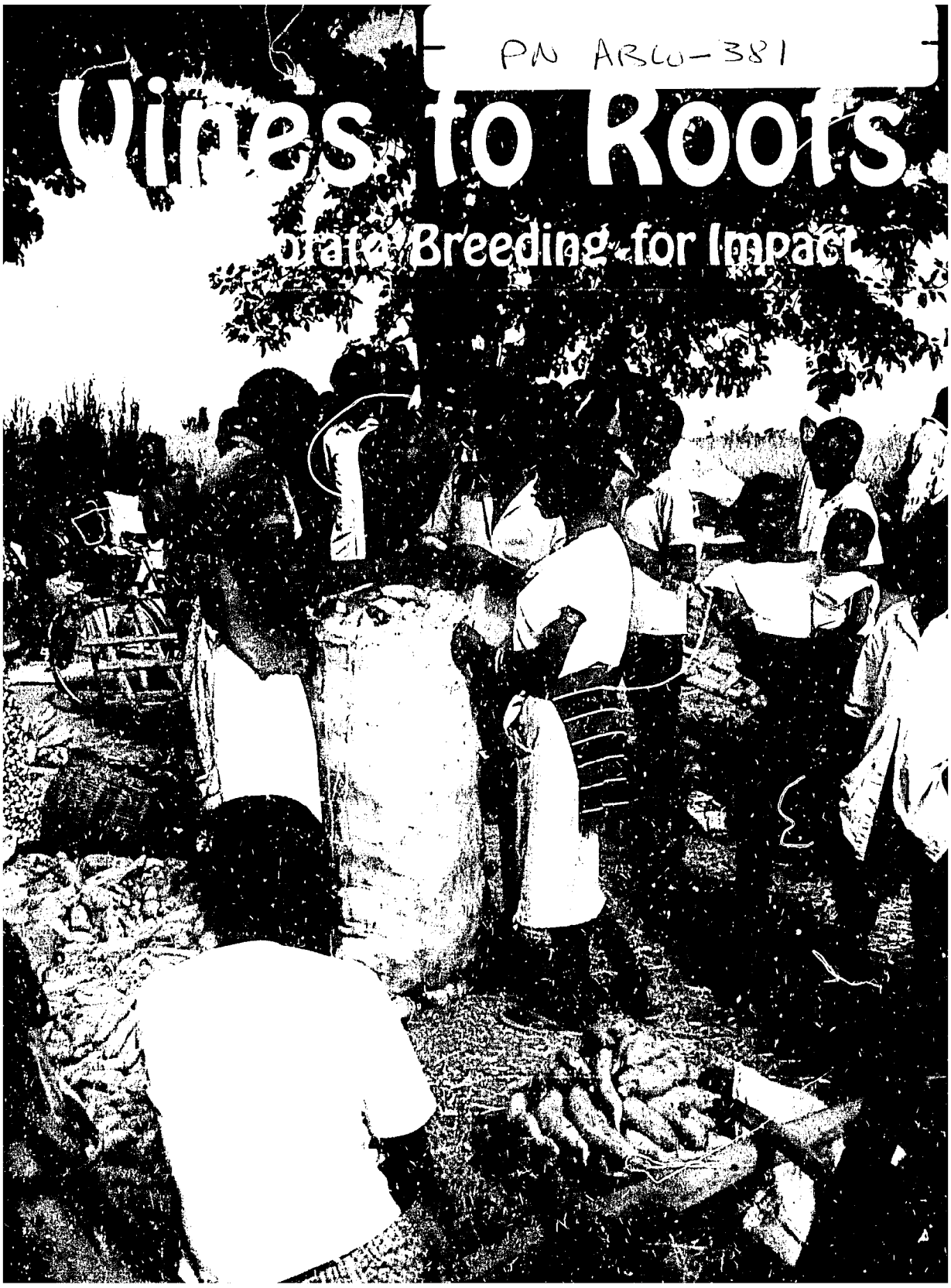
PN ABCU-381

Vines to Roots

Crop Breeding for Impact



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Cover:
Photo of marketing of sweetpotato roots in roadside market, Mbale district, eastern Uganda (taken by Greg Scott).

PN ABW-381

Vines to Roots

Sweetpotato Breeding for Impact

Recommendations and Abstracts from an international workshop held in Lima, Peru, June 1-3, 1994

INTERNATIONAL POTATO CENTER (CIP)

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Contents

	Page
Foreword	v
Acknowledgments	vi
Workshop Objectives	1
Recommendations	7
Abstracts	17
Workshop Program	38
List of Participants	42
Acronyms	46

Foreword

Few major food crops are so genetically diverse and underexploited as the sweetpotato. In a world with rapidly growing numbers of hungry people, this situation needs changing, and the sooner the better. To that end, CIP is eager to update and refine its breeding strategy for sweetpotato so as to take full advantage of the crop's remarkably versatile potential as both a food for human consumption and a raw material for animal feed and industry.

CIP is pleased that a select group of outside experts from academia, research institutions, and the private sector was able to join us in the deliberations on our breeding strategy for sweetpotato. We are grateful as well that network coordinators from UPWARD and SAPPRAD could contribute to these discussions. In keeping with past practice, the Center sees meetings like this as a way to actively seek out the views of its collaborators in developing and developed countries so as to better serve our ultimate beneficiaries: poor farmers and low-income consumers in Latin America, Africa, and Asia.

With this workshop, CIP's efforts with sweetpotato have reached a watershed. In the mid1980s, there was talk of the Center assuming additional responsibilities by expanding its mandate to include sweetpotato. This talk became CGIAR policy shortly thereafter. CIP then began a major task: to consolidate the then-existing global germplasm collection, restructure its research program to include sweetpotato, complete the collection of germplasm in the crop's center of origin, hire new staff to work on this crop specifically, and consolidate interaction with collaborating institutions in developing and developed countries for a mutually acceptable program of work. There then ensued a series of national needs assessments involving intensive data collection from farmers and consumers to serve as the raw material for debate and discussion on refining CIP's breeding strategy. This publication represents the essence of the outcome of that interchange and should serve as the cornerstone for CIP's collaborative breeding efforts with our national partners around the world to achieve the sweetpotato's full potential in the years ahead.

Hubert Zandstra

Hubert Zandstra
Director General

Acknowledgments

This publication and the workshop on which it is based would not have been possible without the collaboration of many people. A note of thanks is due to Tom Walker and Ted Carey, who helped put the original list of speakers and topics together and arranged for the participation of scientists from the USA: Janice Bohac from the U.S. Department of Agriculture, Wanda Collins from North Carolina State University, and Paul Thompson from Mississippi State University. We thank Janice, Wanda, and Paul for taking the time to be in Lima and share their ideas with us in these deliberations. Thanks are due as well to Nelly Espinola, who arranged for the participation from collaborating institutions in Peru of Carlos Gómez from the National Agrarian University-La Molina, Estuardo Masías from Almide, Inc., and Juan Pablo Molina from the National Sweetpotato Program.

We are all grateful to Bill Hardy for his help in editing the recommendations and abstracts, and persistence in pushing the publication ahead. Marco Sheen was a key person in text preparation and layout. A note of special thanks goes to Anselmo Morales for his attractive cover design. Thanks as well to Zandra Vásquez, Patricia Chiroque, and Ana María Pérez for sending out so many e-mail messages, invitations, draft recommendations, and requests for abstracts. Finally, thanks to Zósimo Huamán, Ted Carey, and Enrique Chujoy for their special assistance in consolidating the recommendations to everyone's satisfaction.

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Workshop Objectives

Sweepotato production and utilization worldwide are in a state of considerable flux. Area planted and production in Asia and Latin America have sharply declined whereas in Sub-Saharan Africa they have registered noteworthy increases (Table 1). The share of output going to processing for human consumption and animal feed has risen rapidly, albeit unevenly, across the developing world (Table 2). These developments represent valid reasons in themselves for sweetpotato breeders and their collaborators in other disciplines to pause in their efforts and reassess their priorities, methods, and operating procedures. For scientists working at and with CIP, additional interest in reviewing the institution's sweetpotato breeding strategy is motivated by the recent changes within the organization itself.

