the farmers. They yield about 25 t/ha across five zones, compared to local varieties which average only 8.5 t/ha and up to 12 t/ha in zone II. These clones outyield the local ones by an average of more than 130 %. In zone II, on-farm trials have given marketable yields as high as 28 t/ha, under farmer's management. While these two clones have been adopted by farmers in all growing zones, a third clone (Tis 2498) is best suited to zone II. With the planting of about 189 ha of land to these clones in Cameroon (Kamajou, 1989), production is expected to increase tremendously.

The annual rate of increase between 1986-1988 is estimated at 85 % for the material distributed by the research institute. The farmer to farmer diffusion of the planting material is by far more important and was estimated in 1987/88 to exceed by 90 % the material supplied by research stations. This farmer to farmer distribution will likely bring about an annual rate of increase of about 235 % (CNRCIP, 1990). About 43.5 % of farmers and urban consumers are reported to have increased sweetpotato consumption due to better taste and cooking quality.

The 189 ha planted to sweetpotatoes would produce about 236 million FCFA (Kamajou, 1989). This indicates how much could be realized in growing sweetpotatoes for 4-5 months. Sweetpotato can produce high yields in a short time. Their carbohydrate yield in four months is more than that of yams in seven months.

Although sweetpotato requires little labour, it can be easily mechanized. This is not true for other root crops (Onwueme, 1978). The demand for sweetpotato can be stimulated by creating a better image and by developing new handling techniques and marketing channels. Its use as animal feed can be increased through new processing technologies. The limited use of sweetpotatoes in baby foods can be improved. Development of improved storage systems will increase production. The potential for sweetpotatoes in industrial use is limited by the high relative cost of producing the necessary products. The greatest problem hampering sweetpotato production in Cameroon is the lack of post-harvest technology development. Once this is overcome consumers will have access to all forms of sweetpotato throughout the year. With these realizations, future research work will be concentrated on identified disciplines based on zonal requirements (Table 9).

Table 9. General Overview of CNRCIP's Sweetpotato Improvement.

	78/79 80 81 82 83 84 85 86 87	Agro ecological zones
1. VARIETAL IMPROVEMENT	_==========================------------------------	All zones
a.Breeding		
b.Selection	___________________________----------------------	
c.Multilocational yield trials	____________________________-----------------	
2. AGRONOMY	--------______________________===========________	All zones
a.Cropping techniques	___________================___	
b.Fertilisation	______========_	II IV (All zones)
3. PROTECTION	---__________--	
a.Weevil	---___________ ________	
b.Leaf spots	----------------------------	
4. POST HARVEST	------____	All zones
a.Acceptability	------_______________________________ __________	All zones
b.On-farm	________________________	
c.Processing	-------------______	
PREVULGARISATION	-------_____========================	All zones
a.Improved clones	-------_____=================_______	
b.Cropping techniques	=============_______	
c.Post -harvest	_______	
d.Multiplication	==================	

The Author's Contributions to the National Sweetpotato System in Cameroon

Since 1980, work has been conducted on developing improved cultural practices for sweetpotato production. With the development of three improved varieties by the CNRCIP, there was need for improved cultural practices to increase or sustain production. Agronomic work has been conducted in the following areas:

Cropping Pattern

Sweetpotato can be grown alone or it can be grown in association with other food crops like cocoyams, cassava and cereal grains (Ambe *et al.*, 1991). The crop fits into many rotational systems. Continuous cropping on the same land is not advisable so as to avoid disease/pest build-up.

Recommended Varieties

The performances of the three improved recommended varieties varies with the ecological zone (Table 10).

Table 10. Sweetpotato Recommended Varieties per Ecologial Zone and Number of Crops per Year.

Variety	Ecological zone	Number of crops/year
Tib 1	Zones I - V lowland and highland	2 crops in zones I - III 1 crop in zones IV - V
Tis 2498	Zone II lowland and volcanic soils	2 crops
1112	Zones I - V mid and high altitudes	2 crops in zones I - III 1 crop in zones IV - V

Planting Density

The three improved sweetpotato varieties recommended for Cameroon are creeping types with broad leaves. A plant population of 20,000 - 30,000 per hectare is recommended for monoculture. However, as the plant population increases above 20,000 plants/ha, total tuber yield is not significantly affected but tuber sizes decrease (Ambe and Lyonga, 1986). The plant population could drop below 20,000, depending on the crop type and the number of associated crops.

Planting Material

The use of 30 to 40 cm-long vine cuttings has been recommended. There is a reduction in the quality of the planting material from the tip of each vine to its basal portion. The use of good-quality planting material, which is disease and pest free is advised. Where dry spells precede planting, quality planting material can be maintained in swampy areas, by river sides or by using irrigation.

Planting Method

It is recommended that 2/3 of the vine length (about 10 cm) be buried, ensuring that many nodes are put into the ground, with the soil firm around them. This will ensure that more tubers emerge from the nodes. The vine cutting should be prepared 1-2 days before planting and kept well covered under cold sheds.

Weed Control

Sweetpotato fields should be kept weed free for the first 1 1/2 months. When the vines have spread out, further roguing of weeds may be necessary. Higher plant densities create a quick ground cover, smoothering weeds faster. Moulding may be necesary where cracks appear due to bulking of tubers. This is particularly important for crops that mature into the dry season, to avoid weevil damage. Research work needs to be carried out to establish appropriate herbicide recommendations.

Fertilization

There is no doubt that sweetpotato will respond to fertilizer application. Due to the varied nature of the soils in Cameroon, fertilizer recommendations should be zone/soil type specific. Research needs to be done in this area so that recommendations can be made to growers.

Pests and Disease Control

The sweetpotato is attacked by a number of pests and diseases. The major ones include:

a) The sweetpotato weevil (Cylas spp.)
The weevil attacks both the vines and tubers by boring holes and laying eggs within them before dying. This attack is more serious for the crop that matures into the dry season.

Control

The varieties recommended for Cameroon are tolerant to the weevil. Crop rotation, where land is available, is advisable. Only clean materials should be planted. Ridges should be moulded when cracks appear or when tubers are exposed. All tubers in the soil should be harvested. Harvesting should not be delayed as this will increase weevil infestation. The use of chemicals has not yet been developed for Cameroon.

b) Sweetpotato virus disease (SPVD)
This disease, which attacks the crops mostly during the rainy season is transmitted by a white fly. The population of the vector is known to drop in the dry season.

Control

The varieties recommended for Cameroon are known to be tolerant to SPVD. The use of clean planting material or of resistant varieties is recommended, as is roguing and burning of infected plants. The use of chemicals has not yet been developed for Cameroon.

Harvesting

Signs of maturity include yellowing and senescence of leaves, dying of vines and sap exudation from the necks of tubers and at the crown of vines. To harvest, the initially planted vine should be cut off at the crown adjacent to the ridge or ground. The ground is carefully opened up and the roots are dug up avoiding bruising. Harvesting tools differ with the culture of the people. Large scale producers leave the harvested tubers on the ground to cure. Care should be taken not to skin the tubers as this predisposes them to diseases and insect attack.

Storage

Disease/pest free and unbruised tubers are sorted and left in the sun to cure for four to six hours before being transported and stored. Many storage methods exist, but the most common in Cameroon is to spread the tubers on a dry, cold floor or shelf until needed. This is mostly for short durations of two to three months. Regular inspection should be made to remove rotting tubers and sprouts.

The clamp system is also used in the drier areas of Cameroon. A pit of about 0.5m x 0.5m x 0.5m is dug in the ground and lined with dry grass. Sorted tubers are cured, packed in the pit and dusted with woodash up to 20 - 25 cm from the ground level. These are covered lightly with dry grass and topped with soil. Waterproof material should be used to cover the pit. This practice of storing tubers for well over 4 months, is common with small growers.

Extension agents and pilot farmers have been trained in the production of sweetpotatoes. Planters' bulletins have also been prepared and released to farmers as guides. With these achievements, sweetpotato production in Cameroon will increase but post-harvest technology still needs serious attention.

Table 11. Agricultural Calender for Sweetpotato Production in Cameroon.

Zone	Date of land preparation	Planting date	Harvesting date	Cropping cycle (4 - 5 months)
I	February	March/April	July/August	1st crop
I	June/July	August/Sept.	Dec./Jan.	2nd crop
II	February	March/April	July/August	1st crop
II	June/July	August/Sept.	Dec./Jan.	2nd crop
III	February	March/April	July/August	1st crop
III	June/July	August/Sept.	Dec./Jan.	2nd crop
IV + V	April/May	June/July	Sept./Oct.	1st crop

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SWEETPOTATO RESEARCH AT IITA: 1971-1987

JAMES ABAKA-WHITE

Introduction

Sweetpotato, (*Ipomoea batatas* L. Lam.), is a perennial crop which is used as an annual. It is grown over a period of three to seven months, depending on the cultivar and environmental conditions, between latitudes 40°N and 40°S and from sea level to 2300m (Hahn, 1977). It is drought tolerant and planted in relatively high rainfall areas but cannot tolerate water logging. Cultivated by subsistence farmers either as a secondary crop or in various associations, yields are reasonable even under low fertility and low pH soils. Production cost is relatively low, requiring little labour and external inputs from farmers. Two crops are possible in the humid tropics.

It serves as a major energy source for millions of people in the tropics and sub tropics. The leaves are often used as a vegetable providing proteins, vitamins and minerals. To a relatively small extent, sweetpotatoes are used as industrial raw material and livestock feed.

Among the root crops - cassava, yams, cocoyams and sweetpotato, sweetpotato production ranks third in the world and in sub-Saharan Africa (Hahn and Hozyo, 1984). Average world production (1975-84) was nearly 117 million metric tons on 9 million hectares, of which sub-Saharan Africa accounted for 4% of the production using 9% of the area. The average yield in sub Saharan Africa is about half that of the world (15mt/ha). However, yields of 40 tons of fresh tubers are possible (Hahn and Hozyo, 1984). Major producing countries in sub-Saharan Africa are Rwanda, Uganda, Tanzania, Burundi and Madagascar.

Production Constraints

Although sweetpotato is an important food crop, it has serious production constraints in the tropics. The major biological production constraints are the sweetpotato virus disease complex (SPVD), weevil and nematodes. SPVD reduces yields by up to 80% while weevils not only reduce yields (40%) of tuberous roots, but also that of leaves through reduction in quality at harvest and in storage. The market value is subsequently reduced.

Rapid physiological losses from high ambient temperatures affect stored tubers causing storage rots. Preservation of the vegetative planting material during long dry periods affects production. A major constraint to widespread production and consumption in some parts of Africa has been the unappreciated sweet taste of tubers.

Crop Improvement

The International Institute of Tropical Agriculture initiated sweetpotato improvement activities in 1971 with the following objectives:

1) Improving yields in terms of dry matter per unit of land and time.
2) Breeding for resistance to and cultural control of economically important diseases and insects.
3) Improving storage qualities.
4) Breeding for improved quality in terms of consumer acceptance, processing and nutritional values.
5) Breeding for wide adaptation.

Two goals were followed in the genetic improvement program: (a) a short term goal for development of high-yielding cultivars resistant to SPVD, weevil and nematodes, and (b) a long term effort to promote and develop a wider genetic base so that seeds can be evaluated and selected by national scientist under local conditions.

To fulfill the various needs of national programs through provision of diverse source material in seed form for selection under their conditions, a population improvement program was recognized as the most appropriate system to pursue. A recurrent selection scheme involving half-sib family testing with selection between and within families, followed by recombination among selected parents was supplemented by mass selection, and inter-varietal hybridization for the highly heritable characteristics. This was supported by pre-breeding activities using a multi- and inter-disciplinary team of physiologists, pathologists, nematologists, virologists and tissue cultural specialists. This system permitted improvement of genetic populations while retaining a very high degree of variability through continuous evaluation, selection and recombination.

Initial assemblage of source populations for the breeding activities was hampered due to restrictions placed on importation of vegetative material because of fear of introducing new diseases and pests into the country. Also, the lack of a world-wide sweetpotato repository for obtaining germplasm to augment the few local varieties then available in Nigeria, restricted initial activities. Germplasm in seed form was introduced from many countries in Africa, America and Asia as an alternative.

Several selected clones with good performance and high breeding values for the important traits were intercrossed to produce new source populations. A system to promote synchronous flowering was developed through overhead irrigation of selected parents in isolation. Then hand crosses were effected. Sparsely flowering clones were grafted on to *Ipomoea setosa*, Brazilian morning glory, and subjected to short days of 9 hours to induce flowering for subsequent seed production.

With the establishment of the tissue culture laboratory at IITA in 1977, studies were conducted on the etiology of SPVD complex and reliable virus indexing techniques were developed to ease restriction imposed on exportation and importation of vegetative material. The tests and techniques developed were fully endorsed by the African Phytosanitary Council of OAU and the Federal Quarantine Office of Nigeria. A collaborative agreement was established with the Research Institute from Plant Protection (IPO) in Wageningen, the Netherlands, to assist in germplasm exchange through tissue culture.

Selection

The standard selection procedure adopted was carried out over 7 years using 2 seasons per year. Preliminary observation plots were established in the rainy season of the first year, with about 10,000 seedlings raised in the nursery. In the second season (dry), the 10,000 resultant clones (two plants per clone) were planted in the field two months before the end of the rainy season and were left for an additional two months in the dry season. They were screened for resistance to viruses, weevil, drought, and tuber conformations.

In the first season (rainy) of the second year, about 500 selections were cloned and planted for clonal evaluation using single row plots 4m long and 1m between the rows, with 30 cm spacing between plants within the row. Every 10 clones standard variety was planted for comparison. The first year, evaluation for resistance to virus and weevil, and tuber conformation were reconfirmed. About 250 clones which were good in terms of establishment, growth, resistance to viruses and weevil were selected. In the dry season, the selected clones were replanted and screened for resistance to weevil, viruses, drought tolerance and for yield potentials.

In the first and second seasons of the third year, preliminary yield trials were conducted with 100 promising clones, planted in single row plots using four replications. Thorough yield evaluations were done, in addition to testing for resistance to viruses and weevil, percent dry matter and keeping quality.

In the first and second seasons of the fourth year, the best 25 clones selected from the preliminary yield trials were put in advance yield trials in two row plots (10m long and 1m apart) with four replications. Advanced yield trials were conducted in three locations covering a wide range of environments. Evaluations were done for yield, resistance to weevil and viruses, dry matter percent, consumer acceptance quality, adaptation and keeping quality.

In the first and second seasons of the fifth year, the most promising 15 clones from the advanced yield trials were tested in uniform trials in six locations within Nigeria, using two row plots and four replications. Testing sites included Ibadan, Warri and Mbiri in the region of moderate rainfall and soil fertility; Onne, located in the high rainfall zone on poor sandy soil; Mokwa, in the derived savanna with medium rainfall; and Zaria in the dry savanna zone. The clones were evaluated for yield, consumer acceptance, keeping quality and adaptation.

In the sixth year, the five elite clones were evaluated by farmers in on-farm trials. From the seventh year, the clones which were most popular with farmers were multiplied and distributed for popularization.

Accomplishments

The achievements of IITA on sweetpotato improvement during 1971-87, before primary responsibility for sweetpotato in the international agricultural research system was transferred to CIP in 1988, is summarized as follows:

Sweetpotato Virus Disease Complex

The sweetpotato virus disease complex was found to result from an interaction between two separately transmitted viruses, one white fly (*Bemisia tabaci*)-borne and the other being aphid (*Myzus persicae* and *Aphis gossypii*)-borne. The presence of one results in little or no economic loss and symptoms might not even appear. Plants with both viruses show symptoms of vein yellowing, puckering, leaf strapping, chlorosis, stunting, fan leaf or other symptoms. Spread of SPVD was normally through the vegetative propagation of sweetpotato, since transmission by vectors was extremely low.

It was determined that resistance to SPVD did not necessarily depend on resistance to the vectors, but was more closely associated with resistance to infection. Screening for resistance was thus based on a phenotypic expression of symptom incidence and severity and a core-grafting technique. Heritability of SPVD was found to be high (80%) using field tests, diallel crosses and core-grafting. Clones tested and found resistant were TIS 2498, TIS 3228, TIS 3053, TIS 2532, TIS 2534 and TIS 2544.

Since doubts lingered about the origin and spread of specific sweetpotato viruses, IITA scientists developed the virus indexing technique and used it in conjunction with a virus elimination method (meristem tip culture) to guarantee that improved sweetpotato clones that were distributed were indeed virus free. The guarantee was a prerequisite to international exchange of germplasm in vegetative form.

Weevil

Cylas puncticolis and *C. brunneus* were found to be the most serious of the six *Cylas* spp. known to attack sweetpotato in West and Central Africa. *C. formicarius* was mainly distributed in East Africa. Major economic losses result when the adults and larvae tunnel through tubers and cause rots due to secondary fungal and bacterial infections. At high populations during the dry season, damage to stems and leaves could reach economic levels.

Build up of weevil population is supported by the cultural practices used by the small-scale farmers. Planting is usually done about 2 months into the rainy season, exposing tubers to higher weevil populations at harvest-time in the dry season, since the hot, dry days cause soil cracking, providing easy access to tubers.

Over twenty clones were identified as having moderate to high resistance to *C. puncticolis*. These included TIS 3053, TIS 3030, TIS 3017, TIS 2532, TIS 8524, TIS 8266 and TIS 9172. Heritability for resistance to weevil was estimated as 0.84 for tubers and 0.79 for shoot. The clones have been cultured in vitro, virus indexed, multiplied and distributed in tissue culture form to national programs.

In addition to the resistant clones, other control measures were developed, based on an integrated pest management approach. Life cycle studies of *C. puncticolis* revealed that control was possible through early planting and harvesting, which exposed the tubers to low weevil populations. Re-ridging the crop 30-60 days after planting significantly reduced weevil damage. Females used tubers for oviposition rather than as a food source and laid eggs on stems during early growth. Leaves were essential to adult weevils for a balanced diet and older, lower stems were preferred to the younger, more tender parts of the plant. Larvae tunnelled through the soft pith and not the harder vascular bundles of the neck. Weevil populations changed with environment and were affected by root depth, soil type and season. Higher weevil populations were observed on clay than on sandy soils due to soil cracking, which offered more breeding places. However, the weevils did not stay deep beneath the ground.

Apart from the significant differences in resistance among clones, orange-fleshed clones were found to be more susceptible than white-fleshed clones. No relationship existed between weevil damage and root yield and storage root weight. Cultivars with high dry matter percentages and high starch content tended to be less susceptible to weevil attack. Varietal differences in oviposition, larval mortality and weevil growth indicated that antibiosis was the most probable mechanism behind resistance. A combination of these factors could increase the level of resistance against the weevil.

Large-scale production encouraged weevil population build up while crop rotation reduced the population.

Nematodes

The root-knot nematodes, *Meloidogyne incognita*, *M. javanica*, ***M. arenaria*** and ***M. hapla***, are serious sweetpotato pests in the tropics and subtropics. They feed on the fine roots, causing rotting and deformed tubers, either cracked or scarred. The estimated loss due to nematodes ranged between 20-30% depending on soil, cultivar and types of stress under which the crop is grown. Nematode populations varied yearly, however, and under high stress, growth of sweetpotato was severely affected. The traditional bush fallow systems practised in Africa tended to keep nematode populations below economically important levels. With reduction in bush fallow for continuous cropping, nematode problems are bound to increase.

Control methods which minimized farmer input, were developed, affecting the nematodes ability to feed, reproduce and survive. Hundreds of lines were screened and a total of 55 clones were found to have high resistance to root-knot nematode. Crop rotation, heat treatment through burning wood over a seed bed or solar heat trapped under clear plastic killed most nematodes to a depth of 30 - 40 cm. Hot water steeps and chemical dips of infected tubers helped control nematodes under post-harvest conditions.

Use of resistant cultivars in combination with any of the above-mentioned systems offered a highly effective means of controlling nematode populations.

Physiology

Studies on sweetpotato physiology and environmental factors which influence yield were conducted to aid in developing improved varieties and agronomic practices.

Four types of roots- young roots, fibrous roots, pencil-form roots and tuberous roots, form during growth. Dry matter production of the tuberous roots is the most important aspect of increasing sweetpotato yields. Radiation, temperature, moisture, nitrogen and potassium were the most important agro-climatic factors which affected dry matter production.

Because of its capacity to produce dry matter over long period of time, sweetpotato has the highest solar energy efficiency among food crops (Hahn, 1977). Cool nights (20°C) promoted initiation of tuberous roots and temperatures of 25°-30°C promoted their development (Kim, 1961). Both processes are limited at temperatures of 10 - 15°C (Spence and Humphries, 1972). Although sweetpotato is a drought tolerant crop, yields were decreased by the lack of soil moisture (Tsuno, 1981), while excess moisture caused poor tuberous root development and rotting (Ghuman and Lal, 1983). Dry weather favors tuber development.

Potassium (K) exerted the greatest chemical influence on sweetpotato yield (Tsuno, 1981), by accelerating the translocation of photosynthates from the leaves and shoots to the tuberous roots for bulking. Significant yield increases were obtained when potassium was applied to sweetpotato grown in soils with low exchangeable K (Juo, 1985). Sweetpotato responded to nitrogen (N) and potassium applications in highly weathered, lateritic soils. When sweetpotato plants became deficient in K the leaves turned pale or yellow with irregular leaf surfaces. The plant tended to produce more fibrous roots and yield was greatly reduced.

High N promoted leaf development. Nitrogen was most critical in the early leaf forming stages and less so when sweetpotato entered the tuber forming stage. The balance between N and K was important in maximizing sweetpotato yield. The limiting factor in maximizing dry matter production was the relationship between the source (leaves and shoots) and the sink (roots). Yield was reduced when either one of the factors was limited, because photosynthesis was reduced (Hahn, 1977).

The total dry matter yield of sweetpotato tubers depended on photosynthesis by the leaf canopy, the capacity of the plant to translocate assimilates from the leaf source to the tuberous root sink, and the capacity of the tuberous roots to accept assimilates (Hahn, 1982). Therefore, it was possible to genetically influence yield by selecting sweetpotato on the basis of its source and sink capacity. The clones which showed large sink capacity were TIS 70683, TIS 71102 and TIS 70357. Clones with large source potential were TIS 2497, TIS 3295, TIS 70995, TIS 71139 and TIb 2.

IITA scientists showed that cultivars with inherently large sink capacity responded more to differences in source than those with poor sink capacity. Conversely, scions with potentially high photosynthetic productivity were more affected by the capacity of the sink than those with limited productivity, (Hahn, 1977).

Results of these experiments indicated that sink (root) characteristics affected photosynthesis and translocation more than the source, and that sink capacity has a more regulatory effect on dry matter production and yield.

It is more difficult to attempt to select sweetpotato on the basis of source capacity or potential than to select on the basis of sink capacity (Hahn, 1982). The sweetpotato source is more complex than the sink and is affected by many genetic, physiological and environmental factors. Thus, IITA scientists used sink capacity in making breeding selections for sweetpotato improvement.

Storage

Sweetpotato tubers have a fairly short shelf life, sprout quickly after harvest and are susceptible to rot when weevil and nematode infestations are carried over into storage.

Leaving tubers unharvested to avoid storage problems was shown to incur losses ranging from 12-90%, due to weevil infestation. Harvested tubers infested with female and immature weevils serve as source of weevil infestation to other tubers when placed in storage together.

Temperatures affected the survival rate of weevils. Temperatures below 23°C extended the development period and lowered the survival rate, while temperatures of 27-34°C shortened the development period and increased the survival rate.

Underground storage was the easiest method devised. Under this storage system, pits were dug and lined with a layer of dried grass or leaves. A layer of sweetpotatoes treated with wood ash was placed on top of the dry grass, followed by another layer of dried leaves or grass and at least 5cm of soil. Tubers could be stored for two to three months under such conditions. Four precautionary pre-storage methods were developed to control infected tubers entering storage.

a) Immerse tubers in water for 24 hours and air dry.
b) Immerse tubers in hot water at 52°C.
c) Bury tubers under a light layer of soil for 3 days when soil temperatures are extremely high.
d) Place tubers in polyethylene bags and leave in the open air for 3 days.

Varietal differences in sprouting after harvest were found to exist. IITA selected varieties that could be stored without sprouting, under ambient temperature for about two months. TIS 2153, TIS 2532, TIS 2534 and TIS 3017 proved to have good storage quality. Breeding against weevil damage in storage still remains a problem.

National Program Development

In 1971, when IITA began its sweetpotato improvement program, there were no national sweetpotato programs in Africa. IITA encouraged the establishment of national root crops programs that have sweetpotato research as part of their mandate. Scientists and government officials were made aware of the benefits of increased emphasis on root crop production. When a country showed interest by providing financial and personnel support, IITA assisted with scientific and technical support. This assistance was aimed at strengthening the research capabilities of national programs by training research personnel, upgrading research facilities, and improving the quality of research. By the end of 1987, there were 27 national root crops programs in Africa, with numerous trained research personnel working in countries outside Africa.

Training played a central role in the development of sweetpotato improvement programs. At the end of 1987, 333 persons from 58 countries had participated in the root and tuber production and technology transfer course, 62 persons from 36 countries had participated in the tissue culture course while 87 participants from 13 countries took part in the rapid multiplication group courses. Hundreds of research and extension personnel have taken part in in-country training programs offered in collaboration with IITA. Eleven persons completed M.Sc. programs while eight completed Ph.D. work involving sweetpotato research.

National program staff learned the methodologies developed at IITA to handle improved breeding materials. They were then able to nurse the improved seed population and undertake the selection procedure to identify and select varieties suited to the environmental conditions and consumer preferences of their countries. As tissue culture (TC) material of new sweetpotato germplasm became available, they were sent to national programs.

No morphological differences have been observed in TC material, compared with the same material maintained in the field. However, significant differences in tuber yields and marketable tuber numbers were obtained. *In-vitro* material had higher yields and more marketable tubers. This was attributed to the virus-free status of planting material and was expected to decline over successive planting seasons, depending on disease pressure and variety.

The result of these efforts has been the widespread testing and dissemination of IITA improved sweetpotato varieties. Many national programs have gone beyond the mere screening and selection of improved germplasm and have established their own varietal improvement programs, including elaborate systems of plant breeding, selection, on-farm testing, multiplication and dissemination. These efforts facilitated the spread of improved IITA breeding materials to the farmer level and provided the needed feedback to IITA's sweetpotato researchers.

Germplasm Distribution and Impact

Elimination of diseases, rapid multiplication, germplasm conservation and international distribution of improved clones of root crops were the main goals of IITA's tissue culture unit. At the beginning of 1988, sweetpotato germplasm in tissue culture form had been distributed to 37 countries in Africa and 26 countries outside Africa, while 44 countries had received true seed germplasm.

Because of their high yield potential and built-in resistance to some pests and diseases, the acceptability of the IITA improved varieties among farmers has been very high. The IITA materials have been selected and tested in a number of locations, both on-station and on-farm, and have consistently out-yielded the local varieties. Improved sweetpotato material has been released to farmers in Sierra Leone, Ethiopia, Burundi, Uganda, Mozambique, Zambia, Kenya, Madagascar, Italy, Peru, Malawi, Cuba, Congo, Sudan, Angola, Nigeria, Liberia, Cameroon, Tanzania, Sudan, Ghana, Gabon, Seychelles, Fiji, Samoa, Solomon Islands, Jamaica, and Puerto Rico.

