SD Publication Series
Office of Sustainable Development
Bureau for Africa

Developments in Potato Research in Central Africa

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Technical Paper No.5
December 1994

USAID

Productive Sector Growth and Environment Division
Office of Sustainable Development
Bureau for Africa
U.S. Agency for International Development

Developments in Potato Research in Central Africa
Project Evaluation:
Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Centrale (PRAPAC)

Review Team
Humberto A. Mendoza / Seme Debela / David R. Martella

Evaluation Mission: May 18–June 5, 1992

Grant to the
International Potato Center (CIP), Lima, Peru

by the
Bureau for Africa, U.S. Agency for International Development

through
USAID/REDSO/ESA, Nairobi, Kenya

December 1994

Publication services provided by **AMEX International, Inc.**
pursuant to the following USAID contract:

Project Title:	Policy, Analysis, Research, and Technical Support Project
Project Number:	698-0478
Contract Number:	AOT-0478-C-00-3168-00

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Foreword

It became obvious in the 1980s that the many small national research systems in Africa could not establish and maintain full-scale programs for all commodities and themes of relevance to their national development plans. Neither the human nor the financial resources were available for this. At the same time, it was clear that institutional mechanisms needed to be developed to enable the national systems to take advantage of—and modify—the technology being generated by the international community. In this context, in the mid-1980s the U.S. Agency for International Development (USAID) and other donors provided support for collaborative regional research networks.

This report makes an important contribution to our understanding of the progress and impact being made in East Africa through investments in regional collaborative research activities.* It provides details on technical constraints addressed and on technology generated and adopted. The report also provides details on the role of the regional program in strengthening the national potato programs in East Africa.

Most important, this report provides findings to substantiate the notion that regional research programs play an important dual role to increase the availability of technology and strengthen national research systems. The findings and approach used by PRAPAC (*Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Centrale*, or the Regional Potato Improvement Program for Central Africa) will be particularly useful in providing guidance for future regional research programs.

The PRAPAC network was coordinated by the International Potato Center (CIP). USAID project management was provided by the Regional Economic Development Support Office (REDSO) in Nairobi, Kenya. Funding continues under the Policy, Analysis, Research, and Technical Support Project in the Africa Bureau's Office of Sustainable Development / Productive Sector Growth and Environment Division (AFR/SD/PSGE).**

The evaluation was conducted by REDSO staff in collaboration with CIP and national research authorities in East Africa. We would like to acknowledge the key roles that Richard Edwards, Hudson Masambu, and David Martella from REDSO played in managing and implementing both the regional programs and this evaluation.

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* The evaluation was completed in June 1992, almost two years before Rwandan President Juvénal Habyarimana was assassinated on April 6, 1994, and months of political upheaval and ethnic massacres ensued in Rwanda.

** Formerly the Office of Analysis, Research, and Technical Support / Division of Food, Agriculture, and Resources Analysis (USAID/AFR/ARTS/FARA).

Acknowledgments

The evaluation team visited field and station sites in Rwanda, Burundi and Uganda (only border gates for Zaire). The assistance provided to the evaluation team by the National Agricultural Research System (NARS) scientists and technicians is gratefully acknowledged. We hope that our conclusions and recommendations adequately reflect the widespread, shared concern for continued support to develop and sustain the capacity for improved agricultural research and development throughout eastern and southern Africa.

We also acknowledge the participation of Dr. Kenneth J. Brown of the International Potato Center (CIP-Lima) during the evaluation field work, although his presence was limited.

Our special thanks to the PRAPAC directors' for their support and time spent in making this evaluation mission possible. In addition, special thanks to the following individuals: Drs. Marco Soto, Pierre Tegera, Mr. Charles Muvira, Mr. Bouwe Nasona wa Baseko, Mr. D.R. Akimanzi, and CIP staff: Drs. Sylvester Nganga, Peter Ewell, Hailemichael Kidanemariam, Lyle Sikka, and Donald Berrios.