Since making sweetpotato part of its global mandate in the late 1980s, CIP has devoted considerable time, effort, and money to learning more about the crop in Latin America (CIP, 1988b), Africa (CIP, 1988a), and Asia (CIP, 1989b). These initiatives enabled us to become more aware of the needs of our collaborators in national programs and the constraints they felt the crop faced (CIP 1989a, 1991). We also spent time learning and absorbing a great deal of knowledge about the plant from other scientists (Mackay et al., 1989; Woolfe, 1992) and, most importantly, from farmers and consumers, our ultimate beneficiaries (UPWARD, 1991).

With this information, CIP reassessed its long-term goals in a new strategic plan (CIP, 1991b). We also scrutinized our scientific objectives and their potential for impact (Collion and Gregory, 1993) as well as the means for achieving those goals in the medium term (CIP, 1992). As we put these plans into operation in the process of applying this knowledge, CIP paused again to bring this group together to look at the Center's sweetpotato breeding strategy in light of all that has gone on in the interim.

The objectives of this workshop follow:

1. Review recent progress in sweetpotato breeding both in CIP and with collaborating institutions and networks in developing countries.

2. Consider current workplans for sweetpotato breeding activities so as to foster greater regional and global integration of procedures for the purpose of accelerating impact.

3. Analyze current plans and future proposals intended to complement recent progress.

4. Expand contact and coordination with sweetpotato breeders in developed countries so as to encourage broader collaboration in the future.

5. Review and update CIP's global sweetpotato breeding strategy.

As we work together to achieve these objectives, the importance of impact deserves particular attention. In reviewing past activities and planning for the future, we must all ask ourselves how well the work under discussion has contributed, or will contribute, to CIP's impact on our partners, the NARS, and the people they serve. Any activity that is unlikely to achieve practical agricultural impact must have a low priority for the use of our resources, however interesting it might be from a research perspective. In developing CIP's sweetpotato breeding strategy, we must remind ourselves that precisely because breeding is often a long-term activity in which results can be achieved only after 10 or 20 years, the impact orientation from the outset is critical. As we engage in this bit of individual and institutional introspection, with these considerations in mind, I am confident that we have the right to expect that results will not only serve us well in our future work but will also lead to improvements in production, consumption, and nutrition that poor farmers and low-income consumers so urgently need.

Peter Gregory

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Table 1. Sweetpotato in developing countries, 1961-93.

Region	1991-93			Change (%)[a]		
	Production (000 t)	Area (000 ha)	Yield (t/ha)	1	2	3
Asia[b]	113,874	7,396	15.4	30.6	-36.3	104.9
China	105,150	6,228	16.9	33.6	-39.7	121.7
Vietnam	2,437	387	6.3	111.4	63.7	29.1
Indonesia	2,163	228	9.5	-29.6	-51.0	43.7
India	1,195	144	8.3	20.7	-0.7	21.6
Philippines	663	137	4.9	-8.9	-7.4	-1.6
Bangladesh	462	48	9.6	32.1	23.1	7.3
Africa[c]	6,256	1,338	4.7	84.9	110.1	-12.0
(Sub-Sahara)[d]	6,137	1,334	4.6	85.9	110.9	-11.8
Uganda	1,861	439	4.24	238.4	179.8	20.9
Rwanda	773	161	4.80	51.6	116.6	-30.0
Kenya	593	60	9.83	295.6	135.1	68.3
Tanzania	269	210	1.28	27.0	584.8	-81.4
Cameroon	160	31	5.15	44.3	-27.3	98.6
Nigeria	38	5	7.67	-75.1	-61.5	-35.3
Latin America[e]	1,774	265	6.7	-36.4	-23.4	-16.9
Brazil	609	59	10.3	-58.0	-59.2	3.0
Cuba	230	57	4.0	18.4	29.3	-8.5
Peru	147	10	14.2	-2.0	-36.7	54.9
Total	123,760	9,109	13.6	22.8	-30.1	75.5

a. 1 = Production (1991-93 vs. 1961-63); 2 = Area (1991-93 vs. 1961-63); 3 = Yield (1991-93 vs. 1961-63).
b. Asia - (Israel, Japan) + Oceania - (Australia, New Zealand).
c. Africa not including South Africa.
d. Africa - (Morocco, Algeria, Tunisia, Egypt, Libya) - (South Africa).
e. North and Central America + South America - (Canada, USA).
SOURCE: FAO Basic Data Unit, unpublished statistics.

Table 2. Utilization (%) of sweetpotato in developing countries, 1961-90.

Region	1961-63				1988-90			
	Food	Seed	Processing	Other[a]	Food	Seed	Processing	Other[a]
Asia[b]	76.7	12.5	4.8	6.0	49.6	39.4	5.6	5.4
China	76.1	13.5	5.1	5.3	46.9	42.1	6.0	5.0
Vietnam	85.0	10.0	0.0	5.0	85.0	10.0	0.0	5.0
Indonesia	90.0	0.0	0.0	10.0	88.0	2.0	0.0	10.0
India	94.0	0.0	1.0	5.0	94.0	0.0	1.0	5.0
Philippines	90.0	5.0	0.0	5.0	90.0	5.0	0.0	5.0
Bangladesh	90.0	0.0	0.0	10.0	90.0	0.0	0.0	10.0
Africa[c]	84.6	3.1	0.0	12.3	86.4	2.4	0.0	11.1
(Sub-Sahara)[d]	84.4	3.2	0.0	12.3	86.4	2.5	0.0	11.1
Uganda	79.9	0.0	0.0	20.1	85.0	0.0	0.0	15.0
Rwanda	91.7	0.0	0.0	8.3	94.0	0.0	0.0	6.0
Kenya	90.0	0.0	0.0	10.0	90.0	0.0	0.0	10.0
Tanzania	95.0	0.0	0.0	5.0	95.0	0.0	0.0	5.0
Cameroon	88.0	2.0	0.0	10.0	88.0	2.0	0.0	10.0
Nigeria	80.0	0.0	0.0	20.0	80.0	0.0	0.0	20.0
Latin America[e]	66.5	20.4	0.0	13.1	73.8	13.1	0.0	13.1
Brazil	50.0	35.0	0.0	15.0	50.0	35.0	0.0	15.0
Cuba	80.0	10.0	0.0	10.0	80.0	10.0	0.0	10.0
Peru	80.0	10.0	0.0	10.0	80.0	10.0	0.0	10.0

a. Other = (Seed + waste + other uses).
b. Asia - (Israel, Japan) + Oceania - (Australia, New Zealand).
c. Africa not including South Africa.
d. Africa - (Morocco, Algeria, Tunisia, Egypt, Libya) - (South Africa).
e. North and Central America + South America - (Canada, USA).
SOURCE: FAO Food Balance Sheets, unpublished statistics.

Recommendations

Based on the presentations, questions and answers, as well as round-table discussions, the workshop participants prepared two subsets of recommendations regarding CIP's sweetpotato breeding strategy. One subset focuses on issues related to collection, characterization, and conservation of sweetpotato genetic resources. The other concerns sweetpotato germplasm enhancement and utilization. Together, these recommendations cover the essential components of CIP's breeding strategy for sweetpotato.

GROUP 1
Conservation of Sweetpotato Genetic Resources

In order to effectively safeguard global sweetpotato genetic resources using both a scientific and needs-based approach, CIP needs a conservation strategy that covers (1) collection activities, (2) characterization and evaluation of present and future collections, and (3) conservation of genetic materials with diverse techniques.

Recommendations

Collecting activities. Despite the numerous collecting expeditions conducted by CIP and NARS in the primary center of diversity of the sweetpotato, we recommend that the collection component be continued if it is determined that appropriate genetic diversity in the wild species of Section Batatas does not exist in the present collection. Similarly, we recommend that *Ipomoea batatas* germplasm continue to be collected in areas designated as high risk by the matrix approach, with more emphasis on some regions in Asia and Africa.

For wild species, future activities should continue to concentrate on species of Section Batatas. High priority should be assigned to those species for which very few, or no, living accessions exist in the genebank (e.g., *I. tabascana*). Major emphasis should be given to defining levels of genetic diversity in the existing accessions. Therefore, collecting will be reduced until the genetic diversity within these species is known.