Reports from other countries show that IITA materials are performing well, and that the breeding and selection program initiated by IITA scientists is paying dividends in terms of higher yields and consumer acceptability. As more improved materials are released to sweetpotato growers, country yield averages should increase.

It is certain that most of the major constraints still limit efficient production in many parts of Africa, but these can be overcome as more farmers gain access to improved cultivars and knowledge of improved cultural practices through the national programs.

The Cameroon National Root Crops Improvement Program (CNRCIP), in collaboration with IITA, established an improvement program with an elaborate technology transfer system involving training, on-farm testing, multiplication and distribution to spread improved IITA breeding materials to the farmer. This resulted in over production in certain regions of the country.

Technology Transfer-the Case of CNRCIP

One major objective of CNRCIP was to transfer the new technologies developed at research centres/stations to targeted beneficiaries: farmers and consumers. The Cameroon government places research institutes under the Ministry of Scientific and Technical Research, while the Ministry of Agriculture oversees general agricultural management policies. Each Ministry has its own structural establishment with minimal interrelationships.

The training and visit system has been very effective in transmiting improved technologies to farmers. However, the system has an independent budget, personnel and equipment. Therefore, zonal networks were established to penetrate farming communities within each agro-ecology and systematically distribute material, follow-up, supervise, evaluate the impact of improved technologies. It was resolved to use the organizational system of the Ministry of Agriculture and other agricultural units, penetrating at a level which put CNRCIP in direct contact with farmers and attracted the attention of agricultural policy makers.

CNRCIP assured the participation of farmers in solving their own problems by including the farmers as partners in research, with their observations and judgement serving as guidance to the researchers. Through the network, a direct link was established to respond to farmers problems and obtain quick feedback on technologies. The networks had four principal objectives:

a. To acquaint and link field extension personnel with research conducted by CNRCIP.
b. To build on-farm research, multiplication and distribution systems.
c. To train extension agents and farmers to better exploit the developed improved technologies.
d. To enhance adoption by farmers of improved production technologies and assure feedback.

Training

Several training initiatives were undertaken to improve the process of technology transfer. Three different courses were organized to develop the zonal networks, acquaint and link extension personnel and farmers with CNRCIP's research activities and to enhance exploitation and adoption of improved technologies for improved root crop production. After much discussion and the consideration of problems and possible solutions for the four objectives addressed, long term strategies for transmission of new technologies from research centers to farmers were developed.

Three main groups researchers, Ministry of Agriculture personnel, and personnel of other Agricultural organizations, were distinguished as actors in the different training activities directed towards farmers. However, the different groups have diverse problems which include: communication techniques, logistics and equipment, enclavement, land availability for demonstration purposes, number and qualification of personnel at different levels, non-participation of educated masses (primary, secondary schools, etc.) in training programs and demonstrations, limited frequency of training and turnover of extension personnel, lack of communication of research results to extension agents and lack of transmission of the desires of farmers to researchers ("feed back") when elaborating and aligning research programs.

Long term solutions will require the permanent and regular communication of research results to and multi-disciplinary training courses for extension agents. Regular meetings to update extension agents, the creation of demonstration plots, utilization of the media and all other appropriate communication methods for the diffusion of innovations to as many farmers as possible, production of extension bulletins in simplified language for better communications and working in a perfect system of cooperation towards the creation of a solid network of diffusion will benefit the producer. This should involve all services of the Ministry of Agriculture, different non-governmental organizations, cooperative village leaders, centers for young farmers, youth centers, primary and secondary schools, the necessary political structures and all the interested individuals within the zone concerned.

As a result of this training, collaboration can be auto-critical, with continuous updating of information to obtain the necessary compromise between the demands of science and technology and the "rural" world. This assures a wide information transfer towards farmers with the largest possible collaboration.

On-farm Testing

Until recently, research findings in food crop production have not reached farmers, and when findings do get to farmers, researchers do not receive the feedback they need to evaluate their programmes. To improve the link between small farmers and researchers, on-farm testing was used to involve farmers and extension workers in generating, assessing and spreading technology. The overall objective was to test the micro-ecological adaptability, stability and acceptability of varieties and demonstrate improved technology to farmers.

In these trials, farmers participated in solving problems by actually comparing local and improved technologies and helped in the choice of those that were adaptable to their farm environment and within their resource levels. Production constraints were fed back to researchers for improvement. This link between farmers, extension agents and researchers promoted accord among all those involved in technology development.

The effectiveness of on-farm trials could be improved if they were widely distributed to include a site in every production domain. Extension agents should collaborate with researchers to link them to appropriate locations with innovative farmers who would be better instruments of diffusion of new technology. The trial plots should be easily accessible to as many farmers in the area as possible. The level and complexity of the trials should be appropriate for the farmers of a particular locality. Proper crop husbandry methods should be practiced on all trial plots. There should be homogeneity of on-farm testing between the researcher and the extension agent so that planting and cultural practices on every plot can be carried out around the same time. This would provide a fair basis for the evaluation of the results. Harvesting the test plots should occur on "field days" during which the researchers, extension workers, farmers, schools, parastatal organizations and co-operatives should be present to appreciate the results of the trials.

Since researchers cannot supervise all these trials at different locations due to inadequate resources, it is suggested that extension agents assume a larger load of project implementation, while researchers supervise at regular intervals. For an effective on-farm testing programme to be sustained, it is imperative that all actors: researchers, extension agents and farmers, are actively and devotedly involved.

Farmer-managed trials do not receive the care and maintenance of on-station or on-farm research trials. From the data available, farmer yields are less than those of the research trials. However, this helps to predict likely farmers' yields, in relation to research yields. In some cases, trials harvested at different durations can help to not only identify superior clones, but to measure the expected yield surplus across varied farm conditions.

Multiplication

In examining multiplication in relation to improvement of root and tuber crops, it was recognized that research institutes, extension services, food crop development authorities, schools, cooperatives, rural councils, parastatals and farmers should actively participate.

The major constraints which can affect effectiveness of multiplication could be resolved through: improving the link between research/extension/farmers; decentralizing multiplication activities and encouraging their establishment at the village level; providing enough basic seed material for multiplication by research centers; intensifying multiplication activities by extension personnel and attracting the attention of government and other agencies to provide funds for multiplication; creating food crop development authorities within different zones; training farmers on multiplication techniques; providing land and labour for multiplication by rural councils; educating co-operatives on the importance of food crop production and the necessity to diversify their activities to include cash and food crops; and scheduling multiplication programmes for efficient utilization by farmers.

Multiplication of superior clones was initially concentrated at the research centers and later decentralized with the help of development organizations, parastatals, extension services, schools and churches, local councils and chiefs at strategic locations. Farmers were encouraged to provide land, use the rapid multiplication techniques and participate in multiplication activities.

Distribution

Creating effective distribution centers required extra financial and logistic support to the existing traditional structures of Ministry of Agriculture. Long distances between farms and research centers, difficulties in transportation and limited collaboration between researchers and extension workers hindered distribution. Constraints could be overcome by the diffusion of research results to the nearest extension services, creation of distribution centers close to farmers, encouragement of private initiatives for the creation of distribution centers, and the creation of suitable infrastructures. Distribution of improved planting material was done at all levels, without bias to human relations. Farmers were informed that they could get improved material with or without charge at the research centers, and that they should proceed there to be provided. It was necessary for all the middlemen to ensure follow-up and evaluate the crop performance and its impact on production.

Distribution of propagules can be an arduous task, particularly among many small, scattered settlements with poor roads. Closer, denser settlements with better roads also present difficulties, which include the volume of materials that needs to be transported in relation to available vehicles.

Feedback

The main sources of feedback were extension agents of the Ministry of Ariculture and organizations that collaborated with CNRCIP. These were obtained through reports, visits and field inspections, training sessions, and during distribution of planting material. Overall, farmer feedback centered on quality characteristics which were overwhelmingly favorable, and their needs. These opinions included high rates of tuberization resulting in the possible early harvest of large, good quality tubers yielding two to three times that of local varieties. Difficulty in conserving vines during the dry season was raised because most tubers were large, and were harvested. Only a few, small tubers were left in the soil to provide vines (as is the case with local types), for future planting.

Conclusion

During IITA's 17 years of sweetpotato improvement program, scientist were successful in producing improved sweetpotato clones which were high yielding, resistant to weevil, viruses and drought, good in keeping quality under ambient conditions, and had good adaptation. The IITA breeding populations, improved in agronomically important characteristic, were distributed to many national programs. Progress has been made in countries such as Sierra Leone, Liberia, Cameroon, Zaire, Burundi, Seychelles, Indonesia, in addition to Nigeria. However, further effort is needed to improve sweetpotato for much higher levels of resistance to weevil and improved keeping quality in the tropics.

Primary responsibility for sweetpotato in the international agricultural research system was transferred to CIP in 1988.

SWEETPOTATO CULTIVATION IN GHANA: PROGRESS AND DIRECTION OF FUTURE RESEARCH

A. Asare-Bediako

History and Importance

Sweetpotato (*Ipomoea batatas* L.) is not a native of tropical Africa. It is believed to have originated in tropical central or north-western South America.

The crop was introduced into West Africa by the Portuguese in the 17th Century, during the slave trade.

In his review of root crops in Ghana, Doku (1966) has given a vivid description of the agriculture and the crops grown on the coastal savannah of what was then the Gold Coast (about 1660-1700). He noted that William Bosman, a Dutchman attached to the Elmina Castle and also a trader, had written of yams and sweetpotatoes as major cultivated crops. Bosman described sweetpotatoes as follows: "These potatoes are oval in shape, commonly like the large long turnips with us; they as well as the yams are perfectly white on the inside and are boiled or roasted and eaten. They are sweet and eat much better than yams tasting very much like our boiled chestnuts".

The spread of the crop at that time was quite rapid because of its palatability and ease of establishment.

In spite of its long history of cultivation, the crop has continued to be fourth in importance, after cassava, yams and cocoyams among the root and tuber crops cultivated in Ghana. Sweetpotatoes are mainly grown in the interior and Coastal Savannah Zones, all on a small scale. The crop has therefore not received much attention as it is not yet an important root crop, compared with the others. Its present extent of cultivation and importance to the national economy is unknown. Even though the acreages and production of the various root crops have increased over the years, the same percentage and relative importance has been maintained by sweetpotatoes. Within the last few years however, sweetpotatoes have risen in importance from a minor crop position to one of a cash crop, especially in the coastal savannah area.

Recent Data on Production and Consumption

Although sweetpotatos have been cultivated in Ghana for nearly two centuries, it is only recently that any empirical production records have been documented. The earliest recorded data on yields of sweetpotatoes was the testing of introduced varieties at Kpeve Station in 1931-32. The main yields of ten varieties over a two-year period were as follows:

Variety	tonnes/ha
Six Week	5.4
Brook's Seedling	4.1
Trinidadian	3.5
Jackson	2.9
Caroline Lee	2.8
Red Vine	2.2
Palime	1.9
White Sealy	1.8
Brooks Gem	1.8
Red Nut	1.4

In recent times, the Nyankpala Agriculture Experimental Station, located in the Guinea Savannah Zone of Ghana, has documented information on the cultivation of the crop both on station and in farmers fields.

1) Farmers do not have names for specific varieties. They only distinguish between red- and white-colored tubers. Many prefer white-colored cultivars.

2) The crop is mostly grown in mounds about 1.2m diameter; 1m high.

3) Most sweetpotato fields are located outside of village compounds, although some are located on compound fields.

4) Yields from farmers' plots are not available but two improved clones, TIS 8266 and TIS 84/0320, gave on station yields of 29.6 tonnes and 31.0 tones/ha respectively, at a plant population of 40,000 per hectare (1m x 0.25m) for a period of five months' growth.

5) Farmers plant sweetpotatoes in late June or early July and harvest in November/December.

6) Sweetpotato is only eaten fresh (not processed).

7) Planting materials for the following season are obtained from buried tubers (from previous season), buried vines under shade, buried vines near houses or ratoon vines on previous year's crop.

In 1988, a National Root and Tuber Crops Improvement Project was set up at the Crops Research Institute to carry out, on a sustainable basis, research to increase the production and productivity of the major root crops. About 30 sweetpotato lines were obtained from IITA for evaluation, in order to select high-yielding varieties adapted to the various ecological condition in the country.

Based on a two-year evaluation, it has been possible to select seven high-yielding and pest-tolerant varieties.

These lines gave mean tuber yield as follows:

Variety	tonnes/ha	Dry matter %
TIS 8266	18.8	30.9
TIS 84/0320	18.0	32.4
TIS 9465	18.0	28.9
TIS 8441	19.7	30.1
TIS 83/176	16.5	37.1
TIS 86/0350	19.0	36.5
Local Red	21.5	36.0

These varieties have proved consistent in both the forest and Coastal Savannah Zones. The top 5 lines, Local Red, TIS 8266, TIS 84/0320, TIS 8441 and TIS 86/0350 are being multiplied for testing in farmers' fields.

It is difficult to obtain data for sweetpotato consumption and industrial use because marketing of the crop is highly localized.

Production Constraints

Sweetpotato cultivation is concentrated in the interior and Coastal Savannah Zones of the country. For production in these traditional areas to increase as well as to spread to the other regions, there must be serious improvement in the production practices.

In this connection, the following are identified as the major constraints limiting the large-scale production of the crop:

1) Government or national food policy.
2) Lack of improved materials in the system leading farmers to plant low-yielding varieties.
3) Lack of dry-season nurseries to provide adequate planting materials (vines) at the right time during the planting season. No multiplication of materials, tissue culture laboratories or screenhouses.
4) Diseases (mostly viral) and pests (*Cylas* spp., *Alcidodes* spp.) are very prevalent.
5) Available materials in the system are too high in sugar and cannot be used as staples.
6) Marketing and storage problems.

Principal Consumption Patterns and Uses

Sweetpotatoes in Ghana have not occupied the same importance in the diet as have the other root crops because most of the varieties being cultivated taste too sweet. Most people interviewed prefer moderately-sweet varieties. Recently-introduced improved varieties are not sweet and these could be readily accepted as staples.

In Ghana, the cooked and fried forms of the tuber are the most common. These are normally carried around for sale by women. Thus sweetpotato is still regarded as food to "kill the hunger" and not eaten at the main meal, as is cassava or yam. The performance of sweetpotato in composite flour manufacture has also been found to be excellent.

The tubers are also a good source of starch, glucose and alcohol. However their high potential has not yet been discovered by the industries and sweetpotato marketing has remained unimproved and unexpanded.

Prospects and Plans for the Future

Sweetpotato cultivation in Ghana is a reality. Production can be intensified and high yields obtained with the necessary research support.

For the future, we must intensify our effort in clonal selection to produce better varieties than those being grown at present. Fortunately, flowering and seed setting in sweetpotatoes are not serious problems. We should therefore, conduct more breeding work on the crop to produce plants that exhibit great diversity in their characters to help in the selection process.

With the help and support of the International Potato Centre, the National Root and Tuber Crops Improvement Project should be able to do continuous cleaning of the accepted varieties to free them from viruses which appear to be the most important disease of the crop. There must also be frequent and constant exchange of germplasm and information between our programme and other national programmes.

Education should also be intensified to teach farmers to improve their production practices such as timeliness of planting and harvesting and cultural methods to control insect pests. Also, we must organize a better growers' association, and better marketing and utilization of sweetpotatoes.

A DESCRIPTIVE ANALYSIS OF ROOT AND TUBER CROP BASED FARMING SYSTEMS WITH PARTICULAR REFERENCE TO SWEETPOTATO IN THE NORTH WEST AND SOUTH WEST PROVINCES OF CAMEROON

A. Nnoung, A. Mbassa, E.T. Acquah[1] and J.C. Mboua

Abstract

The farming systems in the South West and North West provinces of Cameroon are basically mixed cropping systems dominated by crops like cassava, corn, macabo, taro yam, sweetpotato and plantain. The basic ascribed characteristics revealed that the average age of the farmers was found to be 42 years and 39.5 years with the active group constituting the major labour force accounting for 73.3% and 80.5% respectively for South West and North West. In the root crop system sweetpotato constitutes a minor crop, with 7.4% of the farmers in the South West province and 38% in North West province growing the crop on their farms. Sweetpotato is grown for both market and household consumption. Female labour dominates the work force. The average land area allocated to the crop is higher in North West (1200 square meters) than in South West (79 square meters). The importance of the crop in North West surpasses that of South West, both in its dietary and monetary contribution and in relative proportion of land allocated. Thus, extension activities should be intensified in the South West Province. Technologies for increasing sweetpotato production and training should focus on women farmers. More land should be released by farmers for sweetpotato production in the study area.

Introduction

Root crops in the humid and sub-humid zones of Africa are greatly relied upon as major subsistence staples. Developing countries produce and consume most of the world's production of cassava, yam, and 80% of the world's sweetpotato production (International Institute of Tropical Agriculture, 1977). The status of sweetpotato production in Africa is that of a secondary crop and is consumed locally (IITA, 1977). The relative importance of this crop is increasing because it gives high yields of edible material in a relatively short time, and requires very little care (IITA, 1982). In this respect, IITA has developed sweetpotato varieties that can yield 20 to 30 tons per hectare in four months without fertilizer. Average on-farm production is eight to nine tons per hectare. Sweetpotato is grown over a wide range of environmental conditions, between latitudes 40°N and 40°S and from sea level to 2000 meters (Hahn, 1977).

Until the inception of the Tropical Root and Tuber Research Project (ROTREP) in 1987, root and tuber crop research in Cameroon was solely conducted by Cameroon National Root Crop Improvement Programme (CNRCIP). ROTREP covers four (South West, Littoral, West and North West) of Cameroon's ten provinces. In Cameroon, sweetpotatoes (*Ipomoea batatas*) are grown in most administrative provinces, but are not a major staple crop. They are generally grown in association with other crops such as cassava, maize, yams, beans, etc. In some localities such as in Bambili, in Mezam Division of the North West Province, they are occasionally grown alone during the second season (August to January) (Lyonga and Ayuk-Takem, 1983). The national production of sweetpotato was around 50,000 tons in 1984-85. By the year 1990-1991 the total production of sweetpotato was expected to be 70,000 tons (Ministére du Plan et de l'Aménagement du Térritoire, 1986). To achieve expected increased production the dissemination of storage techniques, the improvement of marketing channels and the distribution of improved varieties of sweetpotatoes were identified as necessary.

The most serious constraints to sweetpotato production in Cameroon are attacks by weevils and viruses, although as well as poor drought tolerance and storage problems. Other important problems exist related to the production and productivity of these tuberous crops. A major constraint to increased root and tuber crop production has been the absence of a well-organized seed multiplication sector to cater to farmers' needs (ROTREP, 1987). It has also been reported that the availability and efficient use of various factors of production is a stumbling block in small farmers production systems. Therefore, a description of the farming systems based on root and tuber crops in two of the four ROTREP mandated Provinces, North West and South West, is a prerequisite for a better understanding of the constraints to root and tuber crop production in general, and sweetpotato in particular.

This paper describe and analyzes sweetpotato production within the root crop based farming system in the North West and South West Provinces of Cameroon.

Objectives

The objectives of this study were:

1- To characterize root and tuber crop farmers in North West and South West Provinces;
2- To describe root and tuber crop based cropping systems as a whole and sweetpotato systems in particular, in both provinces;
3- To identify the major constraints to sweetpotato production in the study area and ;
4- To derive policy implications, where necessary.

Methodology

Cross sectional primary data was utilized for this study. The data was generated by the Root and Tuber Research Project (ROTREP) which operates within the Institute of Agronomic Research based at Ekona. A formal survey of root and tuber crop based farming system was carried out in the North West (1990) and South West (1989) Provinces of Cameroon. The study involved 14 localities and 404 farmers in South West, while 10 localities and 258 farmers were surveyed in North West. The data was collected by trained enumerators who administered a formal questionnaire to the farmers.

Selecting the respondents required a three-stage sampling technique. Through the use of secondary data the major root crop producing divisions and subdivisions were identified. Sec-ondly, all divisions were visited and information on the type of root and tuber crop and areas under cultivation, peak production localities, and production levels for the crops was obtained. Finally a random systematic sampling technique was used to select a total of 662 farmers who predominantly grew root crops.

Results and Discussions

Basic Ascribed Characteristics.

The average age of the farmers was found to be 42 years, with a range from 18 to 85 years, in South West Province, and 39.5 years, with a range of 18 to 85 in North West province. The active group, considered to be the major labour force was made up of farmers from (25 to 59 years). This accounted for 73.3% of the farmers in South West and 80.5% in North West. Older people constituted 19.6% of the farm labour force and younger people constituted 7.1% for South West. In North West the older people comprised 7.8% (Table 1) and the younger constituted 11.7%. In terms of gender, in both provinces women dominanted root and tuber crop production - 57.0% women in South West and 74.0% in North West (Table 2). It is worth noting that a higher proportion of the farmers (81.3%) in the North West than in the South West 74.7% were married. The high proportion of married couples may have some important labour implications. With regard to education, the average number of years spent in school was 6.7 years for South West Province farmers and 3.4 years for the North Western farmers. Forty-six percent of the farmers in North West and 35% in South West had never been to school. These differences in farmers average age, sex, marital status and education could influence the production of roots and tubers, especially sweetpotato in many ways. First, the amount of education, along with farmer's age has a direct effect on the adoption of new technology. Educated, younger farmers tend to be more open to new methods of production than older, illiterate farmers. Second, the high proportion of women and their marital status could influence the decision-making process, as regards the choice of crop. Since food crop production is known to be the women's activity, the allocation of various factors of production could give priority to the production of roots and tubers.

Cropping Systems

Seventy-seven percent of the farmers in North West and 86% in South West practiced a mixed cropping system. Only 2.1% farmers in North West practiced monocropping compared to 12.4% in South West. The cropping system in the South West Province is dominated by crops like cassava, macabo, taro and yam which are intercropped with sweetpotato, corn and plantain. In the North West Province, corn, cassava, macabo, taro and yam dominate the cropping system and these crops are intercropped with sweetpotato and plantain. It is clear that sweetpotato is a minor crop in the root crop system. In fact 7.4% of the farmers interviewed in South West province had grown sweetpotato whereas in North West, up to 38% of those interviewed were growing sweetpotato on their farms. Looking at the importance of the crop in the root and tuber cropping system in both provinces, it was noted that no farmer's field had sweetpotato as a leading crop in any crop association pattern. However when the crops are ranked in terms of their importance as a cash generating source and as a household consumption product, 1.9% of the farmers ranked sweetpotato first as a source of cash and 0.4% ranked it first for food in North West Province. Meanwhile in South West Province, the crop was ranked second as both a food and cash source. This observation emphasizes the relative importance of sweetpotato in North West. The contribution of the crop both to the diet and revenues of the farmers in the two study study areas influences the allocation of factors inputs for root and tuber production.

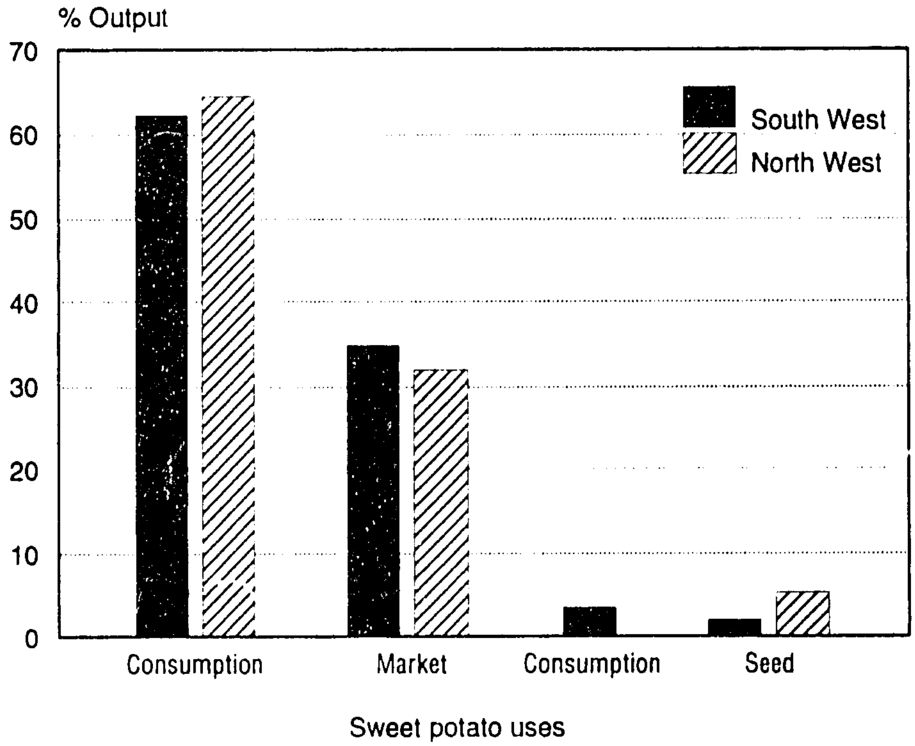
In the two provinces each farmer had an average of 3 fragmented farms, with a range from 1 to 9. However, when the farmers were asked if they would like to have their farms in one place, 88.7% in North West were in favor of the idea. The main reason behind this preference was to avoid movement from one place to another, gaining more working time by concentrating farm activities in one area. In South West, 51% of the farmers were against having all their farms in one place because of the difference in soil fertility.

Farm Inputs and Sources of Information

A farmer in South West has access to an average of 3.2 hectares of land and can cultivate only 1.34 ha. An average of 1.13 ha of land was devoted to root and tuber crops of which sweetpotato occupied only 79 square meters. In North West, an average of 2.75 hectares of land was available for farming with the farmer cultivating only 1.67 ha. An average of 1.184 ha of land was devoted to root and tuber crops, with sweetpotato covered 1,200 square meters. Labour, another major input, was found to be a limiting factor for root and tuber crop production in both provinces. In sweetpotato production female labour dominated the work force. With regard to planting materials, farmers relied mostly on previous stock, friends and relatives. In South West Province, 6.2% of the farmers received some assistance from agricultural extension services, compared with 4.0% in North West.

The input factors mentioned above influence sweetpotato production in various ways. The average yield was estimated at 1.2 t/ha in South West and 1.52 t/ha in North West. Most farm output is geared towards home consumption in both provinces (Figure 1).

Figure 1.
Distribution Sweetpotato Output into Various
Used by Province



Conclusions and Implications

From the foregoing it may be concluded that sweetpotato is a minor crop in the cropping system of both North West and South West provinces. However, in the former province, is more important the crop in terms of its dietary and monetary contributions and the relative proportion of farm land allocated to its production. Thus, in South West Province extension activities should be intensified by the mandated institutions such as the International Potato Center (CIP), the Institute of Agronomic Research (IRA) and the Integrated Rural Development Project - South West Development Authority (SOWEDA).