— Humberto A. Mendoza
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Executive Summary

Background

In response to farmers' needs, national potato research programs in Burundi, Rwanda, and Zaire were organized in the early 1980s with the support of the Regional Office of the International Potato Center (CIP-Nairobi). PRAPAC (*Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Centrale*, or the Regional Potato Improvement Program for Central Africa) was established in 1982. Presently this potato research network is composed of four countries: Burundi, Rwanda, Uganda, and Zaire; Uganda joined the network in 1987. These four countries are located in the same agroecological zone and share many of the same problems.

In February 1986, REDSO/ESA awarded a five-year, $1.6 million grant to CIP to continue and expand the potato improvement research network, PRAPAC. In June 1991, the grant was extended until September 28, 1992, and $655,000 in funding was added. Additional funding has been provided over the life-of-project through Mission bilateral activities to support the potato research programs in the participating countries.

The general objective of the PRAPAC network is to improve potato production through support to the National Agricultural Research System (NARS). The network promotes intercountry collaboration to share scarce resources to meet common goals. This involves training to enhance institutional capacity, joint research planning to avoid duplication of effort, and the publication and sharing of results for adoption by other members.

The ultimate goal of the network is to make available to farmers disease-resistant, high-yielding varieties, and other technologies. The network's strategy to achieve this is to strengthen research capacity in the national programs through coordinated research, training, information exchange, and institutional support. The intermediate goals of PRAPAC can be summarized as follows:

- Develop a functional, institutionally sustainable research network with demonstrable gains in efficiency, compared to what the programs could achieve working in isolation.
- Improve capacity to evaluate and select improved genetic material both on-station and in farmers fields, leading to the release of improved varieties as a regular output of the research programs.
- Increase the efficiency with which a range of production, pest management, and post-harvest technologies are introduced, tested, and transferred to farmers.
- Develop improved systems for the production, multiplication, and distribution of high-quality planting material.
- Provide training to researchers and extensionists efficiently on a network basis, and encourage on-farm research and other linkages for the benefit of the farmers.
- Improve the capacity for the monitoring and evaluation of research and transfer of technology to farmers.

This document provides an opportunity to assess how effectively the four national potato research programs have worked with each other and with CIP to achieve common goals. The donor will also evaluate how effectively the funding in support of the network has been

utilized.

The evaluation team visited the following PRAPAC member countries: Rwanda, Burundi, and Uganda in that order. The team was unable to visit the program in Zaire due to border closures; however, the Zaire potato research program leader was able to meet with the evaluation team in Nairobi to discuss the available data on the Zairian program. CIP Regional activities in Kenya that relate to the PRAPAC network were reviewed. The evaluation team met and interviewed REDSO management, the network coordinator, PRAPAC network policy makers and researchers, as well as the USAID bilateral missions that are supporting the PRAPAC network. In addition, the evaluation team reviewed the draft report of PRAPAC's monitoring and impact assessment, as well as the external consultant's report on activities in Uganda.

Conclusions

In Rwanda, Burundi, and Uganda, the success of the initial introduction of varieties and later on the selection of new varieties showing a better adaptation and a higher level of resistance to late blight is evident. There has been an active interchange of advanced materials in the network as indicated in Table 2. This shows that the variety of development technology has been actively shared among the PRAPAC network countries.

With the exception of Cruza-148 (Ndinamagara in Burundi), all the other potato varieties are susceptible to bacterial wilt which along with late blight are the major enemies of potato production in the PRAPAC countries. Given the high pressure for land utilization, the potato monoculture is helping to increase the danger of bacterial wilt attack. It seems necessary, therefore, to place more emphasis on selecting for combined resistance to late blight and bacterial wilt.

The true potato seed (TPS) technology has been showing promising results, particularly in Uganda. Rwanda results indicate that TPS technology helps in areas where potato production systems are not well established. However, the progenies need higher resistance levels to late blight to make this technology more viable.