For *I. batatas*, a matrix of countries in Asia and Africa with potential for collecting activities should be established on the basis of possibility of

diversity (high, medium, low) and likelihood of loss (H, M, L). The highest priority for collecting will be in those countries with high diversity and high risk of loss. Collecting in other countries will be done by priority according to the matrix classification as resources become available.

Characterization and evaluation. The characterization and evaluation component assures that all existing germplasm will be adequately described and evaluated for desirable traits to enhance utilization. This is initially the highest priority component of the present strategy.

CIP should continue to collaborate with NARS to characterize and evaluate existing germplasm in-country where collected. In cases where NARS capacity or interest does not exist, characterization could be done at CIP headquarters or in CIP's regional installations according to CIP priorities and as resources become available through special projects. These activities should be completed quickly to enhance priority-setting (including indigenous knowledge in database form). True sweetpotato seed of different accessions and in vitro cultures of cultivars with desirable traits selected in each country should be included in the collection maintained at CIP headquarters. Data sets with passport, characterization, and evaluation data should be stored in CIP's germplasm databases.

Genetic diversity studies using DNA-based techniques should be prioritized according to morphological variation and number of accessions from each country.

Conservation. The conservation component of CIP's sweetpotato breeding strategy should aim to ensure a carefully balanced, scientifically sound, and needs-based maintenance of both genetic and genotypic diversity. The recommended conservation strategy has as its focal point the BASE, RESERVE, CORE, and REGIONAL CORE germplasm collections.

The strategy aims to disperse the responsibility for global conservation of sweetpotato genetic resources and to define CIP's role clearly.

The BASE collection will be composed of seeds obtained from the clonal collections and will be stored under internationally agreed-upon conditions for long-term storage.

The RESERVE collection will be composed of specific sweetpotato cultivars that represent the maximum genetic diversity from countries in the primary and secondary centers of diversity. This collection will comprise a selection of cultivars that minimize similarity between accessions from those countries. It should include the most widespread

cultivars and those with resistances to diseases and pests, and other desirable traits of national, regional, or global importance. CIP should maintain the RESERVE collection until NARS develop facilities and expertise to take full responsibility for maintenance of the accessions collected in their countries.

The CORE collection will be composed of cultivars that represent the genetic spectrum available in the whole collection maintained at CIP. Selection of the CORE collection will require the use of modern techniques in order to cover the maximum genetic diversity in existence within the clonal collection. This CORE collection should be thoroughly evaluated and made available to users as pathogen-tested clones.

To sustain this conservation strategy adequately, REGIONAL CORE collections should be organized in Latin America and the Caribbean, Asia, and Africa. These collections will most likely contain greater genotypic diversity. Within each region, in-country systems for the conservation of national sweetpotato collections should be promoted. In-country collections could be maintained both *ex situ* and *in situ* depending on the interest and resources available in each country. In those countries where CIP collaborated with NARS in collecting activities, the collections maintained *ex situ* could be composed of a duplicate set of the clonal collections from that country maintained at CIP, their own collections of native cultivars, and working collections of advanced genetic materials. Depending on national interest, research will be needed to determine the feasibility of *in situ* conservation of wild *Ipomoea* species of Section Batatas in protected areas. Similarly, on-farm maintenance of native cultivars (landraces) should be attempted at selected sites within the microcenters of sweetpotato diversity. The in-country collections will most likely maintain an even higher level of genotypic diversity because of the specific interest of each country. A sample of botanical seed from in-country collections in Asia and Africa as well as a selected set of cultivars with desirable traits for worldwide use should be obtained for storage in the BASE collection maintained at CIP headquarters to increase its genetic diversity.

Members of Group 1:

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GROUP 2
Sweetpotato Germplasm Enhancement and Utilization

The group recognizes that recommendations regarding CIP's strategy for sweetpotato germplasm enhancement and utilization must of necessity address a number of important, interrelated issues. They include: (1) the key operational elements and expected outputs from CIP's sweetpotato breeding activities; (2) global breeding priorities; (3) CIP's breeding sites, linkages, and responsibilities; (4) the role of conventional breeding methods at CIP; and (5) the use of nonconventional breeding methods in CIP's total sweetpotato breeding effort.

Recommendations

Key elements and expected outputs. The group endorses the key operational elements of CIP's strategy for germplasm enhancement and utilization. Operationally, CIP has put in place a highly decentralized, collaborative, and demand/user-driven sweetpotato breeding program. The group recognizes the strategic importance of such an approach in terms of its contribution to achieving the Center's breeding objectives. Given the regional differences in growing conditions and end-user requirements for sweetpotato, the group fully supports CIP's approach of locating plant breeders in regions where the crop is important, and seeing to it that these breeders work closely with NARS as members of CIP multidisciplinary teams. This provides needed disciplinary input to breeding by nonbreeders, and also facilitates user participation and feedback to the breeding process by national collaborators. There are three main centers of CIP's germplasm enhancement activity: Latin America (LAC), at Center headquarters in Peru; the East and Southeast Asia and the Pacific region (ESEAP), in Indonesia and the Philippines; and Sub-Saharan Africa (SSA) in Kenya, Cameroon, and Nigeria.

The group strongly concurs that the expected output from CIP's breeding program is both improved populations and advanced clones for variety release or use as progenitors by national collaborators. The group recommends that this continue to be achieved through evaluation and utilization of available genetic resources, including elite varieties, landraces, and, to a lesser extent, the wild *Ipomoea* species closely related to sweetpotato. The group recommends that improved sweetpotato populations (in the form of botanical seed) be made available to provide genetic diversity to national sweetpotato breeding programs that want to

use this type of material. In addition, the group approves the release of advanced clones to selected countries.

Global breeding priorities. Globally, the group recommends that CIP's main breeding goals should be processing characteristics, drought tolerance, and weevil resistance (Table 1). The group also endorses the importance given by CIP to virus resistance as a breeding objective in SSA. Sweetpotato will be improved in earliness and root yield under conditions typical for sweetpotato production systems.

Table 1. Main breeding goals by region after assessment of constraints and opportunities in sweetpotato.

Factor	CIP region			
	LAC	SWA	ESEAP	SSA
Weevil		x	x	x
Virus				x
Drought	x	x	x	x
Dry matter (starch)	x		x	x
Foliage	(x)[a]	(x)		(x)
Non-sweet varieties				W. Africa
Storability	x	x		x

a. (x) = potential demand for forage-type sweetpotato (forage only).

Processing characteristics for feed and food are of major importance throughout the developing world. They are particularly important in ESEAP, where more than 90% of the developing world's sweetpotatoes are grown, as well as in LAC. Processing for human consumption and as a source of fodder are of less importance in South and West Asia (SWA) and SSA.

Weevil resistance was consistently considered important in ESEAP, SSA, SWA, and LAC.

Drought tolerance was most important in SWA and SSA, with secondary importance in LAC and ESEAP.

Viruses appear to be a major constraint to increased sweetpotato production in eastern Africa, particularly in Kenya, Rwanda, Tanzania, and Uganda.

Given recent trends in sweetpotato production and utilization, the group endorses the selection of fifteen priority countries considered to have the highest potential for greater impact from CIP activities in sweetpotato breeding (Table 2). The group agrees that these countries should include China, Vietnam, Indonesia, and the Philippines in ESEAP; India and Bangladesh in SWA; Peru, Cuba, and Brazil in LAC; and Uganda, Kenya, Rwanda, Tanzania, Nigeria, and Cameroon in SSA.

Table 2. Goals for CIP sweetpotato breeding.

Breeding site	Main breeding goal
Peru	High dry matter/starch Drought
Indonesia	High dry matter/starch Weevil
Eastern Africa	Drought Virus Weevil High dry matter/starch

Note. Improved earliness and yield are important objectives at all locations. Evaluation for high dry matter and/or starch content will be considered according to regional needs.

In light of CIP's global breeding priorities and the focus on selected countries, the group recommends that CIP's sweetpotato research be increasingly done within an agroecological perspective. The subtropical lowlands, humid tropics, semiarid tropics, and highlands should be emphasized. The group notes that these priority agroecologies are well represented in the countries with increased collaboration with CIP in sweetpotato breeding and evaluation.