Women were identified as contributing the major labour force in root and tuber crop production in general and sweetpotato production in particular. Therefore technologies for increasing sweetpotato production and training should be directed towards women farmers.

The proportion of farm land allocated to sweetpotato was found to be relatively low in both provinces. Thus, there is a need for farmers to release more land for sweetpotato production in the study area.

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Table 1. Summary of Age Distribution of Root and Tuber Crop Farmers by Province.

Province	Young people 18-24 years	Active People 25-59 years	Old people > 60 years	Total
South West	7.1	73.3	19.6	100
North West	11.7	80.5	7.8	100

Table 2. Summary of Basic Ascribed Characteristics of Root and Tuber Farmers by Province

Province	Average Age (years)	Sex (percent) Male	Female	Average time spent in school (years)
South West	42	43	57	6.7
North West	39.5	26	74	3.4

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SWEETPOTATO IMPROVEMENT IN CAMEROON

J.M. NGEVE

Absract

Two sets of studies were conducted: the first to investigate the performance, adaptation and the response to altitude of twenty sweetpotato clones in seven locations in Cameroon over four years; and the second, to investigate the reaction of eight clones in one location for two years to sweetpotato virus disease (SPVD) and obtain a better appraisal of yield losses caused by SPVD. Using four stability methods, clones 048, TIb 1, 1639, 502, TIS 2498 and TIS 2544 were identified as high yielding and stable. The clones did not show any differential response to altitude; the high yielding clones performed best at all altitudes. Two of the eight clones that showed symptoms of SPVD were tolerant of the disease; their yields were not significantly depressed by the disease. Among the remaining six clones, plants that showed virus symptoms, had fresh yields of storage roots depressed by 56-90%. Significant correlations were found between disease severity and yield reductions among clones. The implications of these results for sweetpotato breeding in Cameroon is discussed.

Introduction

Sweetpotato (*Ipomoea batatas*) is an important root crop in Cameroon, where it has an excellent potential to provide calories and essential nutrients to both rural and urban populations. In some places it is also used as a source of livestock feed. The major producing areas in Cameroon are the Centre, Adamamoua, Southwest and Littoral Provinces, where the crop is sold in urban centres. It is estimated that more than 70,000 tonnes of sweetpotato are produced annually in Cameroon. Production is uneven, with some areas, such as the Adamaoua region, producing more than can be consumed and others, such as the Littoral area, producing much less than the demand for the crop. Low production in areas where the commodity is most needed, is caused by several production constraints.

Production Constraints

The major constraints to sweetpotato production in Cameroon are diseases, insect pests, weeds and soil and cultural factors.

Diseases

The most serious disease is the sweetpotato virus disease (SPVD) complex whose symptoms appear as a combination of leaf strapping, vein clearing, chlorosis, puckering and stunting. Less important diseases are the concentric leaf spot, which occurs mostly during the dry season and is caused by *Phyllosticta batatas* and the root knot nematode, *Meloidogyne* spp.

Insects

The major insect pests are the sweetpotato weevil, *Cylas* spp., and aphids, *Aphis* spp. and *Myzus persicae* which transmit the sweetpotato virus disease complex.

Weeds

Sweetpotato suffers serious weed competition during the first month of growth before effective ground cover is established. The weeds commonly found competing with sweetpotato in Cameroon are *Ageratum Conyzoides*, *Cyperus* spp., *Chromolaena odoratum*, and *Tallinum triangulare*.

Soil and Cultural Factors

Soil moisture and temperature, methods of seedbed preparation and soil erosion are the major soil physical and cultural factors which affect sweetpotato production. Sweetpotato prefers warm climates and tolerates temperatures as high as 40°C, but hardly grows at temperatures as low as 15°C.

Low-yielding Varieties with Poor Adaptability

The prevalence of local low-yielding varieties is one of the major causes of decreased sweetpotato production in many areas of Cameroon. The local varieties are usually very susceptible to viruses, root knot nematodes, fungal diseases and insects.

Overcoming the Constraints

A breeding programme was initiated in 1980 to study the cultural problems of sweetpotato and to select high yielding, disease resistant cultivars better adapted to the diverse environments of Cameroon. The main objectives were to: (i) determine crop performance in the different ecological zones of the country; (ii) study the effect of altitude on sweetpotato growth; (iii) detect stable sweetpotato genotypes for the different regions; (iv) evaluate statistical methods for determining yield stability in sweetpotato; and (v) to study the reaction of several sweetpotato clones to the sweetpotato virus disease complex.

The Selection Procedure

Since it is possible to have two sweetpotato crops in one year in areas with bimodal rainfall patterns, the following 3-year scheme was used to obtain improved clones.

Selection Scheme for Sweetpotato

1980	Season I	Seedling nursery	2000 seedlings
	Season II	Clonal evaluation	500 clones
1981	Season I	Preliminary yield trial	50 clones 4 replications
	Season II	Advanced yield trial	20 clones 4 replications
1982	Season I	Uniform yield trial	5 clones 4 replications
	Season II	Multilocational trial	5 clones 4 replications

Materials and Methods

Experiment 1: Evaluation of Experimental Selections

Clones and Locations

Eighteen clones obtained from the uniform yield trials of 1982 and 1983, and two local cultivars (described in Table 1) were grown in seven locations for 4 years in Cameroon to study their performance and adaptation. The locations were Nyombe (80 m), Ekona (450 m), Hondole (650 m), Ebolowa (650 m), Nkolbisson (750 m), Bambui Plain (1330 m), and Bambui Upper Farm (2000 m). The locations also differed in soil type. Ekona and Nyombe have humic volcanic soils; Hondole has sandy soils; Nkolbisson and Ebolowa, hard lateritic soils (all in a forest vegetation); and Bambui Plain and Bambui Upper Farm have humic soils, with basalt as parent material, in a grassland vegetation.

Cultivation

The experimental areas were cleared, ploughed, harrowed and ridged with a tractor. The 50 cm high ridges were one meter apart, and 10 m long. Three-row plots were used, giving a basic plot size of 30 m^2. Thirty cm long tip cuttings were planted two-thirds buried and 50 cm apart, giving 20 plants per row, and 20,000 plants/ha.

All experiments, arranged in a randomized complete block design with 4 replications, were planted in April and harvested 4 months later, except in the cool Bambui Upper Farm site where the crop was harvested after 9 months to allow for slower growth. Only the middle row of plants was used for data collection. Harvesting was done by hand; vines were cut, ridges opened up with a hoe and the storage roots dug out, separated into marketable and unmarketable storage roots, counted and weighed. Storage roots considered marketable had a cross-sectional area of at least 4 cm.

Statistical Analysis

The individual experiments were analysed separately, and later subjected to combined analyses of variance to examine genotype x environment effects. Genotype stability was calculated using four stability methods; Eberhart and Russell (1966), Perkins and Jinks (1968), Shukla (1972), and Francis and Kannenberg (1978).

The role of altitude on sweetpotato growth was determined by comparing crop performance and adaptation at the various altitudes.

Table 1. Some Characteristics of the Sweetpotato Cultivars Used in the Study.

Cultivar	Leaf shape	Petiole color	Storage root skin color	Storage root flesh color	Storage root shape
1112	Entire	Green-purple	White	Cream	Roundish
1611	Shouldered	Green-purple	Violet	Cream	Roundish
048	Entire	Green-purple	White	White	Roundish
TIS 2544	Entire	Green	Purple	White	Roundish
502	Dentate	Purple	Violet	Cream	Roundish
076	Dentate	Green-purple	White	Cream	Longish
1592	Dentate	Green	White	Cream	Longish
Tlb 1	Entire	Green	White	Cream	Roundish
Tlb 2	Entire	Green	White	White	Longish
TIS 2498	Entire	Green-purple	Purple	White	Roundish
1487	Entire	Green	Violet	Cream	Roundish
002	Entire	Green-purple	White	White	Cylindrical
1692	Shouldered	Green-purple	Red	Cream	Roundish
1669	Entire	Green	White	Cream	Longish
1530	Entire	Green	Purple	Cream	Roundish
1639	Entire	Purple	Purple	Cream	Roundish
1602	Entire	Green-purple	Purple	White	Cylindrical
1597	Dentate	Green	Red	Cream	Cylindrical
Local Njombe	Entire	Green-purple	White	Cream	Longish
Local Nkolbisson	Parted	Green	White	White	Longish

Experiment 2: Effect of Sweetpotato Virus on Crop Performance

Eight of the 18 experimental selections that showed symptoms of the SPVD complex were used in a split-plot experiment at Ekona (Cameroon) to determine the effects of the virus on sweetpotato clones with varying levels of susceptibility to the disease. Planting material was taken from two nurseries, one of which consisted of apparently healthy planting material and the other, of infected plants.

Tip cuttings of either symptomless or obviously diseased plants were planted 50 cm apart on ridges in single-row plots. The treatments, planted in alternate rows, were arranged in a split-plot design with clones serving as the main plots and type of planting material (diseased or symptomless) serving as sub-treatments, and replicated four times. The experiment was planted in August 1985 and 1986 and harvested 4.5 months later. Diseased plants could be recognized in rows of symptomless plants two weeks after planting and were immediately rogued and replaced with symptomless ones. Care was taken to prevent diseased vines from intermingling with plants in symptomless rows. As a result symptomless plants remained so until harvest. No fertilizers or insecticides were used. At harvest, data were collected as described in Expt. 1, above. In addition, virus disease severity scores were taken on diseased plants in the 1986 trial.

The results of the trials were analyzed by analysis of variance, and means separated using Fisher's least significant difference test.

Results

Experiment 1

Storage Root Yields Across Locations

Yields varied significantly among clones, and from location to location. Clones 1112 and 048 gave the highest yields (14.9 and 14.8 t/ha, respectively) across locations, followed by clones 1611, TIS 2544 and 502 (Table 2). The local checks produced the lowest yields of 6.6 and 4.8 t/ha.

Yields also varied among locations. The highest yields were recorded at Nyombe (17.4 t/ha) and the lowest yields (5.2 t/ha) at Bambui Upper Farm (Table 2).

Table 2. Mean Storage Root Yields (t/ha) of Clones Across Locations.[w]

Cultivars	Nyombe	Ekona	Nkol-bisson	Bambui Plain	Bambui Upper Farm	Hondole	Ebolowa	Mean	LSD (0.05)	CV (%)
1112	18.6	16.5	16.5	14.8	7.5	14.0	17.2	14.9		30
1611	20.9	17.1	9.7	14.2	4.8	9.0	7.7	12.1		43
048	22.8	14.9	13.4	13.3	7.0	15.1	18.2	14.8		27
TIS 2544	19.1	6.0	11.8	14.9	6.1	11.7	12.8	11.7		34
502	16.6	8.5	11.3	13.7	9.0	9.5	14.3	11.7		24
076	15.3	8.3	9.2	8.1	5.2	11.6	11.5	9.8		40
1592	19.9	10.2	9.2	9.9	5.1	8.4	12.6	10.7		39
Tlb 1	18.5	10.2	12.3	14.6	7.1	9.9	13.1	12.2		35
Tlb 2	12.1	6.3	10.5	11.9	5.0	8.1	9.0	9.0		42
TIS 2498	18.4	10.5	10.8	7.9	5.8	8.8	12.3	10.6		40
1487	14.5	6.2	8.2	6.9	4.9	7.7	10.1	8.3		35
002	15.8	9.7	7.1	10.1	5.5	6.9	9.3	9.2		42
1692	18.3	13.4	9.7	7.9	3.7	7.6	8.8	10.0		41
1669	21.4	8.4	9.7	8.7	2.6	7.8	9.9	9.8		38
1530	14.9	6.3	8.7	8.7	4.7	7.9	10.9	8.8		29
1639	18.5	11.5	11.4	8.5	6.0	9.1	12.8	11.1		31
1602	17.1	7.1	6.6	6.7	4.8	8.2	10.7	8.7		39
1597	16.6	4.6	4.4	3.9	2.4	3.4	4.9	5.8		40
Local Njombe	15.1	3.5	6.6	4.6	3.1	4.5	9.2	6.6		38
Local Nkolbisson	13.5	2.2	4.6	4.0	2.7	3.2	3.3	4.8		53
Mean	17.4	9.1	9.6	9.7	5.2	8.6	10.9	10.1	1.6[x]	-
LSD (0.05)[y]	0.7[y]						1.0	0.4[z]	-	-
CV (%)	27	42	34	27	41	39	38	-	-	-

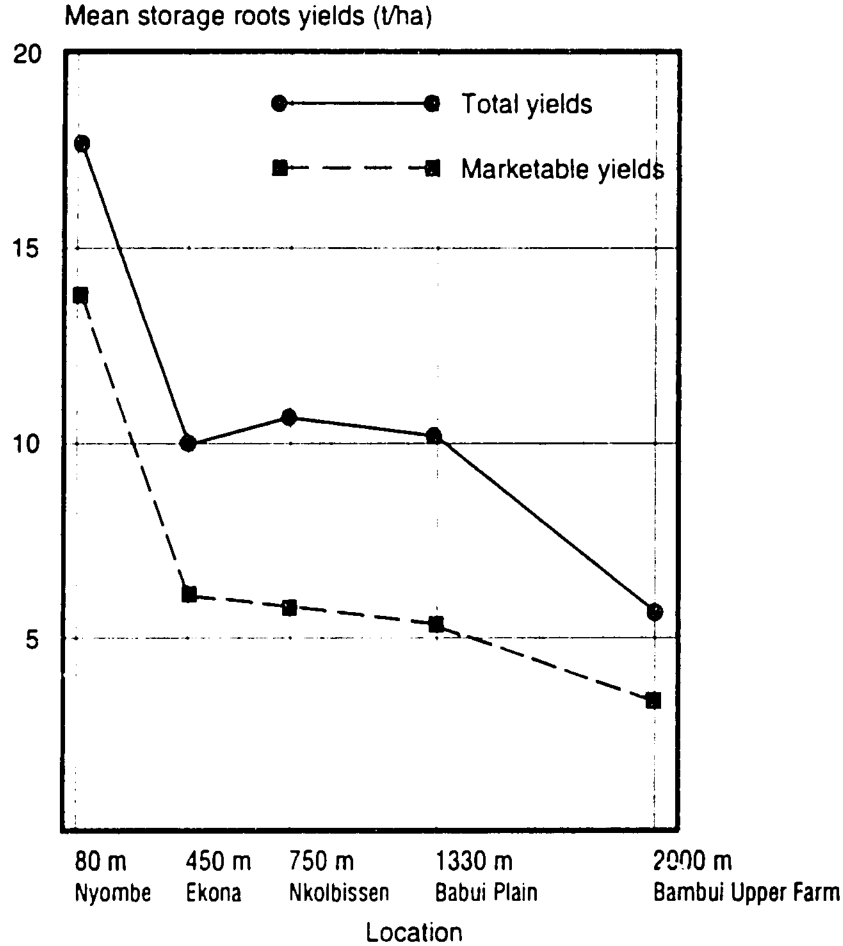
[w] Mean yields of 4 years, except Ebolowa where means were averaged over 3 years; [x] LSD for comparing yields among locations; [y] LSD for comparing yields within locations; [z] LSD for comparing cultivars over locations.

Effect of Altitude

Fig. 1 shows a sharp drop in total and marketable yields from a high at Nyombe (80 m) to Ekona (450 m), a levelling off to Bambui Plain (1330 m) and another sharp decline to Bambui Upper farm

(2000 m). In terms of storage root yields, sweetpotato clones behave in a similar manner at elevations of 450 to 1300 m. Hence, the most favourable altitude for obtaining high yields is 80 m (a warm climate) whereas the least suitable is 2000 m, with a climate too cold for root bulking.

Figure 1.
Mean Total and Marketable Yields (t/ha) Across Altitudes



Stability analysis

The statistical methods used in determining stability differed in some cases when genotype stability was judged. Ten clones and the two local varieties, with regression slopes equal to unity were considered stable by the Eberhart and Russell procedure. The most stable clones were 1112, TIb 1, TIS 2498, 002, 1692, 1639 and 1602 (Table 3). However, the residual mean square (s2d) parameter judged 17 clones to be stable, and rated as unstable the high-yielding clones 1112 and 1692, initially described as stable by the regression coefficient parameter.

The Perkins and Jinks method also rated 12 clones to be stable, the most stable being TIS 2544, 1592, TIb 1, TIS 2498, 1692 and 1639 with 1+B values not significantly different (P=0.05) from unity (Table 3).

Stability variances (Shukla 1972) of 17 clones were not different from the within-environment variance; these clones were thus judged to be stable. The highest-yielding clone, 1112, and the lowest, Nkolbisson, were judged to be unstable by the Shukla method (Table 3).

The genotype grouping technique (Francis and Kannenberg, 1978) classified nine clones as stable (Group I), because they had high mean yields and small coefficients of variation (CV). The low-yielding clones (1602, 1597, Njombe and Nkolbisson) with large CVs were found to be unstable (Group IV) (Table 3).

Table 3. Stability Parameters for Total Storage Root Yields of 20 Sweetpotato Clones Grown at Seven Locations in Cameroon From 1984-87.

Clones	Eberhart & Russell b	Eberhart & Russell s2d	Perkins & Jinks 1+B	Shukla s2	Francis & Kannenberg (Groups)	Mean Yield (t/ha)
1112	1.00	17.47*	0.48*	22.8	I	14.8
1611	1.30*	20.22*	1.21*	19.9*	I	13.3
048	1.22*	14.21	1.13	12.7	I	14.3
TIS 2544	1.10	15.64	1.03	11.8	I	11.6
502	0.84*	14.89	0.52*	14.9	I	11.8
076	0.71*	6.71	0.65*	7.6	III	9.2
1592	1.15	7.80	1.06	7.7	I	10.8
TIb 1	1.09	8.32	1.01	6.0	I	12.6
TIb 2	0.76*	12.08	0.70*	9.1	III	9.2
TIS 2498	1.07	8.20	1.00	7.0	I	10.7
1487	0.77*	10.48	0.72	5.6	III	8.1
002	0.96	11.12	0.90	9.5	III	9.6
1692	1.07	21.68*	1.00	10.9	II	10.6
1669	1.20*	12.25	1.14	9.6	II	10.2
1530	0.79*	13.90	0.73*	5.5	III	8.6
1639	1.08	10.77	1.00	7.4	I	11.2
1602	0.97	5.32	0.92	8.1	IV	8.5
1597	0.95	11.43	0.88	3.6	IV	6.4
Njombe	0.92	3.22	0.88	14.0	IV	6.6
Nkolbisson	0.89	14.10	0.85*	21.7*	IV	5.4
Mean						10.2
LSD (P<0.05)						2.7

*Significantly unstable
Groups: I High yield, small variation; II High yield, large variaton; III Low yield, small variation; IV Low yield, small variation

Experiment 2

Effect of Viruses on Crop Performance

Symptomless plants did not differ significantly in root yields among cultivars, except clone 002 which yielded less. Of the eight clones studied, clones 1669 and TIS 2498 were not significantly affected by virus disease, whereas SPVD complex reduced the yields of clones 1639, 1602, 1692, 502 and 076 by 50% or more. Clones 1669, TIS 2498 and 002 were thus judged to be tolerant to SPVD and the rest of the clones susceptible.

Table 4. Yields and Numbers of Storage Roots of Sweetpotato Clones With (+) and Without (-) Symptoms of the Sweetpotato Virus Disease (SPVD) Complex at Ekona, Cameroon[a].

Yields of storageNo. of storage SPVD
roots (t/ha) roots (10 m2) Severity (%)

Clones	-	+	-	+	
1669	15.2	10.7	141	117	16.0
TIS 2498	13.4	10.9	147	117	11.0
1639	17.0	6.3	136	94	30.8
1602	13.8	2.5	161	60	40.3
002	6.1	1.8	79	41	35.5
1692	13.1	1.4	116	31	40.3
502	15.9	1.6	190	48	56.3
076	14.0	2.2	138	22	48.8
Mean	13.6	4.7	139	67	34.9
LSD(p<0.05)					
	x 5.1		46		7.9
	y 1.6		20		
	z 4.6		58		

a Virus disease reaction was rated on a scale of 0-4, with 0= no symptoms, and 4=severe symptoms of chlorosis, vein-clearing, puckering, leaf strapping and stunting. % Disease severity was computed by dividing the sum of scores for a treatment by the maximum theoretical disease severity x 100.

Discussion and Conclusions

Several high-yielding sweetpotato clones have been developed by the Cameroon National Root Crops Improvement Programme. Some of these (Tlb 1, TIS 2498 and 1112) have been distributed to farmers and are already widely cultivated. Clones have also been identified which, although not yet adopted by farmers, may be utilized in future breeding programmes in the country.

The stability methods used to identify stable sweetpotato genotypes, gave differing results in some cases. Nevertheless, the study showed that stability analysis may furnish useful information which could benefit plant breeders in developing countries, where the majority of farmers may not be able afford the best environmental treatments against diseases and declining soil fertility. The different procedures (Eberhart and Russell, 1966; Perkins and Jinks, 1968; Shukla, 1972; and Francis and Kannenberg, 1978) were developed to aid in the identification of stable cultivars. They have been widely used (Ayuk-Takem, 1981; Bacusmo *et al.*, 1988; Ng *et al.*, 1980; Ntare and Aken'Ova, 1985) in the development of cultivars of various crops.

The sweetpotato clones studied did not show any differential response to altitude; that is, there were no clones specifically adapted to the warm (lower) environments, or to the cool (higher) elevations. The high-yielding clones consistently produced the highest yields, irrespective of altitude. Consequently, it was not possible to classify clon . into highland and lowland types, as was reported for maize (Ayuk-Takem, 1982). This may be because sweetpotato is highly adaptable; the crop prefers warm climates but can grows with little yield reduction up to 1500 m, beyond which yields begin to decline because of lower temperatures.

The sweetpotato virus disease (SPVD) caused yield depressions of up to 90%, in the clones tested. This agrees with Hahn (1979) who reported yield reductions of up to 77.5% in a susceptible cultivar. However, this study showed that the clones differed in their reaction to SPVD; some (1669 and TIS 2498) showed symptoms but tolerated the disease and maintained yields.

The information generated by these studies should be able to guide plant breeders and provide materials for sweetpotato farmers nationwide.

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SITUATION DE LA PATATE DOUCE EN COTE D'IVOIRE

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Introduction

La patate douce, comme la plupart des cultures vivrières (manioc, igname, plantain, ...) n'est pas suivie par les services d'encadrement des paysans. Quelquefois, elle est signalée dans les rapports des agents d'encadrement mais seulement au chapître "Autres cultures rencontrées" sans que soient enregistrées les superficies plantées et les productions obtenues (KOSSA et OSSENI, 1990). Les renseignements fournis par les statistiques officielles (tableau 1) montrent une croissance régulière de la production de patate douce en Côte d'Ivoire depuis près de 30 ans (MFEP, 1958; MP, 1976). Cependant, il convient de considérer ces informations comme des estimations.

Néanmoins, à l'issue de deux missions d'enquêtes agricoles à TOUBA, dans le Nord-Ouest du pays, les chercheurs de l'Association Ivoirienne des Sciences Agronomiques (AISA) rapportent que la patate douce est le principal aliment de soudure des populations rurales de cette région (DIOMANDE et al. 1988).

En vue de cerner l'importance de la patate douce et de faire des recommendations quant à son avenir, une équipe pluridisciplinaire et interinstitutionnelle a entrepris une étude sur les "Potentialités agronomiques et la Valeur alimentaire des Variétes de Patate douce cultivées en Côte d'Ivoire". Le travail initié dans le Nord-Ouest a déjà fait l'objet de deux rapports annuels (KOSSA et OSSENI, 1990; KOSSA et al., 1992). La présente communication donne un aperçu des activités déjà entreprises.

Place de la Patate Douce Dans les Systemes de Production

Aucune donnée sur la production de la patate douce dans le département de TOUBA n'est disponible, cependant, à travers les statistiques nationales (tableau 1) et les résultats d'enquêtes, la patate douce fait partie intégrante des habitudes culturales et alimentaires des populations de la région.

Ainsi toute personne, homme, femme ou jeunes gens en âge de s'adonner aux travaux champêtres, a son champ de patate douce, en plus du champ familial entretenu collégialement et placé sous l'autorité du chef de famille. Dans tous les cas, la mise en place de la patate douce débute au mois de juillet après celle des spéculations principales que sont le riz et le coton. A TOUBA, la patate douce occupe la deuxième place des superficies affectées aux principales cultures vivrières (tableau 2). En moyenne, l'aire réservée à la patate douce par famille (0.33 ha) est deux fois plus importante que celle destinée à la fois au maïs et au manioc (0.16 ha). Il convient de signaler d'ailleurs que la superficie attribuée à chaque famille est sous-estimée, car elle ne prend pas en compte celle travaillée et gérée individuellement.

Tableau 1. Estimations des Superficies et Productions de Patate Douce en Côte d'Ivoire de 1949 à 1978

	1949-1953	1954-1958	1959-1963	1964-1968	1969-1973	1974-1978
Superficie x 1000 ha	3,64	7,16	8,00	10,23	11,00	12,00
Production x 1000 tonnes	8,74	16,04	17,75	20,30	21,00	23,00

Source: MINAGREF (1984)

Tableau 2. Estimation des Superficies Affectées aux Principales Cultures Vivrières par Familledu Département de TOUBA (KOSSA et OSSENI, 1990)

Village	Families	Riz (ha) Pluvial	Riz (ha) Bas-fond	Patate Douce (ha)	Mais (ha)	Manioc (ha)	Autres (ha)
	Toure Moussa	2.00	0.35	0.25	0.75	0.00	0.00
Toutie	Kone Valanda	0.00	0.45	0.10	0.00	0.25	0.00
	Kone Kanvale	0.75	0.40	0.15	0.00	0.00	0.00
	Diomande Zouman	2.00	3.00	0.30	0.50	0.00	Igname: 1.00
Trikoro	Kone Yacouba	0.00	2.00	0.55	0.00	0.00	0.00
	Sidibe Soualiho	2.00	2.00	0.10	0.25	0.00	0.00
	Kane Michel	2.00	0.00	0.10	0.00	0.25	0.00
Niena	Kane Siafa B.	2.00	0.00	0.30	0.00	0.00	0.00
	Domande Moafe K.	8.00	0.00	0.24	0.00	0.00	Igname: 0.25
	Kane Gondo J.	1.00	0.00	0.40	0.00	0.00	
Gbonisylakoro	Kane Laurent	1.00	0.00	0.50	0.00	0.00	Igname: 0.25
	Kane Dro A.	4.00	0.00	1.00	0.00	0.00	Igname:0.25 Arachide: 0.2
Total (ha)		24.75	8.20	3.99	1.50	0.50	Igname:1.65 Arachide: 1.00 Niébé: 0.25
Moyenne par famille			2.75	0.33	0.12	0.04	Igname: 0.14 Arachide: 0.08 Niébé: 0.02

La Patate Douce Dans les Systemes de Culture

Dans la quasi totalité des exploitations agricoles, la patate douce vient en tête des successions de cultures juste après le défrichement. Dans la pratique, la portion de terrain destinée aux différentes cultures de l'année est défrichée d'un tenant. Son étendue est fonction de la main d'oeuvre familiale et contractuelle disponible. La sole allouée à la patate douce est choisie à l'avance.