CIP's breeding sites, linkages, and responsibilities. CIP's program emphasizes decentralized sweetpotato breeding activities. However, available resources are limited. The group therefore agrees that Peru, Indonesia, and eastern Africa (Kenya and Uganda) be considered the main regional sites where CIP's sweetpotato breeding activities will be continued or further developed (Table 3). The group recommends that China, India, and the Philippines continue to be secondary regional sites where CIP should use available expertise and improved germplasm. The group commends CIP's efforts to continue collaborating with other important breeding programs in developed countries, such as North Carolina State University in the USA.

Table 3. Priority countries for collaboration in sweetpotato breeding.

ESEAP	SWA	SSA	LAC
China	India	Uganda	Peru
Vietnam	Bangladesh	Kenya	Cuba
Indonesia		Rwanda	Brazil
Philippines		Tanzania	
		Cameroon	
		Nigeria	

The group endorses the rapid exchange of sweetpotato populations and advanced clones and information on their adaptation among CIP's breeding sites as a high priority. The group recommends that the analysis of the adaptation of populations and advanced clones serve to improve breeding efforts.

The group recommends that collaborative linkages with NARS; networks—Southeast Asian Program for Potato Research and Development (SAPPRAD) and User's Perspective with Agricultural Research and Development (UPWARD) in ESEAP, and Programme Régional de l'Amélioration de la Culture de la Pomme de Terre et de la Patate Douce en Afrique Centrale et de l'Est (PRAPACE) and Southern Africa Root Crop Research Network (SARRNET) in SSA; nongovernmental organizations (NGOs); and the private sector facilitate testing of genetic materials in a range of agroecologies and socioeconomic contexts, as well as a range of utilization scenarios. The group concurs that farmer participation in variety selection is essential to the success of breeding activities. These linkages also facilitate the incorporation of selected varieties into seed distribution schemes.

The group acknowledges and approves the differentiation of breeding goals across CIP's breeding sites. In Peru, the group feels it is appropriate that the main breeding goals, in order of priority, should continue to be processing characteristics and drought tolerance. In Indonesia, the main breeding goals should be processing characteristics and weevil resistance. In Africa, the breeding program should focus primarily on drought and virus resistance, with secondary attention to weevil resistance and quality characteristics for fresh consumption and processing.

Priority agroecologies are represented in CIP's breeding sites and secondary regional sites, e.g., the subtropical lowlands (with breeding research to be focused on China); the humid tropics (mainly in Indonesia, with secondary activities in the Philippines and Peru); the semiarid tropics

(eastern Africa); and the highlands (mainly in Peru, with secondary activities in Indonesia and the Philippines).

Conventional breeding methods. The group recognizes the need to use more established breeding techniques to achieve certain specific objectives. In the case of sweetpotato weevil resistance, the group recommends screening for low-to-moderate levels of resistance to the weevil (*Cylas* spp.). It agrees that breeding through recurrent selection will receive priority in ESEAP and SSA in the next five years. Resistance breeding will receive 10-25% of the overall effort within sweetpotato integrated pest management (IPM).

The group advises that potential sources of resistance to the sweetpotato weevil (SPW) (i.e., from the Philippines, Cuba, Indonesia, and other countries) and material from interspecific crosses should be cleaned and utilized in breeding. A screening methodology developed by Mississippi State University (MSU) should be used. Furthermore, the group endorses CIP's collaboration with the USDA Vegetable Lab and MSU to develop biochemically assisted breeding for resistance to SPW.

The group recommends that CIP consider root dry matter and starch content the main processing characteristics. Total sugar content should be considered as required in relation to utilization requirements (e.g., where fried foods are the product). Characterization of existing elite sweetpotato varieties and selected landraces should serve to rapidly identify sweetpotato varieties for processing during the period 1994 to 1997.

The group advises that additional quality factors such as trypsin inhibitor activity and starch digestibility should not receive a high priority for breeding at this time, but should be considered in the future in response to a demonstrated need for their improvement. Nevertheless, the group recommends evaluation of trypsin inhibitor levels in roots and foliage of clones on the CIP pathogen-tested list.

The group notes that sources of high dry matter and starch content or high yield of dry chips are found in Asian countries (China, Japan) and the USA, and recommends that they be used in breeding for processing. Indonesia and Peru should be the locations where CIP breeding activities (including screening and hybridization) focus on processing characteristics (high dry matter and starch content). In SSA, the group agrees that research should be limited to screening for high dry matter and starch content.

The group feels strongly that linkages with China, where much sweetpotato processing is done, on characterization of sweetpotato clones and breeding should continue.

The group recommends that research on forage-type sweetpotato should be limited to the screening of existing sweetpotato germplasm accessions and advanced clones.

For breeding for drought conditions, the group notes that semiarid regions are being cultivated more intensively as farmers migrate from densely populated, more productive areas. The group agrees that sweetpotato can play an enhanced role in both food security and market-oriented production in these regions if appropriate varieties are released and if systems for the multiplication and distribution of planting materials are developed.

The group observes that to adequately select for drought tolerance, an understanding is needed of the critical stages in the development of the sweetpotato plant at which drought can most adversely affect the crop (whether yields, establishment, or ability to maintain planting material). The group further contends that an understanding is required of the mechanisms involved (e.g., escape, tolerance, etc.) as well as simple methods for screening.

The group recommends that breeding for drought resistance focus on eastern Africa, and be complemented by activities at headquarters. Breeding research should be limited to screening and selection for drought resistance. Between 1994 and 1998, clones and simple methodologies developed should be tested in regional locations (e.g., Kenya and Tanzania, India) where drought is a major problem. The group concurs that selection for drought resistance should principally be yield-based.

The group envisions that sources of resistance should include locally adapted drought-tolerant germplasm, and selected clones from the CIP pathogen-tested list. Furthermore, incorporation of methods and information from the work on drought resistance into the breeding process at selected locations will be based on the results of work from 1994 to 1998.

The group observes that epidemiological studies in Uganda will help to develop a proven strategy for screening for sweetpotato virus. At CIP headquarters, clones resistant to sweetpotato feathery mottle virus (SPFMV) have been identified. These should be tested for adaptation in eastern and western Africa prior to initiating a virus resistance breeding program in SSA. The group recommends that CIP identify landraces with

resistance to SPFMV. Breeding research in SSA should be limited to the screening or evaluation of clones and local landraces for resistance to SPFMV.

Nonconventional breeding methods. The group considered the selective use of nonconventional breeding methods as an additional approach for the control of the sweetpotato weevil (*C. formicarius*) and viruses.

The group believes that DNA-based technology has a role to play in CIP's breeding for sweetpotato weevil resistance. The production of sweetpotato with SPW-specific toxins, such as those derived from *Bacillus thuringiensis* (*Bt*), and protease inhibitors are presently the most promising approaches in sweetpotato genetic engineering. The group recommends that CIP's efforts should concentrate on the development of a collaborative research project aiming at the identification of *Bt* toxins or protease inhibitors with high specificity to SPW. They should include communication and collaboration with other institutions that have a comparative advantage to conduct research on transformation. These technologies are needed to develop genetic engineering for *Bt* toxin or any other gene transfer.

As the state of the art develops for molecular markers for sweetpotato and the *Ipomoea* family, the group recommends that this technology should be considered as part of the breeding strategy to enhance SPW resistance.

Given the complexity of virus diseases and the limited knowledge of their impact on sweetpotato productivity, the group recommends that CIP should not allocate resources in the short term to develop sophisticated genetic engineering approaches for virus resistance.

Members of Group 2:

Janice Bohac	Nelly Espinola	Gregory Scott
Ann Braun	Vital Hagenimana	Dapeng Zhang
Edward Carey	Jan Low	

Key Elements in CIP's Global Sweetpotato Breeding Strategy

Edward E. Carey*

Abstract

Three elements characterize CIP's global sweetpotato breeding program: it is user-/demand-driven, decentralized, and collaborative. The program's principal objective is to use sweetpotato genetic resources in collaboration with institutions in developing and developed countries to breed and disseminate improved sweetpotato varieties and populations for the benefit of farmers and low-income consumers in developing countries. Work is focused in selected countries where the crop is important and has a high potential for impact. Principal selection criteria vary with ecoregion, and include agronomic traits (yield and earliness), quality characteristics (for processing and fresh consumption of roots and foliage), and resistances to important diseases (mainly viruses), pests (mainly weevils), and abiotic stresses (mainly drought).

* Sweetpotato Breeder, CIP Regional Office for Sub-Saharan Africa, Nairobi, Kenya.

Varietal Improvement for Sweetpotatoes in Peru: Implications for CIP's Global Breeding Strategy

Humberto Mendoza,
Jorge Espinoza,
Luis Díaz*

Abstract

CIP's Breeding and Genetics Department has incorporated into its strategy of sweetpotato breeding the development of genotypes and clones with high yield, processing quality, and stability. The best clones held in the germplasm bank at CIP and by other sources (USA, Japan, China, and Africa) have been used to produce base populations (through polycross). Selection of clones is carried out in four different environments in Peru: La Molina and Tacna in the coast, and San Ramón and Yurimaguas in the jungle. Recurrent selection and progeny testing are performed, in which clones are gradually incorporated into divergent environments, starting from two specific locations: La Molina and San Ramón. For local use, the objective is to obtain superior genotypes adapted to the coast and/or jungle. Selected populations and clones will be given to NARS in developing countries for their distribution to and use by farmers. Finally, the global objective is to provide materials that can perform well in different areas of the world.

* Geneticist and Liaison Scientist posted at IITA, Ibadan, Nigeria; Associate Geneticist; Research Assistant, Department of Breeding and Genetics, International Potato Center (CIP), Lima Peru, respectively.

Characterization of Production Constraints and Opportunities in Eastern, Central, and Southern Africa

Peter T. Ewell,
Edward E. Carey*

Abstract

We review the major findings of a number of recent studies aimed at assessing needs and opportunities for sweetpotato research in eastern, central, and southern Africa. Studies indicate that sweetpotato is important on millions of small farms in the region, either as a co-staple or secondary food. Although the crop produces reliably under marginal conditions, average yields are low. Farmers are interested in obtaining early maturing, high-yielding varieties with good eating quality. Timely availability of planting materials is a serious constraint in semi-arid agroecologies. Sweetpotato roots are usually consumed boiled. Leaves are eaten as a vegetable in several countries. There appears to be significant potential to increase incomes of poor sweetpotato producers and processors by developing and promoting simple processed foods made from sweetpotato.

* Agricultural Economist and Sweetpotato Breeder, respectively, CIP Regional Office for Sub-Saharan Africa, Nairobi, Kenya.

Targeting Sweetpotato Characterization in Asia: Agroecologies, Production Systems, and Crop Functions

Gordon Prain*

Abstract

Characterization of commodity production has mostly concentrated on either plant-focused constraints research or people-centered needs research. It has given too little attention to the agroecological and systems context of production and underplayed the versatility and multiple functions of sweetpotato within these systems. A better characterization of contexts and clearer elucidation of functions can help both geographical and problem-based priority-setting for breeding work.

Three types of production systems were characterized in the different agroecologies: household gardens, upland systems, and post-rice lowland systems. This paper characterizes them in terms of four crop functions: consumption/nutrition; income and employment; sustainability; and equity.

Though no specific breeding program is proposed for household gardens, short-maturing varieties high in beta-carotene and with low nutrient demands could increase the key role of household gardens in family nutrition and support this role in upland systems. Weevil infestation affects income generation in upland and post-rice systems in most agroecologies, and management requires an integrated approach. In post-rice systems, breeding should address processing quality issues.

Sweetpotato contributes to increased sustainability of household gardens and upland systems through its niche adaptation, ground cover, and perennial habits. Reported increases in fertility caused by sweetpotato require further research, with genotype effects also considered.

Greater productivity of household gardens and upland systems can increase equity through increased flexibility given to women in household provisioning. Support for the establishment of small, household-based processing activities can also contribute to equity by increasing overall family income and the access of women to cash earnings.

* UPWARD Coordinator and Anthropologist, Social Science Department, International Potato Center (CIP), Manila, Philippines.

Characterization of Demand Constraints and Opportunities for Sweetpotato in Developing Countries

Gregory J. Scott*

Abstract

Sweetpotato food systems in many developing countries have witnessed sharp declines in area planted and major shifts in utilization during the past three decades. This scenario suggests that breeders need to be increasingly aware of the emerging constraints and opportunities for expanded use of sweetpotato in the years ahead. This paper synthesizes recent efforts to identify, analyze, and interpret the changing nature of demand for sweetpotato in Asia, Africa, and Latin America. These efforts include formal surveys, regional seminars, analysis of global secondary data, country case studies, and reviews of the scientific literature. Results suggest a growing demand in Asia and, to a lesser extent, Latin America for the use of sweetpotato as animal feed. In Africa, opportunities exist to expand the use of sweetpotato in fresh and processed form for human consumption as well as in the form of fodder for livestock. Well-adopted, high-yielding, improved varieties that satisfy these needs will be in increasingly high demand in these locations. Hence, renewed efforts to ensure their availability merit consideration.

* Economist and Leader, Postharvest Management, Marketing Program, International Potato Center (CIP), Lima, Peru.

Maintenance, Evaluation, and Documentation of Sweetpotato Genetic Resources at CIP

Zósimo Huamán*

Abstract

Until 1985, most sweetpotato genebanks did not have an adequate sample of the genetic diversity present in Latin America and the Caribbean, the crop's primary center of diversity. High priority was therefore assigned to developing a sweetpotato genebank at CIP.

Since 1985, CIP has carried out 90 collecting expeditions, with active participation of NARS scientists in 16 Latin American and Caribbean countries. Besides materials obtained by these expeditions, the collection at CIP was further expanded by donations from other countries; the transfer of sweetpotato collections maintained in other international centers; and donations of breeding lines or advanced cultivars.

The genebank at CIP now maintains a total of 6,526 accessions, including 535 accessions of 11 wild species in section Batatas; 357 accessions of 47 wild species in other sections; 206 accessions of other wild or weedy materials; 4,194 accessions of native and advanced cultivars from 43 countries; and 1,333 breeding lines. These collections are mantained in field genebanks, in tissue culture, and as true seed.

Quarantine restrictions prevent CIP from adequately characterizing all accessions collected outside Peru. Therefore, CIP is undertaking morphological characterization and further evaluations in collaboration with NARS in each country of origin.

The sweetpotato collection is also undergoing a systematic evaluation to identify sources of desirable genes for use in breeding programs. More than 13,000 evaluations have been made. These identified many accessions as potential sources of genes for resistance to pests and diseases, good agronomic characters, long storability, high productivity, and high nutritive value.

Documentation covers data on collecting sites, donor institutions, characterization, evaluations of stresses, and maintenance of the collection.

* Germplasm Curator, Genetic Resources Department, International Potato Center (CIP), Lima, Peru.

The in vitro Sweetpotato Collection at CIP

R. Salinas,
A. Golmirzaie*

Abstract

CIP maintains a sweetpotato germplasm collection of more than 5,000 accessions. Clonal maintenance in the field is expensive and risks loss from diseases and unfavorable climate. In vitro maintenance is more economical, preempts field infections, is protected against unfavorable climate, and permits timely pathogen cleanup and permanent availability of material for propagation and export.

CIP has investigated many tissue culture methods to safeguard these genetic resources. Techniques include in vitro introduction, micropropagation, long-term conservation, pathogen elimination, and in vitro distribution of germplasm.

Clonal in vitro collections held at CIP now contain 5,000 accessions from different sources. Another 402 accessions are pathogen-tested and ready for worldwide distribution.

Long-term maintenance is important for propagation and conservation itself. For clonally propagated cultures, every propagule must be free of even the slightest genetic alterations that may build up from one generation to another and result in major changes affecting uniformity and production. To reduce in vitro maintenance costs, CIP preserves sweetpotato germplasm in long-term storage with growth retardants such as 2% sorbitol and reduced incubation temperature (18°C).

An important aspect in the application of in vitro methods for the conservation of genetic resources is the stability of plants conserved under these conditions. The genetic stability of collections held at CIP is evaluated according to morphological characters and by protein electrophoresis and isoenzyme analysis. New methods such as RFLP and RAPD are considered more sensitive ways to determine genetic changes. These techniques will be used to accelerate the fingerprinting of individual accessions and thus eliminate duplicate accessions in collections.