Le calendrier cultural de la région impose la mise en place du riz et de l'igname généralement aux mois d'avril et de mai. Le mois de juin est réservé au coton, culture qui béneficie d'un encadrement. La patate douce est la dernière spéculation à être mise en place. Elle est souvent pratiquée en monoculture, mais elle peut être aussi associée soit au manioc chez le peuple Yacouba, soit au maïs chez les Malinké. Grâce à son cycle court (3 mois environ pour certains cultivars), sa récolte débute avant celle de bien d'autres cultures. Aussi constitue-t-elle le principal repas lors des travaux de récolte du coton et du riz.

Systeme de Commercialisation

Les renseignements fournis par les statistiques officielles (tableau 3) indiquent des prix de vente de patate douce similaires à ceux du manioc, denrée largement cultivée en Côte d'Ivoire. Le prix de détail du kilogramme à ABIDJAN est en moyenne multiplié par 3,4 par rapport à celui bord-champ (MINAGREF, 1984).

Tableau 3. Prix de Vente au Producteur et Prix de Détail à Abidjan du Manioc et de la Patate Douce de 1973 à 1983

	Prix au productor (F.CFA/kg)		Prix de detail a Abidjan	
Annee	Manioc	Patate douce	Manioc	Patate douce
1973	14	10	44	2
1974	16	10	56	
1975	10	11	47	-
1976	11	12	57	-
1977	35	25	110	79
1978	39	26	93	77
1979	36	40	97	92
1980	49	48	151	93
1981	48	55	141	84
1982	32	26	119	119
1983	40	26	199	146
Moyenne	30.0	26.3	101.3	89.5

Source: MINAGREF, 1984

Dans la région de TOUBA, la vente de la patate douce est effectuée au marché du village, et au bord des grands axes routiers reliant TOUBA aux autres villes du pays. Les tubercules commercialisables sont répartis en tas selon leur grosseur.

Les prix de vente évalués sur l'axe routier TOUBA-BIANKOUMA font apparaître que le prix au kilogramme des tas vendus à 1000 F.CFA est plus élevé que celui des tas à 500 F.CFA. Les tas à 1000 F.CFA sont constitués pour la plupart de tubercules de gros calibre: plus les tubercules sont gros plus ils sont vendus chers (tableau 4).

A partir du prix au kilogramme bord-route, il a été calculé la valeur d'un hectare de production. Dans les conditions de TOUBA, un hectare de patate douce rapporterait au paysan une somme brute de 344 520 F.CFA (KOSSA et al., 1992).

Tableau 4. Estimation du prix d'un kilogramme de patate douce bord route sur l'axe Ouba-biankouma (Kossa et al. 1992)

Nº de L'echantillon	1	2	3	4	5	Moyenne
Tas de 500 F CFA	19.60	15.20	16.00	14.20	17.20	16.40
Tas de 1 000 F CFA	36.23	34.01	26.74	33.80	34.72	33.10
Moyenne	27.90	24.60	21.37	24.00	25.96	24.75

En considérant la production enregistrée sur un hectare de patate douce (30 t) en station de recherche au Sud de la Côte d'Ivoire, et le prix moyen au kilogramme qui est de 26,3 F.CFA (tableau 3), le revenu estimé est de 789 000 F CFA.

Judicieusement conduite, la culture de la patate douce pourrait devenir une activité rentable pour les agriculteurs.

Contraintes a la Production

Les principales contraintes observées et déclarées par les paysans au cours de l'enquête sont d'ordre climatique, pédologique et biologique.

Contraintes Climatiques

Le climat de la région de TOUBA est de type tropical de transition (KOUAME, 1986). Il est caractérisé principalement par

- une saison de pluie s'étendant de mai à octobre, de hauteur annuelle moyenne de 1360 mm> avec une courbe de précipitation unimodale
- une durée d'insolation moyenne journalière de 7 heures,
- une température moyenne de 25°C,
- une humidité relative moyenne de 40 % en janvier et de plus de 90 % en septembre.

Le cycle cultural est déterminé par la seule saison des pluies. Un retard des pluies perturbe profondément l'activité agricole. L'eau représente ainsi le premier facteur auquel est assujetie toute mise en culture des terres. Par ailleurs dans les zones où la nappe phréatique est à grande profondeur, il existe une difficulté de stockage du matériel de plantation en saison sèche.

Contraintes Pédologiques

Certains sols de TOUBA se caractérisent par des affleurements rocheux par endroits, ainsi que des rigoles d'érosion qui les rendent en général impropres à toute mise en valeur, d'autres sols possèdent, dans leurs horizons superficiels, une texture à dominance sableuse. Ceux-ci ne supportent pas une mise en culture de plus de deux années successives et en raison de leur fragilité, nécessitent une jachère s'étendant sur plus de 10 ans.

La patate douce semble préférer les sols meubles à texture argilo-sableuse et à réaction peu acide (pH supérieur à 5). En dessous de pH 4.50 les feuilles prennent une coloration vert jaunâtre, et les tiges croissent très lentement (OSSENI, 1965). Si les sols de TOUBA sont en général légèrement acides (pH proche de 6 CAMARA, 1989) et ceux du Sud du pays sont très acides (pH entre 3,5 à 4,5 GODEFROY, 1975).

Contraintes Biologiques

Plantes Adventices

Les agriculteurs plantent en général des tiges âgés de patate douce. Celles-ci repoussent très difficilement et les parcelles sont rapidement envahies par les mauvaises herbes. Le paysan est alors obligé de faire plusieurs passages de sarclage faute de quoi la production sera fortement compromise. Cette contrainte peut être levée en plantant des jeunes pousses apicales de tiges qui s'etablissent mieux, se développent plus rapidement, donnent une bonne couverture du sol et étouffent les adventices. Dans ces conditions un seul sarclage suffit un mois après la mise en terre des tiges.

Maladie

Certains cultivars présentent des symptômes de virose. Cette maladie provoque le rabougrissement, la ramification excessive et le jaunissement des tiges.

Des nécroses foliaires et surtout des pourritures de tubercules dûes aux attaques de champignons sont également observées. Dans le système de culture traditionnel, caractérisé par la taille réduite des parcelles, la pratique itinérante, et la longue jachère (plus de 10 ans), l'incidence de ces maladies sur la production est peu marquée. Actuellement la réduction du temps de jachère et la tendance à la stabilisation des cultures pourraient accroître leur incidence.

Ravageurs

En cours de végétation, la patate douce subit des attaques d'insectes et de rongeurs. Les insectes foliaires ne constituent pas un réel problème; en revanche les charançons (Cylas spp.) représentent le plus grand danger pour cette plante. L'adulte pond ses oeufs sur toutes les parties de la plante mais particulièrement les racines de réserve (tubercules). Les larves perforent les tubercules et creusent des galéries dans la pulpe où elles restent jusqu'à la fin de leur métamorphose. Elles provoquent ainsi la décoloration et l'amertume des tubercules.

Les rongeurs (rats, souris, lapins, etc...) et des antilopes s'attaquent fréquemment à la partie aérienne et aux tubercules. Les dégâts causés sont d'autant plus importants que les champs se situent au milieu des terres non en culture

Importance de la patate douce dans l'alimentation

La patate douce tend à devenir un aliment de base chez les populations de la région qui la consomment pendant la période de morte saison et surtout au moment des travaux réalisés sur d'autres cultures.

Les principales formes de préparation (bouillie et braisée) sont consommées telles quelles ou accompagnées d'huile de palme. Les populations citadines s'adonnent également à la consommation fréquente de la patate douce. On observe en plus des préparations traditionnelles dans les villages de nouvelles formes de confection culinaire imitant celles de la pomme de terre (frites, purée) et ainsi que celles connues de l'igname (foutou, foufou, ragoût).

La patate douce est également consommée comme légume vert: les jeunes feuilles et le sommet des tiges sont utilisés par plusieurs groupes de populations en sauces, pouvant accompagner les plats de riz ou de foutous (igname, banane, manioc, taro).

Activites de Recherche

L'objectif principal à atteindre est d'arriver à sélectionner des variétés très productives, de bonne qualité, résistantes ou tolérantes aux maladies et aux insectes nuisibles. Il s'agit également d'améliorer les pratiques culturales, en vue d'assurer une productivité élevée. Notre but est aussi de chercher des meilleurs moyens de conservation de la production. Ceci permettra au producteur d'intervenir sur le marché au moment où les prix sont remunérateurs. En outre, il pourra avoir une réserve alimentaire pour les périodes de soudure et être capable de ravitailler régulièrement une unité de transformation.

Identification des Cultivars

Les paysans désignent les différents cultivars de patate douce par la couleur de la peau et de la chair des tubercules. Ainsi ils pensent cultiver trois variétés de patate douce:
- le cultivar ayant les tubercules à peau blanche et chair blanche (PBCB)
- le cultivar ayant les tubercules à peau rouge et chair blanche (PRCB)
- le cultivar ayant les tubercules à peau jaunâtre et chair jaunâtre (PJCJ).

Au cours de la prospection entreprise dans la région de TOUBA, et en utilisant le critère des paysans, nous avons identifié un autre cultivar à peau rouge et à chair jaune pâle (PRCJp).

En fait, une description des plantes de patate douce basée uniquement sur la couleur de l'épiderme et de la pulpe du tubercule ne s'avère pas suffisamment efficace pour identifier distinctement tous les individus réunis dans une collection. Une classification de la patate douce doit prendre en compte plusieurs caractéristiques descriptives relatives aux tubercules, tiges, feuilles, fleurs et à la phénologie (CIP, AVRDC et IBPGR, 1991). L'utilisation de ces critères scientifiques a permis de dénombrer au moins 7 cultivars dans les zones de TOUBA.

Techniques Culturales

En milieu paysan, les principales opérations culturales relatives à la préparation de terrain sont comparables a celles effectuees pour l'igname. Apres le défrichement, le brûlis et le nettoyage post-brûlis, suivent le labour (quand la culture est attelée) et la confection des buttes ou des billons. La densité de plantage des boutures dans les buttes varie de 44 000 a [illegible] a l'hectare et dans les billons de 30 000 a 36 000 a l'hectare. Le matériel vegetal de plantation est constitué de portions de liane (30 à 50 cm) prélevees sur toute la longueur de la tige.

Les recoltes se font souche par souche. Les plus gros tubercules sont d'abord récoltés et les plus petits sont laissés en place pour être recoltes environ un mois plus tard.

Les rendements, dans les conditions de non utilisation d'intrants, fluctuent de 9 à 17 tonnes par hectare. La plus faible valeur est observée en culture purement manuelle (5,0 t/ha) et à forte densité de plantation de bouture. Le rendement le plus élevé est obtenu en culture attelée (20,4 t/ha) à densité de bouture comprise entre 30 000 et 36 000 par hectare.

A la station de recherche, les rendements ont été améliorés de façon significative, la moyenne se situant à 30 tonnes par hectare (extrêmes: 22 et 54 t/ha). Ces rendements élevés ont été essentiellement obtenus par l'amélioration des techniques culturales (labour profond, plantation sur billons, densité de peuplement à 30 000 boutures/ha, meilleur suivi...).

Quelques Transformations Technologiques

A la différence d'autres légumes, les tubercules de patate douce ne peuvent être conservés en bon état de fraîcheur que pendant quelques jours. Il n'y a pas de formes élaborées de transformation en milieu traditionnel en vue de la conservation hormis l'épluchage suivi du séchage des tubercules. En revanche, plusieurs spécialités culinaires sont décrites:

- le "foutou": les tubercules épluchés sont cuits à l'eau puis écrasés au mortier avec un pilon, la pâte obtenue est façonnée en pain. Le "foutou" est consommé accompagné d'une sauce.
- la patate douce bouillie: les tubercules entiers ou découpés en morceaux sont cuits à l'eau avec ou sans la peau. Dans le dernier cas, la peau est enlevée au moment où le plat est servi.
- la patate douce cuite à la braise. C'est la preparation la plus courante; elle est souvent consommée pendant les travaux champêtres.

Des essais de transformation technologique ont été réalisés. Les résultats préliminaires portent sur la production de farine précuite pouvant servir de base à diverses préparations alimentaires, et sur la production de granulés également précuits, immédiatement consommables comme les produits de biscuiterie.

Les premières analyses montrent que la valeur alimentaire des produits de transformation de la patate douce (95 % de glucides, 2 à 3 % de protéines) est identique à celle des tubercules frais.

Quelques variétés à Peau Blanche chair Blanche et à Peau Jaune chair Jaune-pâle ont été transformées en cossettes: aprés tranchage et épluchage, les échantillons ont été séchés à 50 °C dans une étuve ventilée jusqu'à 10 % de teneur en eau. Les produits ainsi obtenus, emballés dans des sachets en polyéthylène et stockés dans une salle à température ambiante (25 °C) gardent leurs caractéristiques normales (non reprise d'humidité ni altération de couleur) après 5 mois de conservation.

Perspectives

La littérature soutient que la patate douce est originaire de l'Amérique Centrale et du Sud. Plusieurs formes de patate douce non domestiquées ont été inventoriées en Afrique. Plus particulièrement en Côte d'Ivoire, dix espèces sauvages au moins dont *Ipomoea mauritiana* Jacq. à racine tubereuse sont signalées (HUTCHINSON et DALZIEL, 1963). De ce fait, il semble possible de trouver dans nos régions des cultivars typiquement africains. Dans le but d'accroître la variabilité de la collection mondiale, notre équipe souhaiterait bénéficier des financements adequats pour, d'une part soutenir ses activités de recherches actuelles et d'autre part, equiper une petite unité de transformation technologique en vue de déterminer les aptitudes à la transformation des différentes variétés.

La finalité de cette étude pourrait être l'installation d'une Petite et Moyenne Entreprise (PME) rurale dans la région de TOUBA où les agriculteurs associés en ont manifesté le désir. Si le projet voit le jour, il contribuera à la solution du probléme de malnutrition infantile accentué en milieu rurale et dans les faubourgs des villes.

La concertation entre chercheurs et développeurs d'autres pays est la voie indiquée pour l'échange d'expériences et d'information sur la patate douce.

Conclusion

La patate douce, principal aliment de soudure des populations rurales de TOUBA, l'est certainement pour toute la région Nord de la Côte d'Ivoire. La plante a des atouts considérables grande productivité à l'unité de surface, richesse en éléments nutritifs, facilité de transformation par de petites industries artisanales... Elle répond bien à la politique de diversification des cultures prônée par notre pays. La patate douce peut devenir un aliment de base au niveau national si son développement est soutenu par une étude scientifique. Elle pourra être une culture de rente à forte valeur ajoutée si le circuit de distribution est maîtrisé, le prix au producteur garanti et l'industrialisation bien ciblée.

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BREF APERÇU SUR LA PATATE DOUCE AU TOGO

TOUGNON KOMLAN

Etat des Productions

Ipomea batatas (L) est une plante herbacée vivace dont les variétés cultivées sont saisonnières. Elle fait partie de la famille des convolvulacées qui compte plus de 400 espèces.

La patate douce originaire de l'Amérique Centrale (CIAT, 1976) existerait déjà à l'état cultivé avant l'arrivée de Christophe Colomb en 1492. La propagation des quelques tubercules ramenés en Espagne par l'explorateur a permis une large connaissance de cette culture pour les Espagnols au Japon, en Chine et aux Philippines (CIAT 1976; Anonyme, 1982).

L'introduction de la patate douce en Afrique serait l'oeuvre d'explorateurs espagnoles et portugais et est fixée vers le 16 et 17 siècle. Dans ce continent les grands producteurs seraient le Nigéria, l'Ouganda, le Rwanda et la Côte d'Ivoire.

Au Togo, la patate douce se cultive un peu partout mais la région maritime serait la plus grande productrice. La production moyenne annuelle est très variable et peut être située autour de 5000 t. Les rendements sont très faibles et variés, entre 600 Kg et 8000 Kg /ha. Les superficies cultivées sont également faibles 300 à 1600 ha/an comme l'indique le tableau 1.

Au Togo, la patate douce entre très peu dans l'alimentation de base de la population. Son rôle économique est également faible. Seuls quelques petits exploitants mettent à la disposition des consommateurs cette denrée consommée souvent sous forme fraîche ou frite.

En général les périodes de mises en place de la production se situent entre Juin et Juillet. Les récoltes sont faites de façon échelonnée en fonction des besoins du producteur entre le 3 et le 6 mois et même plus selon les variétés. La plupart des producteurs cultivent des variétés locales très peu résistantes aux attaques des maladies et ravageurs tels que les viroses et les charançons de la patate douce (*Cylas* sp).

Dans les années 1980, l'Institut des Plantes à Tubercules devenu actuellement la Division des Plantes à Tubercules (DPT) de l'actuel Institut National des Cultures Vivrières créé en 1992 a introduit de l'IITA plusieurs clones de patate douce dits résistants aux maladies et ravageurs et à forte productivité

Le Criblage de ces clones introduits sous forme de vitroplants ou de graines a permis de retenir certains comme intéressants à vulgariser tels que TIS 2532, TIS 2544, TIS 80637, INPT 1003, INPT 1007 etc...

Ces variétés sont actuellement en étude d'adaptabilité dans diverses écologies de production, notamment dans les Régions Maritime, Plateaux, Centrale et Kara.

Les premiers résultats de ces essais multi-locaux laissent apparaître une stabilité dans l'espace et dans le temps des clones TIS 2532, TIS 2544 et TIS 80637 qui sont acceptés par les des consommateurs et ont des rendements élévés comme le témoignent les principaux résultats de la campagne passée.

Principaux Résultats de la Recherche

2.1 Etude de L'adaptabilité Variétale

V1 - Locale
V2 - Tis 2532
V3 - Tis 2544
V4 - INPT 1003

Sites
1. Davié (Région Maritime)
2. Danyi (Région des Plateaux)
3. Atsavé (Région des Plateaux)
4. Sotouboua (Région Centrale)
5. Sarakawa (Région de la Kara)

Dans les essais aucune des variétés n'a exprimé pas à la fois toutes les caractéristiques recherchées (résistance aux maladies et ennemis culturaux, productivité élevée et bonne qualité culinaire et organoleptique). Cependant, des résultats intéressants ont été obtenus sur certains sites avec certaines variétés.

Essai D'adaptabilite 1091: Classification des Sites et des Varietes Pour Quelques Caracteristiques

Facteurs	Rendement en racines/ Rendement aérien (t/ha)		Virose (échelle de 1 à 5)		Attaques de charançons sur les tubercules (échelle 1 à 5)		Goût du tubercule cuit (échelle 1 à 5)	
SITES								
Davié	12,2/30,43	b	1,6	a	2	b	2,2	b
Danyi	11,5/14,9	b	1,5	a	1,33	b	3,4	a
Atsavé	26,86/8	a	2,16	a	4	a	2,30	b
Sotouboua	8,14/4,40	c	1	b	1,33	b	1,10	b
Sarakawa	8,66/5,27	c	.		.		.	
VARIETES								
Local	20,2/12,66	a	1,8	a	2	a	3	a
TIS 2532	23,4/20,17	a	1,5	a	2,25	a	2,6	a
TIS 2544	22,5/15,40	a	1,04	b	2,45	a	2,20	a
INPT 1003	21,6/15,03	a	1,75	a	1,33	b	1,20	b
E T	1,8		0,30		0,38		0,33	
C V								
M G	21,9/12,6		1,52		1,05		2,7	

Tableau 1. Production (t), Superficie (ha) et Rendement (t/ha) de la Patate Douce de 1984 à 1990 au Togo

Annees	1984	1985	1986	1987	1988	1989	1990
Production	7.222	5.200	1.273	4.127	3.590	6.125	7.873
Superficie	800	600	300	793	734	1.625	1.504
Rendement	8,415	7,00	6,00	4,821	4,798	3,360	5,203

Source: DESA, 1991. (DESA : Direction des Etudes et Statistiques Agricoles)

Caractérisation de la Prospection

En 1987, une grande prospection organisée à travers le territoire pour la collecte des cultivars de plantes à racines et à tubercules a permis de rassembler en collection une centaine d'accessions actuellement en observation. Les premières tentatives de caractérisation ont permis de dégager 8 groupes.

Cette année le manque de moyens financiers n'a pas permis de mettre en essai comparatif les accessions apparemment intéressantes.

Il est important de signaler que le maintien et la caractérisation surtout enzymatique de ces accessions posent des sérieux problèmes financiers.

Evaluations morphobotaniques

L'observation des accessions de patate douce a été faite au sein de la seule espèce en collection *Ipomea batatas* à l'aide de deux types de marqueurs:
- marqueurs constants:
. forme du limbe
. Couleur des nervures de la face inférieure du limbe,
. pigmentation du pétiole de la tige,
- marqueurs variables,
. nombre de lobes
. pubescence de la tige,
. longueur du limbe, du pétiole et des entrenoeuds,
. diamètre des entrenoeuds.

Ces descripteurs ont permis d'établir 8 groupes d'accessions (cf. tableau n° 2)

Au sein de chacun des groupes on distingue plusieurs types de port:
- port érigé: plant dont la longueur de tige est inférieure à 0,5 metre, c'est le type 3.
- port semi érigé: plant dont la longueur de tige est comprise entre 0,5 et 1 metre, c'est le type 5
- port déployé: avec une longueur de tige comprise entre 1 et 2 metres, type 7.
- port extrêmement déployés de longueur de tige supérieure à 2 metres, type 9.

Evaluations Phytosanitaires

Les évaluations ont porté sur la résistance à la virose et aux attaques de charançons (*Cylas* sp.).

Toutes les accessions ont présenté des symptômes d'attaque de virus et de charançons à des degrés divers: Trente-six des 125 accessions évaluées (28,8 %) dont 13 sélections sont apparemment saines.

Evaluations Agronomiques

Floraison

L'observation de la floraison chez les 125 accessions a permis la répartition suivante:

- Pas de floraison	93	accessions
- Floraison rare	13	-"-
- Floraison dispersée	5	-"-
- Floraison modérée	5	-"-
- Floraison importante	8	-"-
- Floraison abondante	1	-"-

Forme des racines tubéreuses

Plusieurs accessions n'ont pas tubérisé. Huit différentes formes de racines ont été identifiées dans les 90 accessions évaluées. La répartition est la suivante:

- ronde	20	accessions
- rond-elliptique	42	-"-
- elliptique	7	-"-
- ovale	7	-"-
- longue et oblongue	1	-"-
- longue et irrégulière	3	accessions

Couleur de la pulpe des racines

Quatre couleurs prédominantes et trois secondaires sont observées de la pulpe (chair) des racines des accessions

Couleurs prédominantes blanche, jaune, orange et crème
Couleur secondaire jaune, orange et rose

Coleur de la peau des racines

Les couleurs prédominantes sont crème, brun-orange et rose. La sélection Tib 11 (102) à la peau très pourpre et la chair très orange

Tableau 2. Les Différents Groupes D'accessions de Patate Douce

Group	Pigmentation de la tige	Couleur de la peau de la racine		Nº Des Accessions	
			Locales (TOG)	Selection INPT	Selection IITA
	Verte	Crème	5, 6, 11, 45, 55, 56, 57, 59, 61, 64, 70, 71, 72, 73, 83, 88	1010	TIS 2532 TIS 3270(74) TIS 3290C, TIS 3290, TIB 2 TIB 2(26)
	"	Brun-Orange	27	1002, 1009	TIS 9265 TIS 1499
1	"	Rose	14, 34, 50, 58	1003 -	TIS 2488, TIS 2534 TIS 544, TIS83/0138 TIS 8401, TIS 70688, TIS 1499(10)
	"	Plus pourpre	8, 17, 19, 26, 31, 48, 54, 63, 66, 68, 69, 74, 80, 89	- -	- TIB 11(102)
2	Légèrement pigmentée	Crème	22, 29, 49, 60, 85,	-	-
	"		43, 46	-	-
	Modérément pigmentée	Crème	2, 36, 76		TIB 9(62)
		Brun-Orange	78	1004	TIB 4
3		Rose	7, 24, 30, 33, 35, 40, 42, 47, 75	-	-
	"		3, 15, 28, 51, 67	-	-
	Modérément	Crème	-	-	TIB 9
4	plus pigmentée	Rose	16, 23, 44, 84, 86	-	-
	Plupart pigmentée	Crème	9;62	-	TIS 3247, TIS 8164
	"	Brun-Orange	18	1006	TIS 1487
5	"	Rose	13, 32, 37	1008	TIS 3017, TIS 70357, TIS 80/637,TIS 70683 TIB 10(3)
	"		1, 12, 79	-	-
6	Plupart plus pigmentée	Rose	52, 53, 82	-	-
		Brun-Orange	-	1001	-
	Totalement Pigmentée	Creme	-	1007	-
	"	Jaune	4	-	-
7	"	Brun-Orange	21, 78	-	-
	"	Rose	10, 20, 38, 39, 41 75, 81, 87	1005	-
	"		25	-	-
8	Totalement plus pigmentée	Rose	77	-	-

Rendements

Les rendements sont très faibles et se situent entre 0,6 et 20,6 tonnes-hectare.

Evaluations Organoleptiques et Culinaires:

Suivant des échelles: établies par l'INPT, les racines des accessions ont été évaluées aprés cuisson et dégustation pour leur teneur en fibre, sucre et eau. Une appréciation visuelle de la chair des racines après cuisson a été faite.

Les résultats ci-après ont été obtenus sur 118 accessions testées:

- Les racines de 52 % des accessions ne contiennent pas de fibre.
- Pour la teneur en sucre la répartition des accessions est la suivante:

. Pas sucrée	28 %	des accessions
. Peu sucrée	42 %	-"-
. Moyennement sucrée	15 %	-"-
. Fortement sucrée	15 %	-"-

- Pour la teneur, 41 % des accessions sont farineux et 40 % gélatineux. Les 11 % restants sont dures.

La majorité des accessions (77 %) ont des racines à chair blanche. Les autres (23 %) ont la chair diversement colorée comme l'indique le tableau n° 3

Tableau 3. Coloration de la Chair de Certaines Accessions de Patate douce après cuisson.

Accessions « Couleur »	Locales (TOG)	Selections IITA	Selections INPT
Très Jaune	TOG 18 TOG 78	Tib 4 TIS 9265 Tib 11(102)	INPT 1001 INPT 1004 INPT 1006
Jaune	TOG 9, TOG 21 TOG 29, TOG 46 TOG 86	TIS 70683 Tib 2 Tib 2(26) Tib 9(62) Tib 10(3)	
Jaunâtre	TOG 28	TIS 3290 TIS 8401 TIS 80/0637 TIS 83/0138 TIS 3247 TIS 8250 TIS 1499	INPT 1003

Perspectives D'avenir

- Maintien et caractérisation enzymatique des accessions et leurs évaluations
- Conduite d'essais variétaux avec les accessions intéressantes du point de vue de la productivité et de l'acceptabilité
- Conduite des essais multilocaux en stations et en milieux paysans

Echelles D'evaluation Utilisees Pour la Patate Douce a L'INPT

I Virose

1 - Pas de symptôme visible sur aucun des plants de la parcelle
2 - Symptômes discrets sur 5-10 % des plants;
3 - Symptômes modérés sur 25 % des plants;
4 - Symptômes graves sur 50 % des plants;
5 - Symptômes fortement marqués sur plus de 75 % des plants

Symptômes: éclaircissement de nervures, formation de feuilles filiformes, marbrure duveteuse, rabougrissement, froncement et déformation du plant.