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* Tissue Culture Specialist and Research Assistant; Head, Germplasm Management and Enhancement, Genetic Resources Department, International Potato Center (CIP), Lima, Peru, respectively.

Ploidy Manipulations for Exploitation and Enhancement of Sweetpotato Germplasm

Gisella Orjeda*

Abstract

The general objective of this project is to develop a strategy to make exotic germplasm accessible for sweetpotato breeding.

The goal is to develop 4x storage root producer clones, evaluate wild species for traits related to storage roots, study the mechanism of 2n pollen formation, and study the effects of ploidy level.

* Sub-project leader, Genetic Resources Department, International Potato Center (CIP), Lima, Peru.

Application of Molecular Markers to Sweetpotato Germplasm Improvement

Marc Ghislain,
Gisella Orjeda,
Ali Golmirzaie*

Abstract

CIP will use molecular markers to characterize the structure of the sweetpotato genome by developing a genetic linkage map and to analyze sweetpotato collections by genomic identification. The genus *Ipomoea* has been poorly investigated at all levels and, in particular, for its genomic structure. No genetic linkage map is available. Producing one would later help to map loci determining traits of interest such as a high level of resistance to sweetpotato weevils and viruses. The mapping population will be developed from an intraspecific cross of one of the ancestors of the hexaploid crop, *Ipomoea trifida*, a diploid species. We will use the RAPD technique, which allows us to detect lower levels of polymorphism. Molecular markers will also help to accurately identify duplicates in the sweetpotato germplasm collections, study their diversity, and eventually design a core collection. We have elected the DNA amplified fingerprinting technique (DAF). We are also pursuing genetic engineering approaches to enhance sweetpotato resistance to pests and diseases. Gene transfer techniques are currently being improved. We will attempt to enhance sweetpotato weevil resistance by introducing protease inhibitors to alter insect digestion and introducing a toxin specific to the weevil like those existing in *Bacillus thuringiensis*. Eventually, the combination of protease inhibitors and *Bt* toxins will result in a transoligenic sweetpotato that may have acquired durable resistance to insect pests.

* Molecular Biologist, Cytogeneticist, Plant Breeder and Head, respectively, Genetic Resources Department, International Potato Center (CIP), Lima, Peru.

Multiplication and Distribution of Pathogen-tested Sweetpotato Material

Oscar A. Hidalgo,
José Luis Marca*

Abstract

The International Potato Center (CIP) maintains and distributes internationally in vitro sweetpotato plantlets from the current collection containing 542 pathogen-tested clones. CIP also distributes true seed families generated by CIP scientists at CIP-Lima. During 1993, CIP distributed to a total of 30 countries the following material: 726 samples of in vitro clones, plus 597 true seed families for which there were 38,219 seeds (genotypes). CIP has a list of this collection available (the pathogen-tested list), which includes valuable information about the material for distribution. The list and the genetic material are available upon request. Information available in the list includes morphological data as well as industrial characteristics such as dry matter, starch, and others. Information on the response of clones to adverse biotic and abiotic stresses such as insects, diseases, nematodes, drought, salinity, and acid soils is also included, along with adaptation to different environments, maturity, and use as shoot tips. Problems and perspectives of the increased number of requests and priorities for production and distribution of sweetpotato genetic material are also discussed.

Senior Seed Production Specialist; Assistant, respectively, International Potato Center (CIP), Lima, Peru.

Sweetpotato Crop Improvement in China

Song Bo Fu*

Abstract

CIP clone 490023-1 was found to yield significantly higher than the local control variety. Several Chinese clones suitable for food or processing for starch were also selected in collaboration with the national breeding program, among which Xu 15-12, developed in Xuzhou, has just been released under the name of Sushu 6. Hybrid seeds developed at Nanjing and Guangdong are now available for distribution.

This paper outlines proposed national breeding strategies. One significant development is that breeding for tolerance or resistance to viruses has been put on our agenda. To increase genetic diversity and incorporate useful genes, some new biotechnological tools will be used.

This paper also previews possible future collaboration between CIP and national institutes. We expect to propose a breeding procedure for tolerance or resistance to viruses and corresponding evaluation tools in a joint effort with other breeding specialists.

* CIP Liaison Office in Beijing, People's Republic of China.

Sweetpotato Improvement for Vietnam and the Philippines

E. Chujoy*

Abstract

Vietnam and the Philippines are the second and eighth largest producers of sweetpotato in the world. Breeding research priorities for these countries were identified after workshops, a planning conference, and field visits with national scientists. Priority traits include resistance to weevil (*Cylas formicarius*), high dry matter content, earliness, and tolerance of poor soil fertility. In addition, shade tolerance is important in the Philippines.

Native sweetpotato germplasm was collected and screened for priority traits. Superior clones were identified and selected for high dry matter, earliness (90 days), shade tolerance, and weevil resistance in the Philippines. Heritability estimates for traits were comparable to those reported elsewhere and indicated that genetic improvement can be made using recurrent selection methods. Superior clones were included in a hybridization program. A similar approach for the use of native germplasm is being followed in Vietnam.

Introduced sweetpotato advanced clones and cultivars were evaluated for root yield and earliness in the subtropical and tropical lowlands of Vietnam and in the tropical highlands and lowlands of the Philippines. The best clones identified originated from China, IITA, and the USA. Clones will be evaluated for processing characteristics, such as root dry matter, starch or dry chip yield, and total sugar content. A database is being constructed to incorporate results from the evaluation. The database will help identify the best clones in the region.

* Regional Plant Breeder, International Potato Center (CIP), Manila, Philippines.

Sweetpotato Crop Improvement for Eastern, Central, and Southern Africa

Edward E. Carey*

Abstract

CIP's sweetpotato breeding efforts in eastern, central, and southern Africa are conducted in a multidisciplinary fashion from CIP's regional office in Nairobi, Kenya. Breeding-related research and training activities are conducted under six CIP research programs, in direct collaboration with key national programs, and through participation in two regional networks: the Programme Regional d'Amelioration de la Culture de la Pomme de Terre et de la Patate Douce en Afrique Centrale et de l'Est (PRAPACE) and the Southern African Root Crops Research Network. Principal activities include:

1. Coordinated evaluation and selection of elite local and introduced germplasm for adaptation to key agroecologies, resistances to important diseases and pests, and yield and quality traits.

2. Population improvement for important traits through hybridization and selection.

3. Strengthening of national variety selection and dissemination programs. Breeding/variety selection activities are closely linked to postharvest research efforts to expand sweetpotato utilization.

* Sweetpotato Breeder, CIP Regional Office for Sub-Saharan Africa, Nairobi, Kenya.

Sweetpotato Crop Improvement for South Asia

M.D. Upadhya,
T.R. Dayal*

Abstract

Sweetpotato is the third most important root and tuber crop in South Asia after potato and cassava. It is grown widely in the region. But several pre- and postharvest constraints in its production make average yields in this area lower (8 to 10 t/ha) than in other Asian countries such as China (17 t/ha) and Japan (22 t/ha). Through collaborative efforts of CIP's South and West Asia (SWA) regional headquarters in New Delhi with area NARS, we have identified these constraints and taken measures to overcome them. Since 1989, CIP's SWA regional program has made concerted breeding efforts to develop sweetpotato clones to meet regional needs. Some advanced selections with high yield (15-25 t/ha), early maturity (90-100 days), and dry matter as high as 42% have been made, and have reached the stage of multilocational testing in India. Such clones would fit quite well into the intensive cropping system of South Asian countries.

Thus, short-term priorities in South Asian countries for sweetpotato improvement are early bulking, with average yields higher than 20 t/ha, and maximum attributes to satisfy consumer preferences for taste and quality. For industrial uses, dry matter higher than 35% should be the main breeding criterion. For long-term priorities, in addition to the above short-term needs, we should emphasize resistance to sweetpotato weevil and other physical stresses such as drought and cold.

* Regional Representative, South and West Asia, currently Head, Physiology Department, International Potato Center (CIP), Lima, Peru; formerly Plant Breeder, Breeding and Genetics Department, stationed in New Delhi, India, respectively.