II Attaque de Charançons (Cylas spp)

Parties aériennes
1 - Pas de lésions visibles
2 - Piqûres d'insectes adultes sur 1-5 % de la surface foliaire et léger flétrissement des pousses.
3 - Piqûres sur 50% de la surface foliaire et flétrissement des pousses (dûs principalement à l'action des larves sur les tiges);
4 - Piqûres sur 75 % de la surface foliaire, et flétrissement accentué des pousses - début de die-back (dessèchement des sommités)
5 - Piqûres sur plus de 75 % de la surface foliaire, et die-back complet des pousses.

Sur les tubercules
1 - Pas de lésions visibles
2 - Quelques légères piqûres d'insectes adultes à la surface de la partie supérieure proche du collet sur 1-5 % des racines.
3 - Piqûres de moyenne importance de larves et d'insectes adultes sur le quart supérieur de 25 % des racines.
4 - Importantes lésions causées par les larves et les adultes sur le quart supérieur de 50 % de racines
5 - Graves lésions causées par les larves et les adultes sur le tiers supérieur ou plus de 75 % des racines.

III Test de Cuisson Patate Douce

Présence de fibre dans le tubercule:
1 - Pas fibreux
2 - Peu fibreux
3 - Moyennement fibreux
4 - Très fibreux

Goût du tubercule cuit:

1 - Pas sucré
2 - Peu sucré
3 - Moyennement sucré
4 - Très sucré

Texture du tubercule cuit:

1 - Sèche farineux
2 - Molle (gélatineux)
3 - Dure

Couleur du tubercule:

Mettre la coleur qui décrit le mieux le tubercule cuit

TRADITIONAL AND INDUSTRIAL PROCESSING OF SWEETPOTATO AS APPLICABLE TO NIGERIA

A.O. Oguntunde, Ph.D.

Introduction

Sweetpotato (*Ipomoea batatas* L. (Lam.) is a root crop with advantageous characteristics such as high yield, wide ecological adaptability, low input requirements for cultivation and a shorter growing period than other root crops (Truong, 1991). Although sweetpotato is available in some local markets in Nigeria, information on production statistics and demand in the country is not currently available.

There are about forty-nine varieties of sweetpotato available locally (IITA, 1986). The proximate chemical composition of these varieties has been determined and reported by Oboh (1986) and Oboh *et al.* (1989). Table 1 contains information on the range of values obtained for some of the chemical components of the forty-nine varieties of sweetpotato. The table shows that sweetpotato is mainly a starchy commodity, but it also has a high sugar content, is rich in vitamins A and C and contains some anti-nutritional factors such as phytin, tannins and oxalate.

Sweetpotato continues to respire after harvest, leading to alteration in the starch-sugar ratio, which affects its culinary properties (Edmund, 1971; Hearnsberger, 1978; Picha, 1986). Thus, sweetpotato is normally subjected to a curing process after it has been harvested, in order to prevent changes to its chemical composition and other quality attributes. The cured sweetpotato is then stored prior to traditional or industrial processing, as highlighted below.

Traditional Processing of Sweetpotato

A literature survey indicates that sweetpotatoes are mainly boiled or fried before being consumed by adults or they are incorporated into other foods and used as weaning foods. According to Jansen (1982) traditional weaning foods are starch-based foods such as "ogi" porridge, boiled and mashed yam or sweetpotato. The use of potatoes in the manufacture of weaning foods was also reported by Kaur and Gupta (1982). Instant weaning foods are however, produced using modern techniques such as drum drying, extrusion cooking and spray drying which are very expensive and cannot be afforded by processors at the traditional level.

Although sweetpotatoes are traditionally consumed after heat treatments such as boiling and frying, the sequence of unit operations such as peeling, slicing, grating, pounding, milling as well as the heat treatments vary from country to country and even within the same country. For instance, sweetpotatoes may be peeled before cooking or cooked before peeling. However, the traditional utilization of sweetpotatoes in Nigeria consists of at least the following five combinations of unit operations:

a) Sweetpotatoes are boiled and eaten with stew.

b) Sweetpotatoes are boiled and pounded with either boiled and fermented cassava as "fufu" or boiled yam as pounded yam.

c) Sweetpotatoes are dried and milled for sweetening of gruel or "ogi" porridge.

d) Sweetpotatoes are sliced into chips dried and boiled with beans or vegetables.

e) Sweetpotatoes are sliced into chips or u: ɜd and then fried in vegetable oil.

Industrial Processing of Sweetpotato

Industrial processing of sweetpotatoes is done to increase their agricultural value and to open new markets, as well as making foods high in vitamins A and C more widely available. However, it is virtually non-existent in Nigeria. Thus, industrial processing can lead to the production of foods or non-food items (e.g. starch) as indicated in Figure 1.

Figure. 1. Flow chart for products obtainable from sweetpotato using traditional and industrial processing methods.

```
          /-------------Sweetpotato (raw)----------¬
I         I         I
»         »         »
Cooking/Frying   Canning        Intermediate products
I      or        I     I        I     I     I     I
I      Dehydration     I        I     I     I     I     I
I      or        I     I        I     I     I     I
I      Freezing        I        I     I     I     I     I
I      I         I     I        I     I     I     I
I      I         I     I        I     I     I     I
I      I         I     I        I     I     I     I
»      »         I     »        I     »     I     »
Product          Processed      I Starch I Syrup I Carotene
available        sweetpotato    I       I       I
for immediate    for future     I       »       I
consumption      consumption    I       flour   »
                 (convenience   I               Alcohol
                 foods) »
                                Addition of
                                other food
                                ingredients
                                I
                                I
                                »
                                Sweetpotato
                                based foods
```

Production of Canned, Dehydrated and Frozen Sweetpotatoes.

The food industry utilizes preservation procedures such as canning, dehydration and freezing of raw sweetpotatoes in order to increase their shelf life and make them available to consumers all year round (Edmund, 1971). Canned, dehydrated or frozen sweetpotatoes can be regarded as convenience foods which would need little further processing prior to consumption.

a) Canning procedure - the essential steps in a good sweetpotato canning operation are as follows: (1) receiving of raw sweetpotatoes at the cannery; (2) dry cleaning; (3) pre-heating; (4) peeling; (5) inspection, trimming and sorting; (6) size grading: (7) blanching;(8) filling into cans; (9) syruping; (10) exhausting; (11) closing; (12) heat processing;(13) cooling and (14) storage.

b) Dehydration procedure - the essential operations in the manufacture of pre-cooked, dehydrated potato flakes are as follows: (1) raw material storage; (2) washing; (3) preheating; (4) peeling; (5) trimming; (6) slicing; (7) blanching; (8) pureeing; (9) drying; (10) grinding and (11) packaging.

c) Freezing procedure - the essential operations in freezing sweetpotatoes are as follows: (1) washing; (2) size grading; (3) peeling; (4) sorting and trimming; (5) size reduction; (6) blanching or cooking; (7) cooling; (8) draining and (9) freezing.

Production of Starch and Other Industrial Items

Industrially, sweetpotato starch can be obtained by mashing the potatoes which are then soaked in water for several days. The water is changed regularly with the starch being precipitated. After straining, the starch is sun-dried. Potato starch is used as a thickener and to make desserts and cakes.

Other industrial products obtainable from sweetpotatoes are illustrated in Fig. 1. These are syrup, alcoholic beverages, carotene, protein-enriched pulp and feed yeast, silage and sweetpotato flour (Edmund, 1971; Adegbite, 1979). The latter product can be used as a partial substitute for wheat in baked goods or other local foods. Also, sweetpotato flour could be a suitable form of preserving potatoes due to its low bulk, long storage life, convenience and high utilization potential in local foods.

Constraints Involved in Traditional and Industrial Processing of Sweetpotato and Possible Solutions

A detailed study of the traditional and industrial processing of sweetpotatoes as highlighted above, revealed that the following factors or unit operations constitute constraints that should be ameliorated in order to stimulate the utilization of sweetpotatoes in a developing country such as Nigeria:

Dearth of Data on Production Statistics and Demand for Raw Sweetpotato or its Products

This information is necessary for planning purposes and feasibility studies prior to the setting up of industries and appropriate storage facilities.

Storage of Fresh Sweetpotato

In order to curtail postharvest losses due to the continuation of respiratory activities in sweetpotato after harvest, appropriate storage techniques need to be adopted either on a small scale for household use or on a medium to large scale for industrial purposes, as proposed by Olorunda and Kitson (1977).

Peeling of Sweetpotato

Although manual peeling does not constitute a serious problem at the household level, it would be unhygienic to use manual peeling for industrial processing, which requires a higher throughput of peeled sweetpotato that can only be obtained through chemical or mechanized peeling.

Presence of the Enzyme, Polyphenol Oxidase in Sweetpotato

This enzyme causes the darkening observed when freshly cut surfaces of some plant tissues are exposed to the air, as occurs after peeling, cutting, slicing or dicing sweetpotato. This darkening effect can however, be chemically controlled, or by blanching in hot water.

Presence of Anti-nutritional Factors Such as Phytin, Tannins and Oxalate in Sweetpotato.

These antinutritional factors have been found to inhibit the utilization of nutrients present in food. Consequently, anti-nutritional factors have to be destroyed or eliminated and this could be achieved by heat treatments such as boiling, cooking or frying.

Table 1. Proximate Chemical Composition of 49 Varieties of Sweetpotato (D.M. basis) *

Component of sweetpotato	Range of values
Starch content	30.80-41.80 g/100g D.M.
Total sugar	3.68-10.40g/100g D.M.
Amylose	21.00-38.40% of starch
Amylopectin	61.60-79.00% of starch
Vitamin A	1.0-8.4 mg/100g D.M.
Vitamin C	4.6-11.4 mg/100g D.M.
Tannins	0.02-0.23% of D.M.
Phytin	1.98-14.36 mg/100g D.M.
Oxalate	0.09-1.77%
Crude Protein	1.39-9.40%
Ether Extract	0.38-3.03%
Crude Fibre	3.84-5.89%

* Data culled from Oboh (1986)

Drying of Sweetpotato Using the Sun-drying Method

The traditional method of sun-drying is long and unhygienic due to the exposure of the food to possible contamination by flies, insects, rodents. Unfavorable weather, especially during the rainy season can hamper the process. Sun-drying can be replaced by improved drying techniques such as solar and tunnel/belt dryers which are however, more expensive than the former.

Processing Equipment for Sweetpotato

The industrial processing of sweetpotato requires equipment for performing the unit operations as enumerated in section 3.1 above. Although the processing equipment is available in other countries, it may be too expensive to purchase and import into Nigeria. Consequently, this equipment should be locally designed and built, bearing in mind the purchasing power of the people.

Packaging of Sweetpotato Products

Proper packaging of sweetpotato products is necessary in order to enhance their quality (Nwordu, 1990). Traditional packaging materials such as leaves would have to be replaced by plastic materials which could be vacuum sealed to render them air-tight and prevent undesirable reactions, such as rancidity.

Quality Control/assurance of Sweetpotato and its Products

The traditional method of processing sweetpotato, apart from being tedious could result in an unhygienic and non-uniform product. Poor quality could also result from the industrial processing of sweetpotato. Uniform and desirable quality attributes could be conferred on products obtained through traditional and industrial processing of sweetpotato by the application of proper quality control/assurance procedures.

Consumer Education on the Utilization of Sweetpotato and its Products

The many possible preparations and uses of sweetpotato and its products are currently not known by the majority of the populace. Also more recipes need to be developed, bearing in mind the proximate composition of sweetpotato. Consumers should then be educated in order to increase sweetpotato utilization.

Concluding Remark

Increase in the consumption of sweetpotato using traditional and /or industrial processing methods can be achieved in Nigeria through the acquisition of current production statistics along with planning for increase in production (if necessary) of the crop, followed by research and development activities aimed at improving the storage, processing, preservation and quality of sweetpotato products and lastly, through the enlightenment of consumers on the utilization of the crop.

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VILLAGE LEVEL SWEETPOTATO PROCESSING IN THE NORTH WEST PROVINCE

Mbakwa Godfred Fon

Introduction

The North West Province is one of the leading provinces in root and tuber crop production in Cameroon. The roots and tubers grown include: *Colocasia* spp., cocoyams (*Xanthosoma* spp.), yams (*Dioscorea* spp.), potato (*Solanum tuberosum*), and sweetpotato (*Ipomoea batatas*). These crops play an important role in human nutrition, although until recently, the people of Cameroon knew of only a few ways to consume them. Such is the case with sweetpotato.

In 1984, of the estimated 23,000 tons of sweetpotatoes produced in Cameroon, about 7,000 tons or 30%, was produced in the North West Province. Recently, sweetpotato production has increased greatly due to increased demand for the crop in the cities and due to the introduction of high-yielding varieties (TIB 1 and 1112) which yield up to 20t/ha. Traditional varieties yield only about 7-8 t/ha. This rapid spread of the new varieties with higher yields has resulted in heavy post-harvest losses due to lack of adequate processing and marketing techniques.

Initiatives on Dehydration Techniques (Processing) of Sweetpotato

The processing of sweetpotato has been carried out by CIP in Peru, Burundi, and other countries. In Cameroon, an attempt to process sweetpotato was conducted at IRA-Ngaoundere in 1988. The aim was to process the crop into dried strips for subsequent use in the production of a composite wheat/sweetpotato flour. However, due to financial and technical reasons, this effort was not continued.

Another sweetpotato processing initiative was carried out in the North West Province. The effective introduction of sweetpotato processing in the Province was the result of studies carried out by the FAO/UNDP Post-Harvest Food Loss Reduction Project. A pilot plant for processing roots and tubers was installed at the Trials and Demonstration Center (TDC) at Santa. Trials were carried out on the processing of potato, yams, cocoyams and sweetpotato. These products were processed into dried chips, strips, and flour. The ultimate aim was to introduce simple processing technologies to women's groups and individuals based in the highly productive zones of these crops within the Province and elsewhere in the country. These groups or individuals would produce dehydrated products for sale to private enterprises or individuals for further processing and/or eventual marketing. This initiative has been successful with the sweetpotato, a crop which had very limited consumption patterns at that time.

After the sweetpotato processing technology was developed on station, it was necessary to transfer this technology to village-based groups of economic interest. One such group chosen was the Babungo Women's Group in Ndop Sub-division. The primary aim of this project was to explore the most efficient method of establishing village-level processing units, using experience gained from the station trials at TDC, Santa. The following stages were adopted in establishing the processing unit:

- Site selection and identification of a suitable group;
- construction of the building;
- installation of the equipment;
- training of the group; and
- processing trials.

Selection of a Suitable Site

Babungo was chosen as the site of the processing unit based on two main factors:

1) Babungo lies within the highly productive zone of the Ndop plain, and
2) There already existed a dynamic women's group in Babungo engaged in food (including sweetpotato) production, as well as other activities.

Building and Installation of Equipment

Construction of the building was carried out as a joint venture between the project and the women's group. The women's group supplied local materials and labour, while the project supplied the purchases materials (zinc, nails, etc.).

Training of Group Members

The twenty members of the women's group were trained in four days. Topics covered during the training included:

- Identification of equipment,
- Installation of equipment,
- Introduction to processing; product hygiene, drying, packaging and storage.

After the training, members of the group were able to carry out the processing operations.

The Processing Procedure

Processing operations were as follows: washing, slicing, blanching, cooling, drying, packaging

Washing: This simple operation consists of thoroughly washing the tubers in water using an iron mesh sponge. When well washed, peeling is unnecessary (Table 1). Rotten or diseased portions are removed with a knife. During washing, trials were carried out to determine the efficiency of the washing operation.

Slicing: This is done using a pedal-driven slicer. The most important reason for slicing is to ensure efficient drying and reduce the risk of molding. The tubers are sliced so as to expose as much surface as possible. Since slicing is the most important operation, it could constitute a limiting factor in the processing procedure. Trials were therefore carried out to determine the efficiency of the slicing operation (Table 2).

Table 1. Comparison of Peeling versus Washing

No. of Women		1	2	3	4
Time (min) taken for 1 batch	Washing	55	25	15	10
	Peeling	130	60	45	25

Table 2. Determination of Slicing Efficiency

Batch No.	1	2	3	4	5
Time (min.)	3	3	4	4	5

Blanching: Dehydrated products obtained from uncooked potatoes have a dark color and poor flavor. Blanching is essentially a quick-cooking process that preserves the natural color and flavor of the potatoes. After slicing, the potatoes are partially cooked in 90°C water for about 10 minutes. The blanching water contains 0.5% sodium bisulfate and 0.1% acetic acid. The sodium bisulfate controls enzymatic darkening, while the acetic acid lowers the pH of the water, thus preventing the conversion of ferrous to ferric ions that enhance darkening after cooking.

Cooling: The cooling operation consists of immersing the blanched potatoes in cold water for about 5 minutes before drying. Immersion in cold water allows for rapid lowering of the temperature to reduce the effect of darkening after cooking and also to facilitate spreading during drying.

Drying: The cooked potatoes are spread on raised platforms to dry in tne sun. The platform is constructed in such a way as to allow as much air flow as possible, facilitating the drying process. Drying by this method takes about eight to twelve hours. When fully dried, the moisture content of the processed product is between 12 and 14%.

Results and Discussions on the Babungo Trials

These discussions mainly concern the washing and/or peeling and slicing operations.

Comparison of Peeling Versus Washing

Initial trials at TDC, Santa had shown that there is no difference in the quality of the product obtained when the tubers are either peeled or washed before processing. Only a small difference in the quantity of the processed product was noticed.

During the series of trials conducted to compare peeling with kitchen knives and ordinary washing of the tubers with the iron sponge before slicing, it was found out that peeling took twice as much time as washing (Table 1). It took four women about 10 minutes to wash 15 kg of tubers, while the same women needed about 25 minutes to peel the same quantity of tubers. Therefore, washing the tubers before slicing saves time, which can be used to process more produce.

Determining the Slicing Efficiency

The slicing operation could affect the quantity of chips produced. The slicer is normally operated by two women: one feeding the potato pieces into the slicer drum, and the other slicing. During this trial it was found that slicing provides no major constraint to the production process (Table 2). Two women could slice one batch of potatoes (15 kg) in four minutes.

Processing Economics

Data collected during the training session was used in determining the processing costs. The cost is determined based on a production period of six months (November-April). The dry season is the period under consideration because drying is done using solar energy. The trials also showed that a team of five women, working five days per week, provided the most economical arrangement. Production capacity under this arrangement is 200 kg of fresh potatoes per day. However, the quantity of processed product can increase if artificial dryers are used. Presented in Table 3 are the itemized production costs for the processing period, or for the year:

Table 3. Potato Processing Costs, Cameroon

1)	Depreciation	
	Building: (Lifespan 25 years) = 200,000/25 =	8,000 F
	Equipment:" 15 " = 200,000/15 =	13,000 F
2)	Consumables =	40,000 F
3)	Fresh potatoes	
	(200kg/day x 100 days/yr) x 14 F/kg =	364,000 F
4)	Firewood for blanching (2000 F/wk x 26 wks) =	52,000 F
5)	Labour	
	(400 F/person/day x 5 x 5 dys/wk x 26 wks) =	260,000 F
	Total:	737,000 F
6)	26,000 kg Fresh Potatoes	
	(= 5,500 kg dry or processed product)	
7)	Cost of 1 kg dry product = 737,000 F/5,500 kg = 113 F/kg	

Conclusions and Recommendations

Based on the performance of the women's group, the quality of product obtained, and the economics of production it appears that the processing of sweetpotatoes can be successfully introduced into the rural area. Several factors necessary to ensure continued success are that::

- the project possesses the necessary capacity to transfer the technology;
- local artisans already possess the technology for the manufacture and servicing of the equipment; and
- there is a program underway for the development of recipes using potato products. This will create demand for the potato products.

BIOCHEMICAL CHARACTERISTICS AND UTILIZATION OF SWEETPOTATOES (*Ipomoea batatas*) FOR LIVESTOCK FEEDING

Olumide O. Tewe, Ph.D.

Abstract

Biochemical studies were conducted on fourty-nine sweetpotato varieties obtained from the International Institute for Tropical Agriculture (IITA), Nigeria. Marked varietal differences occured in the levels of carbohydrate components, minerals and vitamins and in the levels of some antinutritional factors of oven dried tubers, vines and leaves. Tubers were rich in carbohydrates (86.56 + 0.27% Dm) with the total starch, 37.01 + 0.40% Dm and total sugar, 6.24 + 0.29% Dm. Some varieties contained appreciable quantities of crude protein and vitamin A. Levels of tannin, oxalates and phytin phosphorous were low in tubers. Vines and leaves are rich sources of protein, fibre and minerals.

Feeding trials conducted with broilers, layers and growing pigs showed satisfactory biological performance with partial substitution of dried sweetpotato for maize. Total replacement in ruminant rations showed satisfactory results in a sheep feeding trial.

Strategies for surmounting the identified problems associated with sweetpotato utilization as a livestock feed component in Africa are rocommended.

Introduction

Sweetpotato is currently a minor root and tuber crop in tropical Africa. It is, however, the only root and tuber crop with a positive per capita annual rate of increase in production in sub-Saharan Africa (Okigbo, 1986). Sweetpotato has a high yield potential in a relatively short growing season and an adaptability to a wide ecological range of 0-2000 m above sea level and 30° N to 30° S (Hahn, 1984). Presently, it does not find much use as a human food in most parts of Africa except in Burundi, Rwanda and Zaire, which accounted for over 42% of African sweetpotato production in 1984 (FAO, 1986). Its high agronomic potentials have been demonstrated in other parts of Africa, including the International Institute of Tropical Agriculture (IITA) and the National Root Crop Research Institute, Umudike, both in the humid and sub-humid zones of Nigeria.

Sweetpotato is an efficient and economic source of food energy. Both roots and leaves are good sources of energy, pro vitamin A, vitamin B, vitamin C, calcium, iron, potassium and sodium (Alvarez, 1986). Over the last 20 years, plant breeders at IITA have developed improved varieties of sweetpotato with yield potentials of up to 40 tons/ha in 4 months, grown without fertilizers in well-managed soils. While this root crop holds high potential as a major component of livestock feed in Nigeria, without serious competition from the human food industry, the biochemical characteristics of cultivated varieties still need to be studied, and tolerable levels in feeds for different livestock need to be established. Constraints to its efficient utilization could then be identified and pragmatic solutions to problems limiting its utilization, particularly in rural communities that produce over 90% of food crops in Africa could be found.

Biochemical Studies on Sweetpotato Leaves, Vines and Roots

Earlier studies on the chemical composition of sweetpotato have indicated variations due to varietal differences, climatic and edaphic conditions, degree of maturity, soil fertility, method of processing and duration of storage. Plat (1962) compared sweetpotato tuber to whole maize grain and reported that it is lower in protein, fat, minerals and vitamins, being mainly a carbohydrate source. Oyenuga (1968) indicated that the unpeeled tuber contains, on a dry matter basis, 71.92% moisture, 5.36% ether extract, 0.33% crude fibre, 90.56% nitrogen free extract and 3.21% total ash. Results published by Onwueme (1978) also showed that fresh tubers contain 5-8% protein, 1.8-6.4% ether extract, 0.5-2.1% reducing sugars, 0.5-7.5% non-starch carbohydrates, 0.88-2% mineral matter. The levels of vitamins on a fresh weight basis include 1.12 mg carotene/100g, 0.1 mg thiamine/100g and 29.4 mg ascorbic acid/100g. Cartigan (1981) reported the mineral content of sweetpotato in mg/100g as follows: Ca 30, Mg 24, K 323, Na 13, P 49, S 20, Fe 0.8.

Biochemical studies on 49 varieties bred at IITA, Ibadan, were undertaken at the Nutritional Biochemistry Unit of the Department of Animal Science, University of Ibadan in 1987. These varieties were being sold for both human and animal food. In addition to the analysis for their proximate and mineral constituents in leaves, vines and roots, levels of various carbohydrates, vitamin A and C and some anti-nutritional factors were determined in the tubers of the 49 varieties.

As summarized in Table 1, there were marked varietal differences in the energy and proximate constituents of the leaves, vines and roots.

Table 1. Dry Matter, Proximate Composition (% D.M.) and Gross Energy Value (kcal/g) of Forty-nine Varieties of Oven-dried Sweetopotato Leaves, Vines and Tubers

Part of Crop	Dry Matter	Crude Protein	Crude Fibre	Ether Extract	Ash	N.F.E.	Gross Energy
Leaves	27.94±T1.27 (26.43-36.36)	11.84±0.44 (5.11-18.31)	20.15±0.85 (5.91-31.00)	2.54±0.11 (0.71-5.89)	9.72±0.19 (6.30-11.80)	59.41±0.83 (46.04-72.27)	3.50±0.09 (1.53-4.59)
Vines	20.20±0.44 (14.92-26.48)	4.94±0.22 (1.80-7.96)	29.47±0.50 (22.11-37.46)	1.61±0.08 (0.18-2.61)	11.30±0.13 (9.20-12.90)	52.53±0.61 (41.92-62.08)	3.42±0.09 (2.13-4.65)
Tubers	28.54±0.57 (17.82-38.18)	4.51±0.26 (1.39-8.60)	4.37±0.10 (3.45-5.89)	0.88±0.06 (0.33-1.90)	4.04±0.17 (1.47-6.33)	86.56±0.27 (80.99-91.55)	4.15±0.07 (2.94-5.45)

NB: Figures in parenthesis are the range of values between the 49 varieties.

The sweetpotato tuber is a rich source of carbohydrates, as indicated by the nitrogen free extract which ranged from 80.99 to 92% of the dry matter content. The dry matter content is however low, with a range of 17.82% to 36.54%. The high moisture content explains the early spoilage usually experienced, particularly during sun-drying. Development of a simple process to reduce the labour involved in dehydrating this root crop, particularly at the sites of production, will reduce the cost of transportation to sites where it can be used for human and animal fooding.

Sweetpotato leaves are the richest in proteins with a range of 7.97% to 18.09%. The vines contain between 1.80 and 7.96% protein, while the tubers have 1.92 to 9.47% on a dry matter basis. This shows that some varieties can replace maize which contains between 8 and 10% crude protein (Oyenuga, 1968). Indeed, the high levels of vitamin A recorded in some varieties (Table 2) makes sweetpotato tuber with a high carotene level a possible alternative to yellow maize, particularly in layer rations which require high carotene for egg yolk colouration.

The vines and leaves are rich sources of crude fibre. This makes them valuable sources of the more complex carbohydrates that are useful for ruminants and monogastric herbivores, such as the rabbit. The leaves and vines are also rich sources of minerals as shown in Table 3. The tubers also contain appreciably high quantities of potassium.

Fractionation of the carbohydrate component of the tubers as shown in Table 4, reveals that fructose, glucose and maltose are generally low in the 49 varieties studied. Fructose has a mean value of 0.55% and glucose, 0.37%. Sucrose was the most abundant soluble sugar with a mean value of 2.27%.

Table 2. Vitamin A and C Levels (Mg/100g D.m.) of Some Varieties of Oven-driedSweetopotato Tubers

Vitamin A	Vitamin C
3.64±0.27	8.36±0.29
(1.0-8.40)	(4.8-11.2)

Figures in parenthesis are range of values between the 49 varieties.

Table 3. Mineral Composition of Forty-nine Varieties of Oven-dried Sweetopotato Leaves, Vines and Tubers (Mg/100g D.M.)

Part of Crop	Ca	Mg	K	Ma	Mn	Fe	Cu	Zn	P
Leaves	348.[illegible]2±6.6	275.96±6.5	1200.60±16.9	326.34±9.9	9.41±0.3	14.41±1.0	2.36±0.08	2.35±0.3	539.35±9.1
Vines	253.86±6.2	251.01±4.1	1439.22±2.3	333.59±10.6	6.26±0.3	28.80±4.3	2.56±0.1	4.24±0.3	518.52±8.9
Tubers	76.7±3.5	25.65±4.9	117.45±12.5	72.29±1.8	1.77±0.2	47.44±2.8	2.40±0.6	3.63±0.4	97.43±5.1

The level of sucrose might determine the relative sweetness of the sweetpotato. High sugar level has been implicated in gastrointestinal disorders in man and animals (Tewe, 1986). Some Japanese varieties have been reported to contain minimal sucrose level (Carey, 1992, personal communication). Breeding for low sucrose varieties can enhance the utilization of the roots for livestock feeding, particularly as a complete replacement for maize. According to Lambou (1958), heating increases the concentration of maltose due to starch hydrolysis. Dehydration by oven-drying might also increase the soluble sugar content, particularly where the starch hydrolyzing enzymes are abundant. It is therefore desirable to investigate the levels of enzymes such as maltose and amylase in raw and processed roots, leaves and vines of sweetpotato varieties that hold promise as food and feed.

Very little information is available on the types and levels of anti-nutritional factors in sweetpotato. However, the solanines and other potato alkaloids have been implicated in problems connected with feeding raw potato to monogastrics. The toxin is particularly concentrated in greened potato or spotted ones (Lampitt *et al.*, 1943).

We have assayed for phytins, tannins and oxalates in the roots of the 49 varieties (Table 5). The presence of high phytin in some of the varieties (range of 4.98 - 14.36 mg/100g) may have significant effects on the utilization of their minerals (especially the divalant minerals) by chelating them, thereby reducing their availability. Values for phytin-phosphorous expressed as a percentage of total phosphorous, reveals that a negligible proportion of this will be unavailable for utilization when consumed by man or animals. Tannin levels were low, with values ranging between 0.02 and 0.28 index units. Similarly, soluble and total oxalate levels were low in the tubers.

Table 4. Total Free Sugars and Starch Content (Gm/100g D.m.) of Forty-nine Varieties of Oven-dried Sweetopotato Tubers.

Total Sugar	Hexoses	Fructose	Glucose	Maltose
6.24±0.27	1.56±0.09	0.55±0.02	0.37±0.01	0.34±0.02
Sucrose	Reducing Sugar	Starch	Amylose as % of starch	Amylopectin as % of starch
2 27±0.02 27.72±0.35			1.22±0.08 72.77±0.35	37.01±0.40

Table 5. Some Antinutritional Factors in Forty-nine Varieties of Oven-dried Sweetopotato Tubers

Tanins (Tannin Index)	Total Acid (Soluble Oxalate %)	Phytin (mg/100g)	Phytin-P as % of Total P
0.071±0.007 (0.02-0.17)	0.71±0.05 (0.09-1.77)	9.93±0.38 (4.98-15.21)	3.45±0.31 (1.11-8.92)

Figures in parenthesis are range of values in the 49 varieties.

Therefore, apart from the high phytin in some varieties, sweetpotato poses less of a poisoning risk as compared to a root crop like cassava. It should however, be noted that biochemical studies on pest/disease resistance have shown that the levels of some antinutrients are positively correlated to resistance to some pests and diseases in cassava (Tewe, 1991) and cowpea (Oke, 1987). In this regard, it is significant to note that high levels of trypsin inhibitor have been reported in raw sweetpotatoes. This might be of significance in its resistance to disease as Oke (1987) has shown that aphid and bruchid resistance in Nigerian cowpea varieties have been found to be positively correlated to levels of trypsin inhibitors, and some other antinutrients in such beans.

Biochemical studies on the levels of some anti-nutritional factors as related to pest and disease resistance in sweetpotato need to be conducted in order to reduce the reliance on herbicides which often leave harmful residues in plants.

Processing and Utilization of Sweetpotato Tubers for Livestock Feeding

Sweetpotato is a high-moisture root crop. Processing to reduce the high water content is therefore desirable to enhance its utilization, particularly for intensive livestock feeding.

Solar drying has long remained an important economical means of converting a harvested product to its dried state, particularly in the tropics. Its disadvantages are that the energy input and product quality can seldom be controlled (Moy and Chi, 1982). These factors become more important in the rainy season when relative humidity is high and intensity of solar radiation is reduced and highly unpredictable.

Such weather conditions allow easy contamination of foods being dried by dust, insects and microorganisms that will thrive abundantly on the high soluble carbohydrate medium provided by wet sweetpotato roots. As a result, the quality of solar dried tubers is often considered inferior to that of other dried foods.

The development of drying facilities for use in rural communities of tropical Africa should de-emphasize the use of electricity, as this is usually not available or poorly maintained. Such a technological package should also ensure easy access to the raw material for generating heat and should be affordable to peasant farmers. A drier suitable for dehydrating tubers at the farm level was fabricated at the Teaching and Research Farm of the University of Ibadan, Nigeria. Sweetpotato tubers were harvested from IITA. They were chopped using a cutlass, sliced thinly with a knife and dried in the locally-fabricated smoke drier to about 10% moisture content within 12-24 hours. A schematic diagram of the drier is shown in Figure 1. The dried tubers were subsequently milled into flour and used in poultry feeding trials. This product was compared to another batch of sweetpotato chips that were sun-dried for 5 to 14 days.

Poultry Feeding Trials

Three feeding trials were conducted with a total of 1,090 day-old broiler chicks in studies that lasted eight weeks each. In trial 1, sun-dried and oven-dried sweetpotato tuber replaced maize at 0, 50 and 100% in broiler rations. Sweetpotato reduced body weight gain and nutrient utilization as compared to the control diet. Performance was, however, better on the oven-dried as compared to the sun-dried sweetpotato based rations (Table 6). The sun-dried samples were discoloured by microbial proliferation on the chips during the dehydration period. These could also contain some microtoxins, such as aflatoxin, that has been reported to occur on sun-dried cassava chips (Clerk and Caurie, 1968). The raw sweetpotato might also contain some anti-nutritional factors such as trypsin inhibitors that can limit its utilization by the birds.

Table 6: Performance, Nutrient Utilization, Carcass Traits and Economy of Production of Broilers Fed Varying Levels of Sun-dried and Oven-dried Sweetpotato.

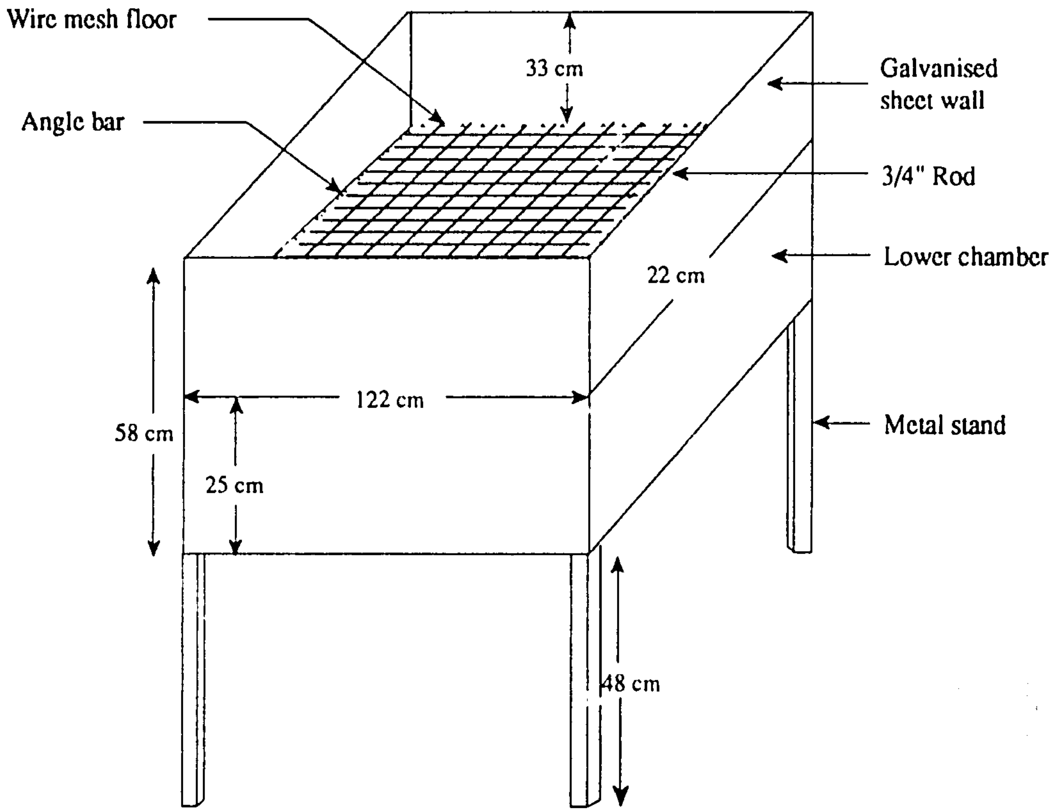
Parameters		Sweetopotato Level (%)			
		Sun-dried	Oven-dried	Sun-dried	Oven-dried
	0(1)[a]	50.0(2)	50.0(3)	100.0(4)	100.0(5)
			Starter phase		
Weekly feed intake/bird (g)	331.45^{a}	259.25^{b}	271.63^{b}	206.75^{c}	214.13^{c}
Weekly weight gain/bird (g)	135.75^{a}	69.50^{c}	82.75^{b}	39.00^{a}	55.00^{d}
Feed intake/weight gain	2.442^{c}	3.899^{b}	3.811^{b}	4.967^{a}	4.139^{b}
Mortality (%)	8	4	8	14	6
Nitrogen retention (%)	63.53	60.14	58.13	57.75	58.57
Protein efficiency ratio	1.780^{a}	1.115^{c}	1.391^{b}	0.854^{d}	1.179^{c}
Feed cost/live weight gain (NGN/kg)[b]	1.61	2.76	2.41	4.36	3.23
Metabolizable energy (kcal/g)[c]	3.225	3.002	3.129	3.131	3.192
			Finisher phase		
Weekly feed intake/bird (g	545.25^{a}	519.88^{ab}	496.00^{b}	443.25^{c}	488.25^{d}
Weekly weight gain/bird (g)	146.88^{a}	130.88^{c}	124.25^{b}	78.0^{d}	88.00^{c}
Feed intake/weight gain	3.712^{d}	3.995^{c}	4.040^{c}	5.683^{a}	4.982^{b}
Mortality (%)	6.67	13.34	13.34	20.01	16.68
Nitrogen retention (%)	74.91	67.32	68.20	66.00	75.89
Protein efficiency ratio	1.402^{a}	1.210^{b}	1.246^{b}	1.046^{c}	1.002^{c}
Feed cost/live weight gain (NGN/kg)[b]	2.17	2.58	2.53	4.17	3.47
Metabolizable energy (kcal/g)[c]	3.265	3.159	3.045	3.168	3.232
Dressing percentage	76.01^{a}	69.91^{a}	71.57^{a}	61.89^{b}	70.14^{a}
Abdominal fat	2.56^{a}	1.11^{b}	1.27^{b}	0.50^{d}	1.03^{bc}

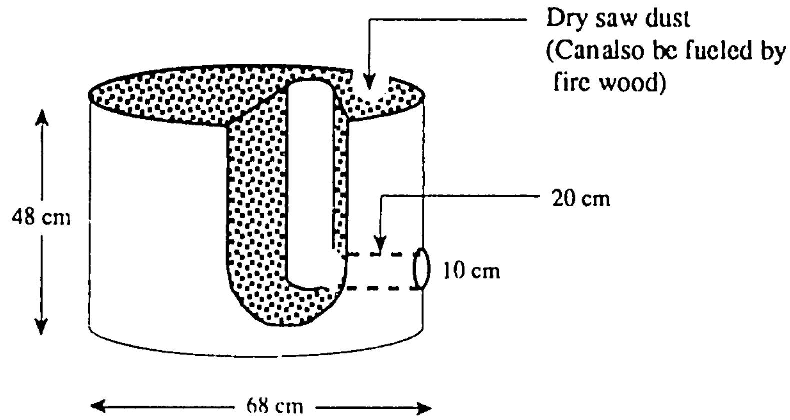
[a] The diet number is shown in parenthesis; [b] In October 1991, 9.8 Nigerian naira (NGN) = 1 United States Dollar (USD);
[c] 1 Cal = 4.19 J; Note: values in the same row followed by the same letters are not significantly different (P>0.05).

The inability of the birds fed on oven-dried sweetpotato to grow as much as those fed on maize can be explained by the dustiness of the feed and the possibility of gastrointestinal disorders due to high sucrose level in the feed. Indeed, the faecal droppings of birds on the sweetpotato diets were watery, which indicates diarrhoea.

In trial 2, oven-dried sweetpotato partially replaced maize at levels of 0, 10, 20, 30, 40 and 50% in broiler rations. Performance was optimal at 30% replacement of maize (or 18% inclusion of sweetpotato) in the broiler rations as shown in Table 7. This shows that, in spite of the dustiness of sweetpotato, it can be included at up to 18% in broiler rations with satisfactory biological productivity. In trial 3, an attempt was made to reduce the dustiness and increase the metabolizable energy of the oven-dried sweetpotato based diets (Table 8). The inclusion of palm oil and variation of metabolizable energy as the starter and finisher phases did not improve biological efficiency in the broilers as shown in Table 9.

Figure 1:
Diagramatic Representation of the Oven Drier





Burner
(To be placed below drier)

Table 7. Performance, Nutrient Utilization, Carcass Traits and Economy of Production of Broilers On Sweetopotato as Partial Replacement for Maize.

Sweetopotato Level (%)	0.0(1)	10.0(2)	20.0(3)	30.0(4)	40.0(5)	50.0(6)
			Starter phase			
Weekly feed intake/bird (g)	331.45^{a}	298.50^{bc}	306.00^{b}	270.95^{d}	288.88^{c}	271.63^{d}
Weekly weight gain/bird (g)	135.75^{a}	113.25^{c}	115.13^{b}	99.38^{bc}	92.75^{c}	82.75^{d}
Feed intake/weight gain	2.442^{c}	2.609^{c}	2.380^{c}	2.785^{c}	3.269^{b}	3.811^{a}
Mortality (%)	8	12	6	10	12	8
Nitrogen retention (%)	63.53	60.08	64.07	60.61	58.18	58.13
Protein efficiency ratio	1.780^{a}	1.650^{b}	1.59^{b}	1.626^{b}	1.431^{c}	1.391^{c}
Feed cost/live weight gain (NGN/kg)b	1.61	1.76	1.85	1.91	2.24	2.41
Metabolizable energy (kcal/g)c	3.225	3.201	3.170	3.074	3.129	0.045
			Finisher phase			
Weekly feed intake/bird (g)	545.25^{a}	496.25^{b}	499.38^{ab}	494.38^{b}	491.13^{b}	496.00^{b}
Weekly weight gain/bird (g)	146.18^{a}		136.13^{a}	139.13^{a}	121.63^{b}	124.25^{b}
Feed intake/weight gain	3.712^{c}	3.759^{c}	4.315^{bc}	4.079^{bc}	4.721^{a}	4.040^{c}
Mortality (%)	6.67	0	6.67	6.67	6.67	13.34
Nitrogen retention (%)	74.91		74.80	73.85	69.88	68.20
Protein efficiency ratio	1.402^{a}	1.367^{a}	1.325^{ab}	1.384^{a}	1.223^{c}	1.246^{bc}
Feed cost/live weight gain (NGN/kg)b	2.17	2.05	2.16	2.16	2.51	2.53
Metabolizable energy (kcal/g)c	3.265	3.217	3.194	3.159	3.204	3.045
Dressing percentage	76.01	78.01	76.42	79.78	70.73	71.57
Abdominal fat	2.56	2.25	1.84	1.50	1.60	1.27

[a] The diet number is shown in parenthesis; [b] In October 1991, 9.8 Nigerian Naira (NGN) = 1 United States Dollar (USD);
[c] 1 cal = 4.19 J; Note: Values in the same row followed by the same letters are not significantly different (P>0.05).

Table 8. Effect of Replacing Maize with Oven-dried Sweetpotato at Varying Metabolizable Energy Levels On Performance, Nutrient Utilizations, Carcass Traits and Economy of Production in Broilers.

Sweetopotato Level %			0		15	30
Energy kcal/g[a] Metabolizable Parameters	2.8(1)	3.0(2)	2.8(3)	3.0(4)	2.8(5)	3.0(06)
Starter phase						
Weekly feed intake/bird (g)	294.25 a	291.00 b	305.25 a	294.00 b	305.25 a	299.12 ab
Weekly weight gain/bird (g)	139.62 b	151.37 a	143.87 ab	149.50 a	138.25	135.75 b
Feed intake/weight gain	2.112 bc	1.900 d	2.140 b	1.953 d	2.257 a	2.043 c
Mortality (%)	3.30	0.0	4.44	3.30	5.56	3.30
Nitrogen retention (%)	73.27	75.38	71.92	73.58	71.56	75.51
Protein efficiency ratio	2.225 b	2.460 a	2.211 b	2.405 a	2.167 b	2.152 b
Feed cost/live weight gain (NGN/kg)[b]	1.36	1.32	1.47	1.47	2.55	2.69
Metabolizable energy (kcal/g)[a]	3.189	3.372	3.179	3.321	3.152	

[a] 1 cal = 4.19 J; [b] In October 1991, 9.8 Nigerian Naira (NGN) = 1 United States Dollar (USD);
Note: Values in the same row followed by the same letters are not significant (P>0.05).

Table 9. Effect of Replacing Maize with Oven-dried Sweetpotato at Varying Metabolizable Energy Levels in Performance, Nutrient Utilization, Carcass Traits and Economy of Production in Broilers.

Sweetopotato Level (%)	0									15.0								30.0
M.E. (Starter)	2.8			3.0			2.8			3.0			2.8			3.0		
M.E. (Finisher)	2.4	2.6	2.8	2.4	2.6	2.8	2.4	2.6	2.8	2.4	2.6	2.8	2.4	2.6	2.8	2.4	2.6	2.8
PARAMETERS																		
Weekly feed intake/bird (g)	439.5	531.0	439.0	465.0	554.0	450.0	446.0	533.0	485.0	463.0	579.0	500.0	579.0	564.0	455.0	551.0	557.0	448.0
Weekly weight gain/bird (g)	144.0	165.01	168.0	147.0	174.0	180.0	137.0	162.0	165.0	130.0	172.0	178.0	144.0	165.0	151.3	140.0	162.2	149.0
Feed intake/ weight gain	3.4	3.2	2.6	3.5	3.2	2.5	3.8	3.3	2.9	3.5	3.6	2.8	4.0	3.4	2.2	4.1	3.4	3.0
Mortality %	3.3	3.3	6.7	6.7	0	0	6.7	0	6.7	3.3	6.7	0	10.0	0	3.4	3.4	6.7	0
Nitrogen retention (%)	77.3	61.3	79.9	77.9	90.7	83.0	74.1	81.0	79.6	89.3	91.8	90.7	81.5	86.2	94.2	78.4	83.4	91.9
Protein efficiency ratio	1.5	1.7	2.1	1.6	1.8	2.2	1.4	1.7	1.9	1.5	1.6	1.9	1.4	1.6	1.8	1.3	1.6	1.8
Feed cost/live weight gain (NGN/kg)[a]	1.8	1.7	1.6	1.7	1.7	1.5	2.1	1.9	1.9	1.9	1.9	1.3	2.5	2.1	2.1	2.5	2.1	2.1
Metabolizable energy(kcal/g)[b]	2.7	3.1	3.3	2.7	3.1	3.3	2.7	3.1	3.3	2.6	2.9	3.3	2.7	3.1	3.2	3.8	3.1	3.2
Dressing percentage	71.2	76.0	78.4	73.6	77.2	80.4	68.4	75.0	76.2	69.8	75.2	78.7	63.8	68.4	71.6	62.7	66.1	69.4
Abdominal fat (%)	0.5	0.9	1.4	0.6	1.2	1.8	0.4	0.8	1.2	1.5	1.1	1.4	0.2	0.6	0.9	0.3	0.5	0.7

[a] In October,1991 9.8 Nigerian Naira (NGN) = 1 United State Dollar (USD); [b] 1 cal = 4.19 J.
Note: Values in the same row followed by the same letters are not significantly different (P>0.05);
M.E. = Metabolizable Energy (kcal/g)

Poultry are very sensitive. Physical factors such as dustiness and chemical factors such as high sucrose content might limit their performance remarkably. Evidence from literature has shown that the inclusion of fibre in foods containing high sugar levels reduces gastrointestinal disorders and diarrhoea in monogastrics (Tewe, 1986). Therefore, a 70-day study was conducted with layers to increase the fibre level in a sweetpotato substituted maize feeding trial. One hundred and eighty 30-week old Harco layer birds were fed a maize control diet or a diet in which 50% or 100% of maize had been replaced with oven-dried sweetpotato at three metabolizable energy levels of 2.45, 2.65 and 2.83 Kcal/g in a 3x3 factorial experiment. The study revealed that oven-dried sweetpotato can completely replace maize at a metabolizable energy of 2.45 Kcal/g with biological performance and nutrient utilization comparable to birds on maize-based rations. The economy of feed conversion was also better on the sweetpotato ration as compared to the maize control containing 2.45 Kcal M E/g. (Table 10).

In the warm, humid tropics of southern Nigeria, metabolizable energy of the ration is recommended as 2.65 Kcal/g in the rainy season. This can be reduced to 2.45 Kcal/g in the dry season in order to allow birds to consume enough feed. This lower metabolizable energy is achieved by increasing the fibre content of the feed. Scarcity of maize, particularly in the dry season, causes astronomical increases in poultry feed prices . This study demonstrates the possibility of complete replacement of maize with oven-dried sweetpotato, particularly in the dry season. It is also worth noting that layer feeds constitute about 75% of total finished commercial livestock feeds produced in Nigeria (Bello, 1988).

Table 10. Performance, Nutrient Utilization and Economy of Production in Layers Fed Varying Levels of Sweetopotato.

M.E. Level (kcal/g)		2.85			2.65			2.45	
Sweetopotato Level % PARAMETERS	0(1)[1]	50(2)	100(3)	0(4)	50(5)	100(6)	0(7)	50(8)	100(9)
Cost of Feed(NGN/t)[2]	775.3	656.6	560.3	728.8	634.5	545.3	640.5	595.0	349.5
NGN/100 eggs[2]	12.29	22.4	38.13	17.86	19.68	22.21	21.01	13.28	18.05
NGN/kg eggs[2]	16	22	29	18	20	22	21	16	18
Weekly feed consumption/bird(kg)	1.2 b	1.09 a	1.03 a	1.18 bc	1.14 bc	1.13 b	1.25 cd	1.20c	1.24cd
Av. initial body	1.545 a	1.70 b	1.74 c	1.61 ab	1.62 c	1.52 a	1.67 b	1.64 b	1.595 a
weight gain Weekly body weight gain	.033 a	.022 a	.04 a	.036 a	.026 a	.033 a	.013 a	.022 a	.0225 a
Weekly no. of eggs produced/bird	5.025 a	3.195 b	1.515 a	4.351 c	3.675 c	2.929 b	3.91 b	3.905 d	3.775 cd
Average weight of eggs(g)	58.1 a	50.02 a	54.46 a	60.88 a	57.3 a	56.67 a	57.96 a	59.74 a	61.16 a
Feed consumption(kg)/ egg produced	2.75 a	2.68 a	2.70 a	2.76 a	2.76 a	2.76 a	8.08 b	2.86 ab	2.89 ab
Feed consumption produced kg/g egg	229.9 a	314.2 b	579.9 d	245.1 a	319.2 a	320.1 a	328.1 b	286.8 ab	328.56
Metabolizable energy (kcal/g)[3]	2.92 c	2.84 c	2.73 b	2.77 b	2.71 b	2.81 ab	2.58 a	2.54 a	2.49 a
Nitrogen retention(%)	55.9 a	55.5 a	64.8 b	54.23 a	67.58 c	59.21 b	81.99 b	69.0 c	71.64 d

[1] The diet number is shown in parenthesis; [2] In October (1991), 9.8 Nigerian Naira (NGN)= 1 United States Dollar (USD);
[3] 1 Cal = 4.19 J; Note: Values in the same row followed by the same letters are not significantly different (P>0.05).

Pig Feeding Trial

A 100-day feeding trial was conducted with large white X Landrace pigs at the weaner (7.7-25kg) and grower (25-60kg) phases, respectively. Sun-dried sweetpotato tubers were compared with a corn-based control ration. Full fat soybean was used as the major protein supplement to reduce dustiness of the feed. Sweetpotato replaced maize at 0, 33, 67 and 100% levels in diets 1-4 at both the weaner and finisher phases.

As shown in Table 11, performance was optimal at 0 and 33% replacement with sweetpotatoes at the weaner and grower phases, respectively. Feed intake was reduced (P>0.05) as sweetpotato level increased in the diet. Economy of feed conversion indicated highest gains at 33% replacement level, particularly at the grower phase.

Pigs are monogastric animals that have tremendous potential for utilizating sweetpotatoes. Pigs can consume sweetpotato dried, raw or cooked and in combination with the leaves and vines. Silages can also be made from sweetpotatoes. The use of the wet form reduces dehydration costs and microbial proliferation that accompanies sun-drying of sweetpotatoes.

Sheep Feeding Trial

Small ruminants constitute the largest stock population in Nigeria, apart from the domestic fowl. Their small investment requirements and adaptability makes them highly favoured in rural mixed farming systems in many parts of tropical Africa. Their productivity is however, highly limited by inadequate nutrition. (ILCA, 1988).

Twenty-four rams of the West African Dwarf X Yankassa crosses were allotted to maize-, sweetpotato- and cassava-based rations. The sweetpotato was sun-dried prior to its incorporation in the concentrate fed as a supplement to grass. As shown in Table 12, replacement of the conventional maize grains by dried milled cassava and sweetpotato tubers did not decrease the growth rate. Indeed, nitrogen retention values were superior in animals fed the sweetpotato supplement as compared to others.