Breeding Sweetpotatoes for Adaptation to Arid and Saline Soils in Peru

René Chavez,
Humberto Mendoza,
Jorge Espinoza*

Abstract

A collaborative research project between the Faculty of Agronomy of the National University of Tacna (UNTAC) and CIP's Department of Breeding and Genetics was established in January 1985.

This project aimed to increase sweetpotato productivity in Peru's arid and saline soils with agricultural potential. For this purpose, crossing experiments were designed, followed by cycles of recurrent selection to generate superior clones adapted to the adverse environments of these marginal soils. The superior clones would be used for food and processing.

During the nine years of UNTAC-CIP collaboration, about 70,000 sweetpotato genotypes were generated, grouped into 370 hybrid families. Some 320 promising clones were identified, of which 43 were classified as superior. Within this group, the outstanding clones with agronomic potential were selected and released to be grown in the Peruvian coastal region. Most of the breeding and selection experiments were carried out at the University's experiment station, located in the Tacna valley.

The main agronomic characteristics of the released varieties are: tolerance of the principal abiotic stresses of Peruvian coastal soils, such as salinity (6-13 mmhs), boron toxicity (5-12 ppm), and drought (restricted irrigation); yield potential of 25 t/ha in 120 days; moderate field resistance to root-knot nematode (*Meloidogyne incognita*); semi-erect growth habit; and coverage of 100% of the soil surface by foliage in 90 days. This last character is important in sandy, arid soils with restricted irrigation.

These varieties clearly have the potential to disseminate rapidly and provide food in areas where growing conditions are marginal and financial resources are scarce.

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* Professor, Facultad de Agronomía, Universidad Nacional de Tacna "Jorge Basadre Grohmann," Tacna, Peru; Geneticist and Liaison Scientist posted at IITA, Ibadan, Nigeria; Associate Geneticist, Breeding and Genetics Department, International Potato Center (CIP), Lima, Peru, respectively.

Sweetpotato Evaluation in Peru

Oscar A. Hidalgo,
Juan Pablo Molina,
Cristina Fonseca*

Abstract

Peru's National Sweetpotato Program is testing genetic material mainly generated by the breeding program and germplasm collection at CIP. Work is carried out in several parts of Peru, especially on the coast, with participation of nine INIA experiment stations, six NGOs, five universities, CIP, and private-sector companies. Evaluation of genetic material is based on a four-phase plan in which observation, advanced, on-farm, and validation trials are conducted. This reduces the number of clones selected before a new variety is released. A new variety, "Cañetano-INIA," was recently released, and is now being multiplied and distributed to Peruvian farmers.

A National Sweetpotato Program publication, edited by CIP, explains the steps for appropriate testing with active farmer participation. The technical and participatory evaluations done by scientists and farmers, respectively, are one way to evaluate clones tested in each step of the process. Materials are tested mainly for selecting for direct consumption as well as for processing and forage. Several hundred clones are tested every year in Cañete, the National Sweetpotato Program's headquarters for testing and distributing sweetpotato genetic material. In addition, four other sites (Chiclayo, Huánuco, Cusco, and Tacna) are being used to redistribute genetic material to another 14 secondary sites in Peru. The selection process, showing number of clones tested/selected, will be presented, especially for Cañete and the other four locations, as an example of progress made. The national program emphasizes the selection of genetic material for industrial purposes, mainly for starch production. Five advanced clones are now at the validation stage, with high yield, dry matter, and starch content. Specific data on clones selected are also presented.

* Senior Seed Production Specialist, International Potato Center (CIP); Leader, Peruvian Sweetpotato Program, Instituto Nacional de Investigaciones Agropecuarias (INIA); Research Assistant, Program I, CIP, Lima, Peru.

Sweetpotato Breeding for Animal Feed from the Animal Scientist's Perspective

Carlos A. Gómez*

Abstract

Sweetpotato is extensively used as animal feed around the world. To increase its demand will depend on how competitive it is in relation to other plants in the supply of available nutrients to animals. In this context, sweetpotato breeding should consider dry matter production and available nutrient content (energy and protein). The structure of starch, trypsin inhibitors, and fiber change nutrient availability, and this is affected by processing (heat treatment) and the animal being fed (ruminant versus monogastric). Collaborative research between the National Agrarian University and CIP has begun to determine the potential of prevalent sweetpotato varieties as feed for poultry and dairy cattle in relation to users' demand. Possible constraints will be identified, and these could require breeding for improvement. Other aspects to consider are the potential for sweetpotato in marginal areas for feed and for increasing the sustainability of agricultural systems.

* Professor and Head, Feed Research Center, Universidad Nacional Agraria La Molina, Lima, Peru.

Sweetpotato Weevil Resistance Breeding in Mississippi

Paul G. Thompson,
John C. Schneider,
Boyett Graves*

Abstract

Weevil resistance sources have been confirmed and new ones identified in field evaluations with low numbers of applied weevils. Twenty accessions from the U.S. Plant Introduction Station produced higher percentages of uninjured roots with yields at least equal to those of Regal, the resistant control. Two lines selected from the breeding population produced 16% and 18% more uninjured roots than Regal. Comparisons of resistance levels of plant materials developed in breeding programs at the U.S. Vegetable Lab and at the International Institute of Tropical Agriculture (IITA) and their progenies show that resistance levels are similar. Intermatings of different sources of resistance have been completed and selections for increased levels are being made. Increased heritability and selection response are expected from progenies of combined resistance sources. Predicted selection gain based on heritability estimates was higher with selection for uninjured root number than percentage of uninjured roots.

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* Department of Plant and Soil Sciences, Mississippi State University, Mississippi State, MS, USA.

Inheritance of Three Major Nutritional and Anti-nutritional Components in Sweetpotato

Dapeng Zhang,
Wanda W. Collins*

Abstract

The purpose of this research has been to study the quantitative inheritance of crude protein, true protein, dry matter, trypsin inhibitor activity (TIA), and starch digestibility (SD).

Significant genetic variation was found for all traits studied. TIA is highly heritable on both an individual and family mean basis. Crude protein and true protein both have moderate family heritability, but the heritability based on individuals is low. Crude protein has very low genetic correlation with true protein. Selecting against TIA would not significantly decrease true protein. Significant genotype x environment interaction (GEI) was detected for TIA, crude protein, and true protein. However, a significant proportion of the GEI could be explained by linear environment effect. Clones with stable crude protein content may not be stable for true protein content.

A simple in vitro screening method was developed to test starch digestibility for breeding purposes. Significant genetic variation for starch digestibility was found in sweetpotato. Genetic variation is the most important component for cultivar differences in starch digestibility. Narrow-sense heritability was estimated as 83% for family mean and 50% for individuals.

* Geneticist and Breeder, Department of Genetic Resources, International Potato Center (CIP), Lima, Peru; Professor, Horticulture, Breeding, and Genetics, Department of Horticultural Science, North Carolina State University, Raleigh, NC, USA, respectively.

Sweetpotato Breeding at the U.S. Vegetable Laboratory

J.R. Bohac,
P.D. Dukes*

Abstract

For about 30 years, the U.S. Vegetable Laboratory has conducted sweetpotato breeding for insect and disease resistance. This has been a team effort by a breeder, plant pathologist, entomologist, weed scientist, and plant physiologist. Due to the polyploid nature and quantitative inheritance of all traits, a mass population breeding methodology is used. The diverse base population contains hundreds of worldwide clones. From this base population, 25 to 30 elite parents are placed in a modified polycross. Thousands of polycross seedlings are screened for resistance to nematodes, *Fusarium* wilt, insects, and horticultural quality. The result has been the release of several cultivars with excellent culinary quality, appearance, and yield combined with multiple resistances to insects (wireworm, *Diabrotica*, *Systena*, fleabeetles, and grubs), nematodes, diseases, and allelopathy. Future objectives will be to continue increasing resistances, quality, and yield, and to develop new types for processing.

* U.S. Vegetable Laboratory, USDA, ARS, Charleston, SC, USA.