Table 11. Performance of Nutrient Weaner and Grower Pigs Fed on Graded Levels of Sweetpotato Meal Based Diets

	% Replacement with Sweetopotato Meal				
	0	33	67	100	SEX
	Weaner Phase				
Average daily feed intake (kg)	0.81^{a}	0.68^{ab}	0.66^{a}	0.51^{c}	0.04
Average daily wt gain (kg)	0.44^{a}	0.34^{ab}	0.28^{bc}	0.19^{c}	0.03*
Feed efficiency	1.85	1.97	2.41	2.86	0.11
	Grower Phase				
Average daily feed intake (kg)	1.69	1.49	1.44	1.30	0.04
Average daily wt gain (kg)	0.69	0.78	0.65	0.54	0.05
Feed efficiency	3.02	2.50	2.86	2.55	0.09

* Values with same superscript in horizontal rows are significantly different ($P<0.05$).

Table 12. Performance of Nutrient Utilization in Growing Sheep Fed Sweetpotato and Cassava Based Diets

Parameters	Experimental Variable		
	Maize	Sweetopotato	Cassava
Daily D.M. gross intake (g)	257.4	255.9	203.0
Daily D.M. concentrate intake (g)	662.4	843.9	708.3
Total daily D.M. intake (g)	919.8	1099.8	961.3
Daily weight gain (g)	121.1	119.9	122.2
D.M. intake/unit wt. gain	7.6	9.2	7.9
N-balance (g/day/W.0.734 kg	1.5	2.06	1.67
Digestible Energy (D.E.) (% of gross energy)	81.59	86.31	83.33

Sun-dried, milled sweetpotato can therefore replace maize completely in small ruminant rations. Tubers as well as the vines and leaves are a valuable source of proteins, minerals and vitamins to ruminants and even monogastric herbivores like the rabbit. The vines and leaves have also been successfully used for daily cattle feeding (Carey, 1992, personal communication)

The sweetpotato therefore holds high promise as a livestock feed component in tropical Africa.

It has however, some surmountable limitations which presently do not allow its wide acceptance in traditional and intensive livestock farming systems.

Conclusions and Recommendations

Sweetpotato is undoubtedly a root that holds high promise for animal feeding in tropical Africa. The tuber is a rich source of energy. Some of the varieties also contain crude protein levels as high as maize, while a few others have appreciable carotene content thus making it an alternative to white or yellow maize. Moreover, the vines and leaves are rich sources of minerals, vitamins and protein. These parts of the crop are highly relished by ruminants and monogastric herbivores. It is even possible to use these for poultry and pigs, if incorporated into their compounded feeds. The utilization of this root crop in livestock feeding is however limited by some nutritional and technological constraints that need to be addressed. Minimum criteria for their efficient utilization in livestock feeding must be met.

Below are suggestions for summounting the problems identified.

Dehydration and Ensiling of Roots, Vines and Leaves

The root has a high moisture content making it quite bulky for transportation to sites where it will be used. There is a need to develop facilities for chopping and rapid drying of the sweetpotato at production sites. Rapid drying is essential to prevent the growth of pathogenic micro-organisms. While driers can be fabricated locally, the cost and availability of wood or sawdust for fuel can make such processing techniques unattractive to the rural producer. Since solar radiation is abundant in the tropics, the vast potential of this energy source for dehydrating this root crop needs to be tapped. As mentioned earlier, sun drying usually results in products of unsatisfactory quality due to contamination by insects and microorganisms.

It is however, possible to chop this root crop together with the leaves and vines for ensiling. The resultant product can be used in its fresh form for feeding all livestock except for poultry (Tewe *et al.*, 1979). Indeed, poultry farmers and scientists in tropical Africa are "brainwashed" into not feeding wet feed to poultry, as is occurring in Cuba where ensiled products are fed to chickens. Free-roaming chickens and cockerels raised in semi-intensive systems in Nigeria are fed on wet brewers grains and other wet kitchen wastes.

Another advantage of ensiling sweetpotatoes is that the fermentation process produces lactic acid which makes the medium acidic. The low pH discourages the proliferation of microorganisms thus allowing solar drying for a considerable length of time. Moreover, the heat of fermentation during ensiling can reduce toxic components, such as the trypsin inhibitors present in raw sweetpotato tubers. Ensiled sweetpotato roots, leaves and vines can therefore be suitable for feeding all livestock species. It can also undergo solar dehydration into an acceptable livestock feed.

Breeding and Selection for Desirable Biochemical Characteristics

As was reported for the poultry and pig studies, performance was generally reduced with high levels of sweetpotato. The nutritional factors that have been implicated include the high soluble sugar level affecting the gastrointestinal tract, presence of trypsin inhibitors and other anti-nutritional factors, particularly in sun-dried samples. Evidence exists that some Japanese varieties of sweetpotato not only have a high protein content of up to 9% but also a very minimal soluble sugar level (Carey, 1992, personal communication). Attempts should be made to introduce and crossbreed these with local varieties, in order to produce low sugar varieties that might be more acceptable for complete replacement of maize in mongastric rations. It should however, be noted that the presence of amylase or other starch-digesting enzymes in the tubers can determine the level of sugar in the final product, especially if the tubers are heated before or during dehydration. Therefore, levels of such enzymes need to be monitored in selected varieties.

It is also necessary to analyze the trypsin inhibitor and other anti-nutritional factors in such varieties as their levels can vary considerably.

It has been shown that the presence of a trypsin inhibitor and some other antinutrional factors confer resistance to some pests and diseases in cowpea, cassava and other food crops (Oke, 1987; Tewe, 1991). Biochemical studies correlating such toxic materials to disease and pest resistance in the sweetpotato need to be included in breeding programmes. Since such tubers can be processed to reduce the levels of antinutrients, their presence in high-yielding varieties should not deter their recommendation for use in animal feeding.

Improvement of Physical Limitations

Dried sweetpotato tuber is dusty, a factor which limits the levels that can be incorporated into dry rations, particularly for monogastric animals. The dustiness causes respiratory disturbance, most notably in poultry. Pelleting, addition of oil and gelatinizing and possibly extrusion, should be investigated as a way to reduce dustiness in sweetpotato-based rations.

Rural Adaptation Strategies for Enhanced Utilization

More than 90% of the food in tropical Africa is produced in rural areas. Lack of facilities for the processing and utilization of such food crops and their residues in production areas has resulted in tremendous post-harvest losses. A further problem of sweetpotato production is that farmers who grow sweetpotatoes for weed control in some parts of south-eastern Nigeria, cannot market their tubers due to lack of demand. Processing the tubers into forms that can be transported for use in the livestock industry is also hampered by a lack of drying facilities and lack of awareness of potentials for their utilization.

Undoubtedly, if production is encouraged there is a need to create a demand for this root crop in such rural areas. Presently in Nigeria, poultry farmers are involved in backward integration by producing a large bulk of the feed for their birds. Encouraging such a group, particularly those located in peri-urban centres, to utilize sweetpotato as a maize replacer in their rations will stimulate production of the root crop and create a demand that rural farmers can meet through cultivation of sweetpotato. Processing the tubers at production sites to reduce their moisture content, will also ease transportation to livestock feed mills. Such a system is being successfully practised in Colombia, where cassava producers are involved in supplying dry tubers to feed millers, through cooperative farming and processing units.

The African agricultural system which is rather heterogeneous, mainly involving the cultivation of roots and tubers, has however, been shown to be the most economical and "convenient" for most tropical areas. In addition, of all the exotic root and tuber crops, only sweetpotato has been shown to have a positive per capita annual rate of increase in production in sub-Sahara Africa (Okigbo, 1986).

If Africa's ever-increasing population is to be saved from imminent starvation, per capita food production must be increased. If the level of protein malnutrition, kwashiorkor and marasmus, particularly in children, is to be arrested and reversed, the animal protein supply needs to be increased in tropical Africa. Clearly, the solution lies in cultivating crops that best suit our ecological potentials. More importantly, livestock production systems must be matched with appropriate farming systems in order to guarantee the availability of feeds for such animals.

Sweetpotato holds great promise in this direction, not only as a source of energy, but also of proteins, minerals and vitamins for humans and livestock. Its adoption by rural farmers and the development of affordable processing techniques need to be undertaken in order to tap the vast potential of this root crop for the tropical regions of the African continent.

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THE SWEETPOTATO IN EASTERN AND SOUTHERN AFRICA AND CIP'S COLLABORATION WITH NARS

Peter T. Ewell

Introduction

The sweetpotato is an important food crop in many countries of eastern and southern Africa. In some areas it is a major staple in the diet along with other starchy foods, particularly bananas, cassava, and potatoes. In others it is a secondary food crop, critical for the food security of many rural households during the "hungry months" and in years of drought or other catastrophe.

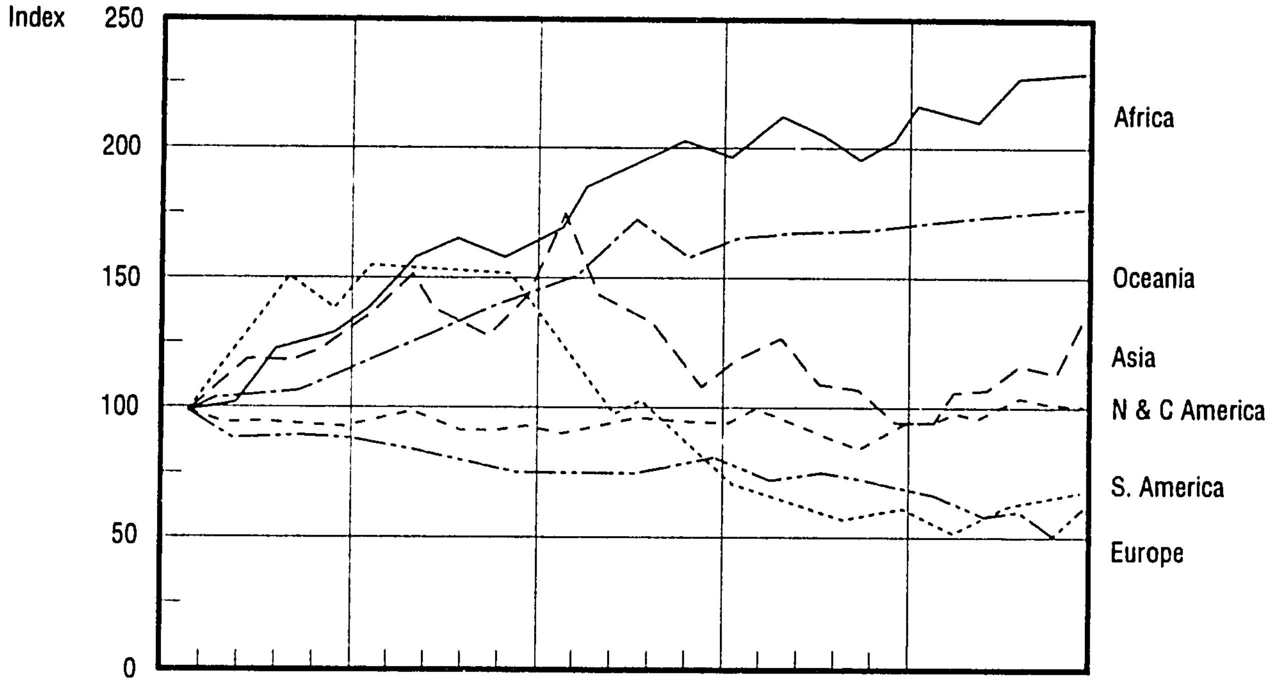
Sweetpotato is a short-season crop which reliably provides food on marginal and degraded soils with a minimum of labor and few or no off-farm inputs. The crop is potentially very efficient in the production of carbohydrates, protein, vitamins, and cash income per unit of land and time. The exploitation of this potential productivity has been limited in eastern and southern Africa by the restricted range of ways in which the crop is utilized.

In 1987 the International Potato Center (CIP) was given the global mandate for the crop among the international centers. We are building upon previous research done at IITA, AVRDC, (Asian Vegetable Research and Development Centre) and many national research institutes. An interdisciplinary team of scientists in our regional office has initiated collaboration with national program scientists for research in the areas of breeding and genetics, pathology, entomology, and socioeconomic studies of various kinds. CIP is collaborating through networks, and provides training and information on the crop. Work in post-harvest processing and product development will have a high priority in the years ahead.

Role of the Sweetpotato in the Food Systems of the Region

According to FAO's statistics for the mid-1980s, just over six million tons of sweetpotatoes (*Ipomoea batatas*) are produced on 1.2 million hectares in Africa (Table 1). This represents about five percent of the total production recorded worldwide. Nevertheless, it must also be noted that Africa is the only continent where sweetpotato production has increased steadily over the past 25 years, at about the same rate as the population (Figure 1). In sub-Saharan Africa, sweetpotato is the third most important root and tuber crop, after cassava (*Manihot exculenta*), and yams (*Dioscorea spp.*) (Table 2). Nearly 90 percent of the total output comes from eastern and southern Africa.[2] The sweetpotato is widely grown for its leaves as a vegetable as well as for its storage roots on a small scale in West Africa, but the total production reported to the FAO is low.

Figure 1.
Indices of Sweetpotato Production by Continent, 1965 - 1987
(1965=100)



Source: Horton, D. 1988. Underground Crops: Long-Term Trends in Production of Roots and Tubers. Morriton: Winrock International.

Table 1. Distribution of Sweetpotato Production in Developing Countries by Region (mean 1986 - 1988)

Region	**Production (t)**	**%**	**Area (ha)**	**%**	**Yield (t/ha)**
China	107,755	86.3	6,287	70.0	17.1
All other Asia[1]	8,506	6.8	1,194	13.3	7.1
Africa	6,264	5.0	1,202	13.4	5.2
Latin America	2,284	1.8	298	3.3	7.7
Total	**124,809**	**100.0**	**8,98C**	**100.0**	**14.0**

1/ Excluding Japan but including Oceania, except for Australia and New Zealand.
Source: Unpublished FAO Data, tabulated in Scott, G.J. 1991. "Sweetpotatoes as animal feed in developing countries: Present patterns and future prospects." Paper presented at FAO expert consultation on "The use of roots, tubers, plantains, and bananas in animal feeding." CIAT, Cali, Colombia January 21 - 25.

Table 2. Roots, Tubers, and Bananas/Plantains in Sub-Saharan Africa (mean 1986-88)

	Sub-Saharan Area (000 h)	Sub-Saharan Mean Yield (t/h)	Sub-Saharan Production (000 t)	E & S Africa Production (000 t)	E & S Africa Output as % of S-S Africa
Potatoes	478	5,8	2,800	2,300	83
Sweetpotatoes	1,150	5.0	5,700	5,100	89
Cassava	8,100	7.1	57,500	33,900*	59
Yams	2,400	9.8	23,600	250	1
Bananas/Plantains	n.a.	n.a.	22,300	16,410	74

* Including Zaire, which alone produced 16.6 million tons, 29% of Africa's total
Source: FAO, 1989. FAO Production Yearbook 1988. Rome: FAO

There may be some doubt as to the accuracy of these official statistics. It has been difficult for national governments, the FAO, or anyone else to assemble reliable figures. Root and tuber crops are grown on small plots on millions of small farms. The harvest is usually consumed directly within the farm households or sold in small quantities in local, unregulated markets. The collection of more accurate data must be given a high priority, but in the meantime these figures provide the only available framework for making broad comparisons between countries and regions.

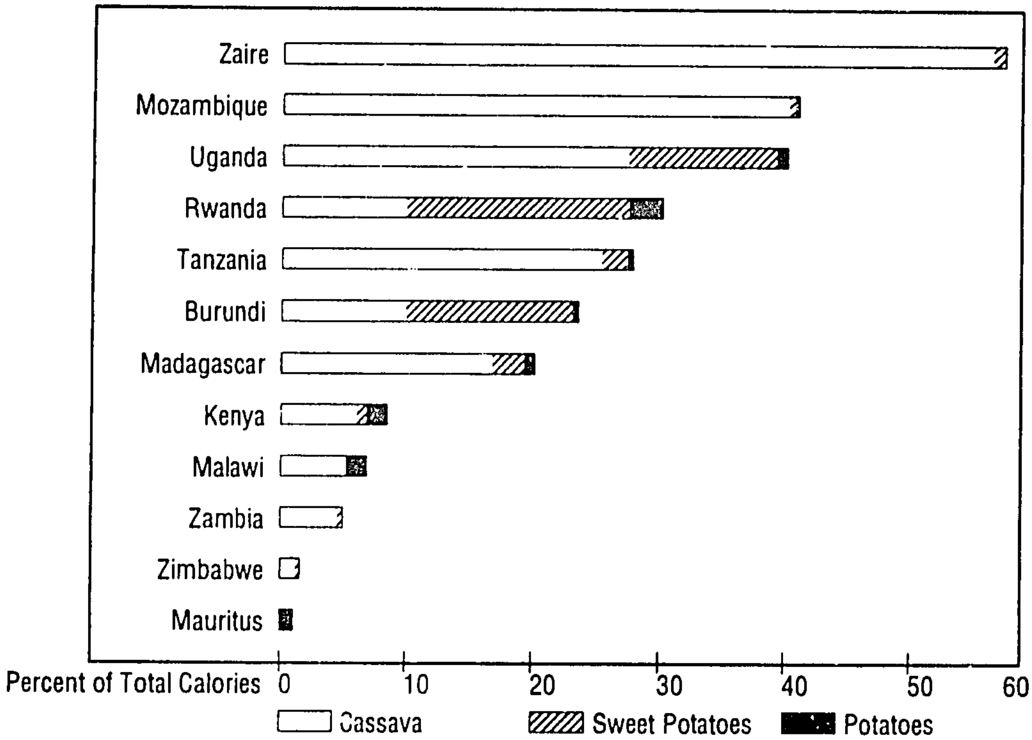
In eastern and southern Africa as a whole, grains play a more important role than root and tuber crops (Table 3). In five countries, however, starchy staples contribute a substantial proportion of the total calories in the average diet (Figure 2). Root crops are relatively most important in Zaire, where the national averages are dominated by cassava. CIP includes Zaire in eastern and central Africa because both potatoes and sweetpotatoes are concentrated in the eastern highlands (Kadiebwe, 1989). Cassava is also a predominant root crop in Mozambique and Madagascar, and a co-staple in Uganda and Tanzania.

Table 3. Major Food Crops in Eastern and Southern Africa

	Area (ha)	Production (t)	Yield (t/ha)
Grains:			
Maize	10,650	13,780	1.3
Sorghum	3,307	2,993	.9
Rice	2,031	3,285	1.6
Millet	1,407	1,482	1.1
Wheat	918	1,475	1.6
Beans	2,675	1,790	.7
Starchy staples:			
Cassava	4,950	33,982	6.9
Bananas & plantains	-	16,411	-
Sweetpotatoes	1,031	5,083	4.9
Potatoes	362	2,315	6.4

Source: FAO, 1989. FAO Production Yearbook 1988. Rome: Food and Agriculture Organization of theUnited Nations.

Figure 2.
Contribution af Root and Tuber Crops to Average Caloric Intake in Selected Countries



Source: Horton, D. 1988. Underground Crops: Long-Term Trends in Production of Roots and Tubers. Morriton: Winrock International.

Sweetpotato as a Major Staple Food

Sweetpotato is a major food crop, grown on almost every farm, in the mid-elevation (1,200 - 2,000 m) regions of Uganda, Rwanda, Burundi, and eastern Zaire. The region is very densely populated, with up to 400 inhabitants per square kilometer of arable land in some areas. The cropping systems are very intensive. The major foods are bananas, sweetpotato, cassava, beans, and sorghum, the last consumed primarily as beer.

With a registered production of 1.7 million tons, Uganda is by far the largest producer in Africa and the fourth largest in the world (Figure 3). Rwanda and Burundi follow in total output, but as they are much smaller countries, they lead in average per capita production. Actual per capita consumption varies significantly within these countries, and reaches over 300 kilos per adult equivalent[3] in parts of Rwanda (Rwanda, 1988).

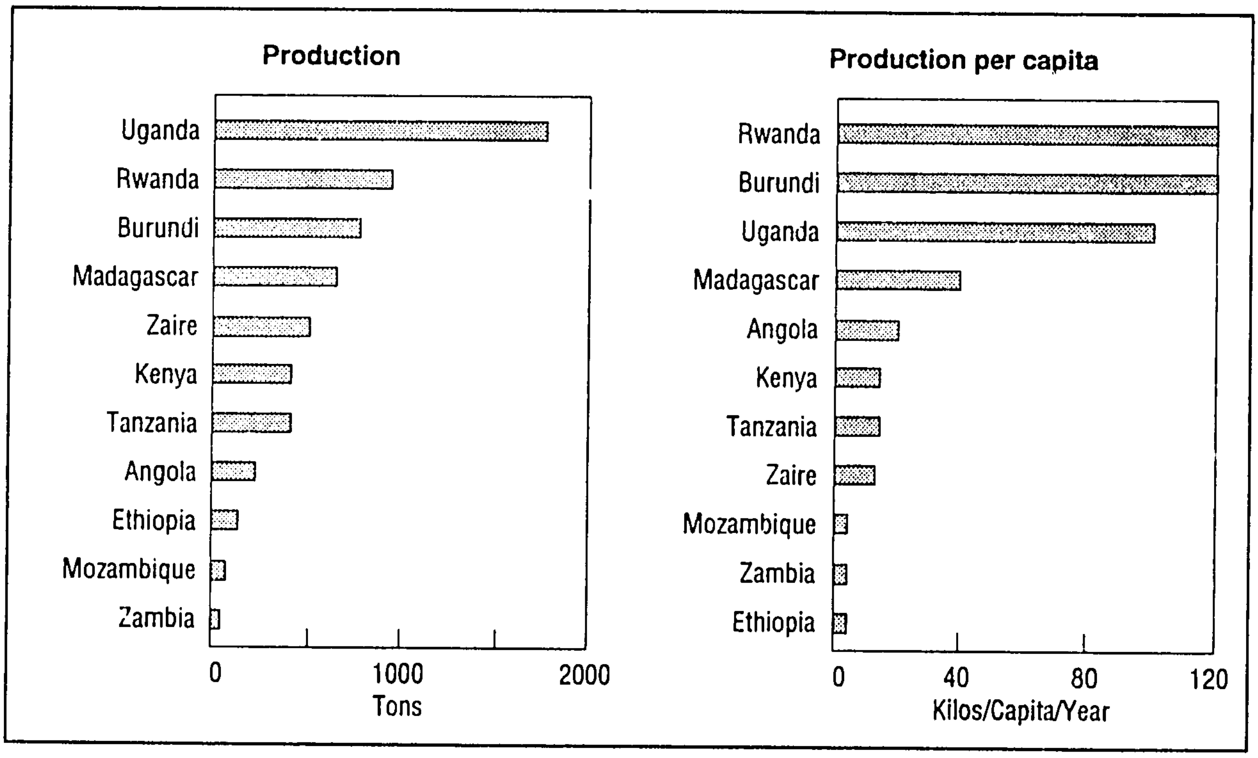
Sweetpotato as a Secondary Food Crop

In areas where the diet is based on grains, average sweetpotato consumption is far less. Madagascar reports per-capita production of 40 kilos per year; Kenya and Tanzania 15 and 13 kilos, respectively. In other countries, total production averages only a few kilos per person, Nevertheless, the importance of sweetpotato is greater than these average figures suggest, for two reasons.

First, sweetpotatoes are consumed within particular regions and cropping systems. The crop is concentrated in densely populated, mid-elevation areas and near urban markets. In Kenya, for example, over 75 percent of national production is found in the western region, in the Lake Victoria basin (Mutuura *et al*, 1990).

Second, sweetpotato is an important secondary food crop which fulfills critical roles for food security (Jana, 1982). Storage roots are kept in the ground and harvested piecemeal. Sweetpotatoes become important in the diet seasonally, typically in the "hungry months" before the major grain harvest, when stocks from the previous year have been exhausted. The crop also provides a food reserve should the major grain crop fail due to drought or other catastrophe. Storage roots are available when needed, and are commonly marketed on a small scale to meet critical needs for cash. These roles for sweetpotato are relatively more important for low-income households, which are most vulnerable to crop failure and fluctuations in income.

Figure 3.
Swettpotatoes: Ranking of Countries in Eastern and Southern Africa by Total and per Capita Production, 1986-88



Source: FAO, 1989. FAO Production Yearboook 1988. Rome:FAO

Production Systems and Constraints

Sweetpotato is commonly produced in complex, mixed cropping systems. Only a few commercial farmers who have developed links with particular markets plant relatively large fields and follow standardized agronomic practices. Many small farmers manage the crop as a flexible food reserve rather than for high yields. They choose relatively infertile soils, plant late - after other more sensitive crops are safely in the ground - apply no fertilizer or manure, and pay little attention to weeding. Nevertheless, the sweetpotato has the potential to play increasingly important roles in many areas, particularly if key constraints can be overcome (Ndamage, 1988).

Varieties

Although it is an introduced crop in Africa, a large number of different varieties of sweetpotato are found in farmers' fields throughout the region. National collections of several hundred cultivars have been made in several countries. Many of these are duplicates or closely related varieties. The identification of varieties by their local names is very imprecise. A single variety is often known by different names in different places; different cultivars are also often known by the same name. Morphological descriptors are being applied to sort out duplicates, both in collections at experiment stations and in farmers' fields (CIP, AVRDC, IBPGR, 1991).

Cooking and eating quality are important to farmers, who are also the principal consumers. Throughout the region, most prefer dry, firm-fleshed storage roots with high dry-matter, moderately sweet taste, and a minimum of fiber. Cultivars with white or cream flesh and either red or white skins predominate.

Farmers commonly mix a number of different varieties in the same plot. Varieties have different maturity periods - from three months to over a year, depending on the altitude - so a mixture is useful when the harvest is extended piecemeal over many months. A reason farmers commonly give for planting mixtures is that they cannot obtain enough of the varieties they want; another is to test new varieties. Earliness is an increasingly important trait in areas where farm size is decreasing and land is at a premium. Resistance or tolerance to viruses, weevils, drought, and other biotic and abiotic stresses could increase yields, while maintaining the sweetpotato's advantage as a low-input crop.

Cropping Patterns

Sweetpotato is most commonly monocropped in small patches scattered through cropping systems. The crop is also inter- and relay-cropped with cassava, maize, sorghum, and a variety of other crops. Sweetpotato is often found in what we can call "informal locations" - small bits of land which would not otherwise be utilized — around the edges of fields, along the roadside, or in urban lots. In the dry season sweetpotato is planted in hydromorphic soils which do not dry out, along water courses or in inland valleys or small depressions. These sites provide food when other crops are scarce, and serve as a source of planting material for upland fields when the rains begin.

Sweetpotato is propagated from vines, which farmers most commonly obtain either from their own or neighbors' fields. The crop is planted on ridges, mounds, or on flat ground. The choice of tillage method is in part a traditional habit which varies between regions, and in part a response to particular soil and drainage conditions. The use of chemical fertilizers or manure is uncommon, although sweetpotato often benefits from the residual effects of fertilizers applied to crops planted in earlier rotations. There is evidence that yields are declining in many areas of Uganda as cropping intensity increases (Ocitti and Mwanga, 1990). Sweetpotato vines cover the ground quickly and suppress weed growth. Studies throughout the region indicate that most farmers weed once or perhaps twice, lightly hilling up around the plants at the same time.

Constraints

Sweetpotato is a rustic crop, which does not suffer from overwhelming problems under normal circumstances. The major insect pest is sweetpotato weevil (*Cylas puncticolis, brunneus, and* *formicarius).* It is a major problem in dry seasons and in drier areas, and causes severe damage to roots stored in the ground. Mole rats, other rodents, and wild beasts cause significant damage.

Virus diseases are widespread; seven different strains have been identified in a recent study in Kenya and Uganda (Table 4) (Wambugu, 1991). Stem blight (*Alternaria spp.*) is a problem in some high-altitude areas. A variety of diseases attack the roots, particularly after harvest.

Table 4. Occurrence of Eight Viruses of Sweetpotatoes Detected in Field Surveys In Kenya and Uganda

		Occurrence (%) of Each Virus[1]							
Samplos From Provinces:	**Sample Numbers**	**SPFMV**	**SPLV**	**SPMMV**	**SPCV**	**SPRSV**	**CMV**	**SPCSV**	**CP[2]**
Coast	120	6	60	2	0	0	15	8	30
Eastern	150	19	54	10	9	0	28	33	29
Central	273	69	64	41	19	10	49	44	24
Rift Valley	231	20	61	27	6	0	37	36	30
Western/ Nyanza	442	51	64	18	15	9	50	55	49
Central Uganda	161	75	58	58	29	0	52	72	-
Mean	-	40	60	26	13	3	39	41	32

1/ SPFMV = Sweetpotato Feathery Mottle Virus; SPLV = Sweetpotato Latent Virus; SPMMV = Sweetpotato Mild Mottle Virus; SPCV = Sweetpotato Caulimo-Like Virus; SPRSV = Sweetpotato Ring Spot Virus; CMV = Cucumber Mosaic Virus; SPCV = Sweetpotato Chlorotic Stunt Virus. Viruses frequently occur in complexes.

2/ The "cowpea virus complex" was identified in a separate sample of 40 in coast province, 66 in Eastern province, 64 in Central province, 47 in Rift Vally province, and 15 in Western/Nyanza provinces.

Source: Wambugu, F.M. 1991. In vitro and Epidemiological Studies of Sweetpotato (Ipomoea batatas) (L.) Lam. Virus Diseases in Kenya. Ph.D. disseration, University of Bath.

Shortage of disease-free vines for planting at the beginning of the rains is a limitation in semi-arid areas with a long dry season. In areas with a more even rainfall distribution vines are available for planting most of the year, but infestation of planting material with virus diseases reduces yields. Programs for the multiplication and distribution of planting material promise to increase yields and permit the expansion of the crop in drier regions.

Utilization

Roots are cooked and prepared in a limited number of ways; most commonly, boiled. They are also cooked together with beans and other foods, and sometimes fried as chips (Woolfe, 1992).

Many small farmers sell sweetpotatoes frequently in small quantities in local markets, obtaining a flexible source of cash. The crop is also sold in urban markets, but the roots deteriorate rapidly after harvest so losses and marketing costs are high. Farmers with well-established contacts with merchants and truckers tend to specialize in commercial production and grow relatively large plots in monoculture (Mutuura et al., 1990).

Sweetpotatoes are harvested and stored in pits in the ground in Malawi and elsewhere in southern Africa, but not further north. Home or village-level processing of sweetpotatoes is relatively uncommon. In areas of Uganda and Tanzania with a long, hot dry season, serious attacks by weevils limit how long roots can be stored in the ground. Farmers harvest, chip, and sun-dry them as a way to preserve and store the crop. Villages level or industrial processing into composite flours, processed foods, animal feed, starch, and other products is common in Asia, but is as yet completely undeveloped in eastern and southern Africa.

The tender tips and young leaves of sweetpotato vines are commonly eaten as a vegetable in Asia, West Africa and in parts of southern Africa (Villareal, Tsou, Lo, and Chiu, 1985). Consumption in this form is rare in countries where root consumption is high-Rwanda, Uganda, Burundi, and Kenya. Vines are sometimes fed to livestock, particularly in central Kenya where small-scale dairying is well developed. Vines are high in protein and vitamins, and their use should be expanded. There is significant potential for new uses of sweetpotato, to take advantage of the crop's high potential.

High Potential of Sweetpotato

Productivity per Hectare per Day

One of the greatest advantages of root and tuber crops, particularly in areas where land is scarce, is their high productivity per unit of area and of time (Table 5). Sweetpotato, a short season, fast-growing crop, leads the list in terms of potential dry matter and edible energy per hectare per day. Although not normally considered as a source of protein, the crop compares very well with the alternatives in terms of edible protein per hectare per day. Market values vary according to local prices, but sweetpotatoes provide a flexible source of cash over an extended harvest period. In addition to these efficiencies of time, sweetpotato also provides food with a minimum of labor input, is not fussy about the timing of cultural operations, and produces adequately well on inferior soils with few or no purchased inputs.

Potential Importance for Nutrition

Like other root and tuber crops, sweetpotatoes are a concentrated source of food energy. The high water content and bulkiness of roots and tubers relative to grains are a problem for transportation and storage. Nevertheless, the cooking process eradicates the difference from a nutritional point of view. Table 6 compares the nutritional content of 100 gram portions of selected boiled foods. Highly processed and enriched white bread is included for comparison.

Table 5. Output per Hectare per Day: Seven Major Crops Compared

	Growth Period (Days)	Dry Matter (Kg/Ha/day)	Edible Energy (000 Kcal/Ha/day)	Edible Protein (Kg/Ha/day)	Market Value (US$/Ha/Day)
Sweetpotatoes	180	22	70	1.0	6.70
Potatoes	130	18	54	1.5	12.60
Yams	180	14	47	1.0	8.80
Cassava	272	13	27	0.1	2.20
Groundnuts	115	8	36	1.7	2.60
Rice	145	18	49	0.9	3.40
Wheat	115	14	40	1.6	2.30

Source: Horton, D., G. Prain, and P. Gregory. 1989. "Sweetpotato research and development: High-level investment returns for international R & D." CIP Circular 17: pp. 1-3

Table 6. Composition of 100 gram Cooked Portions of Selected Foods

	Water (%)	Food energy (Kcal)	Protein (g)	Thiamine (mg)	Niacin (mg)	Ascorbic acid (mg)
Potato	80	76	2.1	0.09	1.5	16
Sweetpotatoes	71	114	1.7	0.09	0.6	17
Cassava	68	124	0.9	0.00	0.0	26
Beans	69	118	7.8	0.14	0.7	0
Maize	87	51	1.2	0.02	0.2	0
Rice	73	109	2.0	0.02	0.4	0
White bread	36	269	8.7	0.09	1.2	

Source: Horton, D., G. Prain, and P. Gregory. 1989. "Sweetpotato research and development: High-level investment returns for international R & D." CIP Circular 17: pp. 1-3

1/ This paper is a modified and revised version of "Sweetpotatoes in the food systems of eastern and southern Africa," by Peter T. Ewell and Josephine Mutuura, presented at the 9th Symposium of the International Society for Tropical Root Crops (ISTRC), Accra, Ghana, October 20 -26, 1991.

2/ The total includes statistics for Angola, Botswana, Burundi, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Somalia, Swaziland, Tanzania, Uganda, Zaire, Zambia, and Zimbabwe. Namibia is not yet included in available statistical series, and data are not available for the small island countries of Reunion, Seychelles, or Comoros.

3/ This means that estimated consumption by children has been adjusted to equal the quantity they would eat if they were "standard adults."

Measured in these terms, sweetpotato ranks third among the crops listed in food energy and fourth in protein, an advantage over cassava. Sweetpotato leaves are also a source of protein, containing approximately 3 grams per 100 grams of raw fresh leaves (Woolfe, 1992). Sweetpotatoes are a valuable source of vitamin A and other nutrients, a few of which are listed in the table. Eaten in combination with other foods, either as a co-staple or as a secondary supplement, sweetpotatoes could play a much greater role as a low-cost source of nutrients (Tsou, 1985).

CIP/NARS Collaboration on Sweetpotato Research in Eastern, Central, and Southern Africa

Over the past four years, CIP's interdisciplinary team of scientists in eastern and central Africa has initiated collaborative research in the following areas (International Potato Center, 1991):

Breeding/Genetics

- Collaboration with eight national programs to evaluate existing varieties.
- Introduction of varieties and advanced germplasm through headquarters, and development of regional distribution from centerin Kenya.
- Collection of local landraces, and the use of morphological descriptors to eliminate duplicates.
- Testing and horizontal transfer of high-performance varieties between countries.

Social Science

- Diagnostic studies of the current roles of sweetpotatoes in foodsystems, to identify priority areas of potentials impact of new technologies.
- Development of a regional database.

- Interdisciplinary cooperation in on-farm research.
- Monitoring and evaluation.

Entomology

- Studies of the biology of the two African species of sweetpotato weevil, *Cylas puncticollis* and *brunneus*.
- Identification and synthesis of pheromones for the two species.
- Surveys of the distribution and severity of all major insect pests.
- On-station and on-farm research on cultural pest control.
- Development of a sweetpotato pest database, in collaboration with the International Institute of Biological Control (IIBC) and the Kenya Agricultural Research Institute (KARI).

Pathology

- Development of diagnostic methods for the identification of virus, fungal, and bacterial diseases.
- Field studies on the distribution and epidemiology of viruses.
- Field surveys of the distribution of non-viral diseases and disorders.
- Development of a sweetpotato disease database.

Agronomy

- Preliminary studies to adapt rapid multiplication techniques to local conditions.
- Support for agronomic research in NARS.

Institutional Support

In addition to collaborative research, CIP provides training, information, and institutional support from the regional office in Nairobi. The Center has helped to organize bilateral support for sweetpotato research programs in Uganda, Tanzania, and Rwanda.

When the mandate for sweetpotato research was transferred to CIP in 1987, IITA had already organized support for a number of national programs through the Eastern and Southern Africa Rootcrops Research Network (ESARRN). As part of an agreement to manage the transition, CIP has provided backstopping in research and training through the current phase of that project, which expired in September, 1992.

PRAPAC *(Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Central)* was funded in 1982 as a research network of the national potato programs of Burundi, Rwanda, Uganda, and Zaire, plus CIP. In 1990 the Directors of the network, who are the Directors of the respective national research institutes, decided to expand its mandate to include sweetpotato and two additional countries, Ethiopia and Kenya. The name of the network has been modified to PRAPACE *(Programme Régional d'Amélioration de la Culture de la Pomme de Terre et de la Patate Douce en Afrique Centrale et de l'Est)*, the Regional Program for Potato and Sweetpotato Improvement in Central and Eastern Africa. The six member countries include most of the areas in Africa where sweetpotato is an important staple food. It must be emphasized that CIP is organized to work with any NARS in eastern, central, and southern Africa with a sweetpotato research program to provide backstopping, training, and other support from our office in Kenya.

Priorities for Future Activities

Sweetpotato is a crop which has been significantly under-researched in the past. Coordinated efforts by NARS, CIP, and other partners promise to open up new opportunities for the increased production of food, animal feed, and processed products

CIP, with its global mandate, is able to bring germplasm from other areas worldwide, into Africa. Many varieties with excellent agronomic, culinary, and processing characteristics already exist. Coordinated testing and breeding focused on local needs should quite quickly get better varieties into farmers' fields. An important part of this process must be support to national programs for the multiplication and distribution of planting material.

The utilization of the crop is confined to a very few uses in most parts of Africa-farmers commonly store sweetpotatoes in the ground, harvest them piecemeal, boil them, and eat them. There is great potential for interdisciplinary research and development on new recipes and products.

Sweetpotato is concentrated in regions where increasing population density is putting land and water resources under great pressure, which is also forcing large numbers of people to migrate into marginal areas. CIP plans to collaborate, with both international and national institutions, in programs of interdisciplinary research on resource management. Both sweetpotato and potato will have important roles to play in systems of production which are both more productive and sustainable.

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PRELIMINARY RESULTS OF A STUDY ON THE UTILIZATION OF SWEETPOTATO TUBERS & FLOUR IN BAKERY PRODUCTS IN BAMENDA NORTH WEST PROVINCE - CAMEROON

by Adhiambo Odaga

Introduction

This paper presents preliminary data from on-going research on the commercial viability of using sweetpotato tubers and flour in bakery products. The research is being carried out in collaboration with the FAO/UNDP project on the "Reduction of postharvest losses for cereals, roots and tubers at the rural level", attached to the Provincial Delegation of Agriculture. Sweetpotatoes are widely grown in the North West province but postharvest utilization is limited. As Mr. Mbakwa has already indicated, the FAO/UNDP project has developed a method of processing sweetpotato tubers into flour which is adapted to local conditions. The aim of the present research is to develop a range of bakery products that utilize composite sweetpotato and wheat flour recipes for bread, cakes, biscuits, pastries and local snacks, which are acceptable to local consumers and to introduce them to local bakeries and bakers.

Bakery products are very popular in Cameroon and quite cheap because of the large subsidy on imported wheat. There are several types of bakers and bakeries ranging from women who fry and sell a variety of local snacks, small often 'traditional' quarter bakeries who hand mix dough and bake in brick wood-fueled ovens, to large 'modern' bakeries with state of the art technology and sophisticated marketing networks. Due to the prevailing economic crisis in the country however, the government is under pressure to remove the subsidy on wheat flour. Indeed in May of this year the wholesale price of wheat flour rose by between 12 to 20 percent. The whole sale price of wheat is not fixed but depends on the quality of the wheat, the quantity being purchased and the place of purchase. Furthermore, earlier this month there was heated debate in the National Assembly on a government proposal to levy a 10 percent tax on wheat flour. The potential savings in foreign exchange and to bakers if the sweetpotato/wheat flour recipes are acceptable, could be significant. The possible increased demand for sweetpotatoes and locally-manufactured processing equipment will also be beneficial to the local economy and should encourage the adoption of improved sweetpotato varieties.

Product Development with Sweetpotato Flour Bread

Initially it was presumed that sweetpotato flour could be incorporated into breadmaking. A local pastry chef was hired to develop recipes for popular local breads. Despite a marked difference in appearance from local bread, acceptability with regard to taste, based on initial palatability tests, and the convenience of using sweetpotato flour instead of tubers in baking prompted the introduction of a recipe comprising 25% sweetpotato flour to a modern bakery, Boulangeries Patisseries du Cameroon, (BPC). The first batch of bread baked turned out well but was rejected by consumers for several reasons. The sweetpotato flour bread looked like wheat bread, which consumers in Cameroon are not familiar with. Since several of the BPC distributors did not let their clients know that the bread contained sweetpotato, the products were rejected on sight. These consumers who did taste the bread found it palatable although some complained that the bread was too crumbly and a little too dry. The bakers also found the sweetpotato flour difficult to work with in breadmaking. They spent hours kneading in order to turn out reasonable dough. This exercise has laid to rest an ongoing debate amongst researchers on whether or not to endorse sweetpotato flour bread recipes. For now we have decided not to recommend sweetpotato flour for bread making.

High Value Bakery Products

In the process of carrying out the experiments with the sweetpotato flour for breadmaking, it became evident that sweetpotato flour was suitable for high-value baked products such as cakes, biscuits and pastries. Consequently, a number of recipes using between 25-75% sweetpotato flour have been developed.

The plan consists of having the pastry chef introduce these bakery products to local bakeries. After this, each bakery will receive 50kg of sweetpotato flour to use in baking their high-value products. Data on production and sales will be collected, compiled and analysed. This will allow us to assess the commercial benefits, if any, of using composite sweetpotato flour/wheat flour recipes.

The recipes have been introduced to the pastry chefs at two bakeries. The staff of the ADU bakery have been particularly impressed with the recipes for biscuits, doughnuts, and croissants containing between 25 and 50% sweetpotato flour. They informed us that the high-value products, such as those we have developed recipes for, are not as popular in the Anglophone North West province as in the Francophone regions. They have, however, been impressed with the quick rate of sale of all the products baked with sweetpotato flour, in their local retail outlet. Both bakeries are now waiting to receive sweetpotato flour for the data collecting exercise.

Local Snacks

At the same time as we were developing recipes for high-value baked products, we decided to explore the possibility of incorporating sweetpotato flour into local snacks recipes. As mentioned above, several women, both in the rural and urban areas fry or bake and sell a variety of local snacks. A recipe that utilizes 25% sweetpotato flour for making 'puff-puff', a local deep-fried doughnut-like snack has been tested and well received. Also, a fish/meat pie using 40-50% sweetpotato flour has been well received. It is planed to begin introducing the 'puff-puff' recipe to the women's group processing sweetpotato tubers into chips for milling into flour at Babungo, as well as to other women in Bamenda who fry this snack daily. Further experiments are being carried out to develop recipes for other local snacks.

Discussion

Generally, we have had a very positive and enthusiastic reception to the sweetpotato flour products we have developed, both from bakers and consumers. Our major concern with regard to introducing sweetpotato flour has been the viability of adoption, given the relatively high cost of the flour (150 CFA) compared to the low price of wheat flour. This concern is mitigated by several factors. First, the recipes have been developed for high-value baked products, which are the most expensive items in most bakeries. Second, 40 to 70% less sugar is used in most of the recipes due to the high sugar content of the sweetpotatoes. Third, the rise in the wholesale price of wheat flour rose recently and there are indications that it may be further raised very soon. And finally, there is an added nutritive benefit in using sweetpotato flour.

On a more technical level, we are not satisfied with the texture of the milled sweetpotato flour. It could be finer. This has also been pointed out by the bakers who have worked with the flour. Sifting the flour is one possibility, but we are trying to avoid it because of the large losses that would be incurred. We are presently exploring other ways of overcoming this problem.

Product Development for Sweetpotato Tubers

At the time that the FAO/UNDP project was developing recipes for sweetpotato flour, they were giv-.a a video tape of a CIP recipe that utilizes grated sweetpotato tubers in breadmaking. Project staff approached a small woman baker who was renting a local bakery, and encouraged her to try out similar recipes. The results were quite promising. All the bread she baked and sold was well appreciated by her customers. After this informal exercise, the 'wet-method' was not pursued further until early 1992 when the FAO/UNDP project and CIP decided to collaborate on a locally research initiative to examine the potential economic benefits of introducing composite sweetpotato flour/ wheat flour bakery products.

We decided to first introduce this method of breadmaking to a small 'traditional' bakery in Bamenda- PETIT EMAC (PEC). The bakery is located in Nkwen, one of the major quarters in the town. They only bake bread- the square loaves, known locally as 'English loaf' or 'Kumba bread'. The french load or baguette is also a very popular type of bread but it is not produced in this particular bakery, they hand mix the dough and bake their bread in a brick wood-fueled oven. They do however, knead the dough in a diesel-powered machine. The chief baker rents the bakery and hires three laborers and another baker at daily rate. Each month the bakery consumes an average of sixty, 50kg bags of wheat flour.

Tne hired baker had previously worked with the woman baker who first used the 'wet-method' to produce bread and was thus familiar with the grated sweetpotato/wheat flour recipe. In April, we were therefore able to use this type of bread to carry out palatability tests to establish the percentage of sweetpotato that would be acceptable to consumers. The data from the palatability tests has been analyzed elsewhere. No significant differences were found in consumer preference for bread containing 20% and 30% grated sweetpotato. We therefore decided to recommend to local bakeries a composite mixture containing between 25-30% grated sweetpotato.

The bakery has made and sold several batches of sweetpotato bread containing 25-35% sweetpotato in the dough. Most of the batches have been less than 50kg in weight. Table 1 presents data comparing the costs and revenue from a mixture of one bag wheat flour, the smallest amount that the PEC bakery mixes at any given time, and one bag of wheat flour plus 17kg grated sweetpotato (i.e 25% grated sweetpotato). We would have preferred to compare costs and income between two similar weights (50kg wheat flour and 35kg wheat flour mixed with 15kg grated sweetpotato). The baker however preferred to make his comparison in the manner presented here. The data clearly indicate that it cost less to produce sweetpotato bread than to produce 100% wheat bread. This is due to the reduced amount of sugar, magarine and water used in the sweetpotato bread, which offsets the additional cost for the sweetpotato tubers, grating and groundnut oil in this recipe. The sweetpotato bread dough was larger and yielded more units of bread, earning 3,000CFA more than the wheat bread. It is important to note that the PEC does not have a scale to weigh its dough before baking, as is normally done. Thus the weight from one unit to the next can vary by as much as 40g. This of course has inplications for the return from any batch of dough. The difference in revenue from the 50kg bag of wheat flour plus grated sweetpotato as compared to the 50kg of wheat flour alone- came to 4,461 CFA, a substantial amount. We are preparing to move the grater that the PEC bakery has been using to the next bakery. The manager is seriously considering investing in an electric grater (approximate cost 265,000 CFA) and has approached us to arrange a meeting with a local manufacturer.

Discussion

We had several concerns as we introduced this method of breadmaking to bakeries. Would the bakery owners be discouraged by the large expense of investing in an electric grater? Would the extra tasks of washing and grating the tubers before mixing the dough pose a problem for bakery staff? Finally, the availability and supply of sweetpotato tubers to the bakeries could pose a potential problem.

The fact that PEC, a small bakery is considering investing in a grater, suggests that the cost of an electric grater may not be as prohibitive to adoption as we had presumed. For the time being, in order to facilitate the smooth running of the exercise, we left the FAO/UNDP project's grater with PEC bakery. The length of time required to wash the tubers (10 minutes), and to grate them (5 minutes) was not viewed as a constraint. Instead, the long time required for the bread to rise posed some problems initially. Once the baker became used to mixing the dough however, it was less of an issue and by they time he was making the sixth batch it was no longer mentioned. Mr Atangana Benoit, the chef we are working with, has suggested that this problem may be due to the fact that the dough is being hand-mixed. He has suggested that if an electric mixer is used, there will be no significant difference between the time needed for the 100% wheat dough and composite sweetpotato dough to rise. We will test this suposition when we introduce this method to modern bakeries who use electric dough mixers.

The extent to which bakeries will have a year round supply of fresh sweetpotato to meet their needs, was identified as a possible disincentive to the adoption of the 'wet method'. However, we did not view this as a major constraint and have decided to get the bakers' views on the matter. So far our discussions with the bakery owners' suggest that they do not view supply as a major problem. They feel that they could easily arrange for a regular supply of sweetpotatoes at short notice, either from rural sites or locally, from urban gardens.

Conclusion

This paper has presented preliminary data on ongoing research. No firm conclusions can yet be made since we are still at the stage of introducing the recipes to bakers and have accumulated limited raw data. Progress has been hampered by the fact that the projects has only one fuel-powered grater to work with. An electric grater is also available but it can only be used in those modern bakeries that have the capability of running its three phase engine. We have had to adjust our work to the pace of each bakery, a factor which has slowed us down but has also allowed us time to contact other bakeries and decide which recipes to introduce to them, based on the products they bake and their equipment.

Our research effort has been boosted by national TV coverage of sweetpotato processing into chips and flour, product development and introduction to bakeries. We are confident that by the end of the year the full cost-benefit data for bakery products using sweetpotato will confirm what we believe to be the great commercial potential for utilization and adoption of sweetpotato in local bakery products.

Table 1. Costs of Production for Sweetpotato Bread Vs. Wheat Bread
Pec Bakery, Ndamukong Street, Bamenda

	Price/kg (CFA)	Wheat flour Unit (kg)	Wheat flour Costs (CFA)	Sweetpotato Unit (kg)	Sweetpotato Costs (CFA)
Wheat flour	140	50.0	7,000	50.0	7,000
Grated sweetpotato	20	—	—	17.0	340
Yeast	1,890	0.3	567	0.15	283
Dough improver	2,500	0.15	375	0.15	375
Magarine	750	2.0	1,500	0.5	375
Salt	150	0.3	45	0.25	38
Sugar	300	5.0	1,500	2.0	600
Groundnut oil	500/litre	—	—	11	500
Water	10/litre	30l	300	16l	160
Fuel[a]			2,400		2,425
Labour[b]	1,250		1,250		1,250
Other costs[c]			470		540
Total Costs		15,407			13,946
Loaves produced:	Unit price(CFA)				
	30		200		200
	80		150		150
	200		20		35
Total Revenue			22,000		25,000
Net Revenue			6,593		11,054

a) firewood, engine oil, diesel; b) one baker and three assistants;
c) depreciation, management, marketing, etc.

RECOMMENDATIONS

Introduction

On the last day of the Workshop, the participants were divided into two groups to deliberate independently and to make recommendations for future sweetpotato research in Africa. The composition of the groups was as follows:

Group One	Group Two
A. Traore (Mali)	A. Bediako (Ghana)
T. Komlan (Togo)	A. Amani (Cote d'Ivoire)
O. Tewe (Nigeria)	J. Koi (Cameroon)
A. Nnoung (Cameroon)	J. Ngeve (Cameroon)
A. Tumanteh (Cameroon)	W. Nganje (Cameroon)
F. Abgo (Nigeria)	T. Oguntunde (Nigeria)

Each group presented its recommendations, which were subsequently discussed by all the participants. It was then decided to merge the recommendations of the two groups into a single set of recommenations.

Constraints

Sweetpotato, a minor crop in tropical Africa, is the only food crop that has a positive per capita increase of production in the shortest possible time. It therefore has the potential for arresting and reversing the present food deficit. Sweetpotato is commonly used for human food in West, Central and East Africa, which account for about 90% of the total African production.

Some countries have developed high-yielding varieties that have met with consumer acceptance. These improved varieties have been introduced to famers in some African countries. Alghough sweetpotatoes are mostly consumed in the traditional way (raw, boiled, roasted) consumer demand continues to increase.

Existing situation in Africa—constraints to sweetpotato production:

The constraints outlined below need to be addressed in order to increase sweetpotato production and utilization in African countries.

1. Reliable sweetpotato production data for the different regions is not available.
2. Breeding, selection and production agronomy for human, animal and industrial uses of sweetpotato have not been sufficiently researched.
3. Organized systems to sustain production and utilization are not available to producers and processors.
4. Post-harvest technology has not been sufficiently developed.

Recommendations

To overcome the constraints to sweetpotato production and utilization outlined above, and to set up the necessary infrastructure, it was recommended that:

a) an organized communication system be established among scientists working on sweetpotatoes within and between countries, particularly in the west and central African sub-regions be established; and
b) this network be promoted by CIP.

The network should be composed of representatives from national organizations working on sweetpotatoes with expertise in the following areas:

- documentation;
- breeding, selection and prouction;
- post-harvest technology;
- socioeconomics;
- training and technology transfer

Objectives

Once in place, the proposed network of sweetpotato specialists would stimulate, facilitate and coordinate research in the African region in order to achieve the following objectives:

1. The development of appropriate post-harvest technologies for sweetpotato.
2. The development of a better understanding of the socioeconomic aspects of sweetpotato production.
3. The development of contracts for sweetpotato breeding and selection to make improved varieties more readily available to farmers.
4. The development of improved and more extensive information transfer and training in new production and utilization systems.
5. The development of new varieties and methodologies for the control of diseases and pests affecting sweetpotatoes.