Utilization of Endogenous Amylolytic Enzymes in Hydrolysis of Sweetpotato Root Starch

Vital Hagenimana,
Louis Philippe Vezina,
Ronald E. Simard*

Abstract

To understand starch hydrolysis conditions by endogenous amylases in sweetpotato roots, α- and β-amylases were purified and characterized, and then, together with starch phosphorylase, localized inside the roots by a combination of immunological detection and activity measurements. We found that α-amylase is strongly localized in the laticifers and in the cambium layers, and very little in storage parenchyma tissues. β-amylase is ubiquitously distributed throughout the root. Starch phosphorylase is concentrated in the anomalous and vascular cambiums. The different distributions, particularly that of thermostable α-amylase in the outer tissues of the root, may be lost during peeling and it would also be synthesized de novo by germinating roots. We found as well that the incubation of root inner portion first heated and appropriately tempered with outer tissue extract containing both α- and β-amylase could hydrolyze a significant portion of root starch in sugars and dextrins. This amylolytic extract, traditionally made from starchy crops like rice, sorghum, maize, cassava, millet, and sago, could be utilized in the thinning of weaning foods generally.

Postharvest Scientist, International Potato Center, East Africa Region, Nairobi, Kenya; Agriculture Canada, Ste-Foy, Quebec; and Department of Food Science, Université Laval, Ste-Foy, Quebec, Canada, respectively.

Workshop

Vines to Roots: Sweetpotato Breeding for Impact

June 1-3, 1994

International Potato Center (CIP)

Lima, Peru

June 1

Time	Activity
07:15-08:15	Breakfast

Introduction
Ali Golmirzaie, Moderator

08:30-08:45	Opening Remarks *Hubert Zandstra*
08:45-09:05	Objectives of the Workshop *Peter Gregory*
09:05-09:20	Discussion
09:20-09:30	Coffee break

CIP's Global Sweetpotato Breeding Strategy and Characterization of Constraints and Opportunities
Thomas Walker, Moderator

09:30-09:40	Key Elements in CIP's Global Sweetpotato Breeding Strategy *Edward Carey*
09:40-10:00	Varietal Improvement for Sweetpotatoes in Peru: Implications for CIP's Global Breeding Strategy *Humberto Mendoza* and *Jorge Espinoza*
10:00-10:40	Discussion
10:40-11:00	Characterization of Production Constraints and Opportunities in Eastern, Central, and Southern Africa *Peter Ewell* and *Edward Carey*
11:00-11:20	Targeting Sweetpotato Characterization in Asia: Agroecologies, Production Systems, and Crop Functions *Gordon Prain*
11:20-11:40	Characterization of Demand Constraints and Opportunities for Sweetpotato in Developing Countries *Gregory J. Scott*
11:40-12:30	Discussion: Integrating Users' and Breeders' Perspectives
12:30-13:30	Lunch

Enhancement and Improvement of Sweetpotato Germplasm
Thomas Walker, Moderator

13:30-14:00	Maintenance, Evaluation and Documentation of Sweetpotato Genetic Resources *Zósimo Huamán*
14:00-14:20	Collection of Sweetpotato Genetic Resources in Iryan Jaya *Jurg Schneider*
14:20-14:35	In Vitro Sweetpotato Collection at CIP *Roxana Salinas* and *Ali Golmirzaie*
14:35-15:00	Discussion
15:00-15:15	Coffee break
15:15-15:45	Ploidy Manipulations for Exploitation and Enhancement of Sweetpotato Germplasm *Gisella Orjeda*
15:45-16:00	Application of Molecular Markers to Sweetpotato Germplasm Improvement *Marc Ghislain*
16:00-16:30	Multiplication and Distribution of Pathogen-tested Sweetpotato *Oscar Hidalgo*
16:30-17:15	Discussion: Germplasm Enhancement in Response to Users' and Breeders' Needs

June 2

Time	**Activity**
07:15-08:15	Breakfast
	CIP's Regional Sweetpotato Breeding Projects *Roger Cortbaoui*, Moderator
08:30-09:00	Sweetpotato Crop Improvement in China *Song Bofu*
09:00-09:30	Discussion
09:30-10:00	Sweetpotato Crop Improvement for Southeast Asia *Il Gin Mok*
10:00-10:30	Discussion
10:30-10:45	Coffee break
10:45-11:15	Sweetpotato Crop Improvement for Vietnam and the Philippines *Enrique Chujoy*

11:15-11:45	Operational Interface Between UPWARD and CIP's Sweetpotato Breeding Strategy *Gordon Prain*
11:45-12:30	Discussion
12:15-13:30	Lunch

June 2

Oscar Hidalgo, Moderator

13:30-14:00	Sweetpotato Crop Improvement for Eastern, Central, And Southern Africa *Edward Carey*
14:00-14:30	Sweetpotato Crop Improvement for West Africa *Humberto Mendoza*
14:30-15:15	Discussion
15:15-15:30	Coffee break
15:30-16:00	Sweetpotato Crop Improvement for South Asia *Mahesh Upadhya*
16:00-16:20	Discussion
16:20-17:00	Open Forum on Linkages Among Breeders Involved in Breeding for Processing/Livestock Feed

June 3

Time	Activity
07:15-08:15	Breakfast

CIP's Center-Based Sweetpotato Breeding Projects
Edward Carey, Moderator

08:30-08:50	Breeding Sweetpotatoes for Adaptation to Arid and Saline Soils in Peru *René Chávez, Humberto Mendoza,* and *Jorge Espinoza*
08:50-09:10	Sweetpotato Evaluation in Peru *Oscar Hidalgo, Juan Pablo Molina,* and *Cristina Fonseca*
09:10-09:25	Sweetpotato Breeding in Peru: The Users' Perspective *Estuardo Masías* and *Nelly Espinola*
09:25-09:40	Evaluating Sweetpotato Germplasm for Fodder *Helen Beaufort-Murphy*
09:40-10:00	Sweetpotato Breeding for Animal Feed from the Animal Scientist's Perspective *Carlos Gómez*
10:00-10:20	Sweetpotato Weevil Resistance Breeding in Mississippi *Paul Thompson*

10:20-10:30	Coffee break
10:30-11:00	Discussion
11:00-11:30	Sweetpotato Breeding for Processing: The North Carolina Experience *Dapeng Zhang*
11:30-12:00	Inheritance of Three Major Nutritional and Anti-nutritional Components in Sweetpotato *Dapeng Zhang* and *Wanda Collins*
12:00-13:30	Lunch

Collaboration with Developed Countries
Gregory J. Scott, Moderator

13:30-14:00	Sweetpotato Breeding at the U.S. Vegetable Laboratory *Janice Bohac*
14:00-14:30	Utilization of Endogenous Amylolytic Enzymes in Hydrolisis of Sweetpotato Root Starch *Vital Hagenimana*
14:30-14:45	Coffee break
14:45-16:00	Discussion: Collaboration in Sweetpotato Breeding with U.S. Institutions
16:00-17:00	Discussion: Up-dating CIP's Breeding Strategy for Sweetpotatoes

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Acronyms

Bt	*Bacillus thuringiensis*
CIP	International Potato Center, Peru
CGIAR	Consultative Group on International Agricultural Research
DAF	DNA amplified fingerprinting
ESEAP	East and Southeast Asia and the Pacific, CIP region
GEI	genotype x environment interaction
IITA	International Institute of Tropical Agriculture, Nigeria
INIA	Instituto Nacional de Investigación Agraria, Peru
IPM	integrated pest management
LAC	Latin America and the Caribbean, CIP region
NARS	national agricultural research systems
NGO	nongovernmental organization
MSU	Mississippi State University, USA
PRAPACE	Programme Régional d'Amélioration de la Culture de la Pomme de Terre et de la Patata Douce en Afrique Centrale et de l'Est
RAPD	randomly amplified polymorphic DNA
RFLP	restriction fragment length polymorphism
SAPPRAD	Southeast Asian Program for Potato Research and Development, CIP network
SARRNET	Southern Africa Root Crop Research Network
SD	starch digestibility
SPFMV	sweetpotato feathery mottle virus
SPW	sweetpotato weevil
SSA	Sub-Saharan Africa, CIP region
SWA	South and West Asia, CIP region
TIA	trypsin inhibitor activity
UNTAC	National University of Tacna, Peru
UPWARD	Users' Perspective with Agricultural Research and Development, CIP network