The development of an efficient basic seed production scheme based on the use of rapid multiplication on a flush-out system combined with other measures for the integrated bacterial wilt control (soil rotation, agronomic practices, etc.) have given very good results. However, it appears in the three countries visited that a solid and well organized system for further seed multiplication and distribution is not in place. The implementation of a seed multiplication and distribution system is very important for the new varieties to achieve a greater measurable impact in the short to medium term.

The facilities for seed production (seed farms, greenhouses, laboratories, seed storage) are adequate at Rwanda and Burundi. In Uganda, there is an urgent need for one or two greenhouses and laboratories to further improve the process of pre-basic and basic seed production. Furthermore, in Uganda the evaluation team found that the personnel at the research stations have limited means of transportation, which decreases their effectiveness in conducting research at several sites.

The technology for diffuse light seed storage appears well developed in Rwanda and Burundi but needs continued effort in Uganda since the potato research program has only recently restarted during the last 2½ to 3 years.

All PRAPAC countries, with the exception of Rwanda, have improved their manpower status, both in quantity and quality, compared to 1986. However, Rwanda has shown a decline not only in number but also in quality of staff. An area of concern to the evaluation team is the dependency of the Rwandan National Potato Program on a single, admittedly competent person. Although the network as an entity can be considered reasonably well staffed, it is difficult to say the same about each national program in the network. For the most part, the manpower situation in each national program is

tenuous at best. Hence, it is necessary for PRAPAC to double its efforts to create a critical mass of at least five scientists at M.Sc. or higher levels and 10 to 15 support staff below that grade to ensure adequate leadership and technical competence in each national program.

Both PRAPAC and CIP have done a commendable job in organizing training for the research staff. However, most of the training is limited to short courses designed to improve skills in specific areas. PRAPAC and/or CIP should consider providing opportunities for degree level training at Ph.D. and M.Sc. levels to ensure adequate leadership in the network. Degree level training, for economic reasons, will continue to be limited, although it is essential for developing leadership potential.

Short-term training activities need to continue but must be more selective not only in topic areas but also in reference to staff nominated for training. There is not much to be gained by having one individual participating in several courses, or in the same course more than once as a trainee, unless it is absolutely essential. This may rationalize the cost of short-term training and allow for the savings to be used to fund advanced degree training.

There is a large degree of variability among the member countries in terms of infrastructure development. Perhaps Uganda is the poorest of the lot in this respect, since it currently has very little in the way of developed infrastructure (except for land). Reports have been made indicating possible improvements in the immediate future, but the evaluation team (and indeed the national program staff) believes that a lot more effort (and funding) is needed to make the programs more effective and efficient as well as to keep up staff morale. It would seem that Zaire is not in much better shape. The situation in Zaire is made even worse by lack of donor support, as USAID has canceled all grants in Zaire. The level of infrastructure development in Burundi and Rwanda is comparatively better, although there is room for improvement in both cases.

Data on available funding in the network is not complete. However, it is very clear from discussions with national program leaders that there is a big disparity among national programs with respect to funding. On one end of the scale, there are Burundi and Rwanda with reasonably adequate levels of funding and good donor support, while at the other extreme, there is Zaire, which faces extreme shortage of funds. In fact, the Zairian national program leader indicated that he had not visited his two substations at Nioka and Kipopo for the last two years because of lack of funds. The Ugandan national program leader also indicated inadequate funding for his program, although it cannot be as severe as in Zaire. Funding is a real constraint for the efficiency and effectiveness of the national programs and, therefore, requires urgent attention by both the national governments and donors.

The technical and managerial support made available to the national programs by or through PRAPAC and CIP is very important. Currently the national programs in Burundi and Uganda have full-time consultants assigned to the programs and the network coordinator is based in Rwanda. The staff of the CIP regional office make frequent visits to all national programs. These are supplemented by visits by experts from CIP-Lima and from other organizations arranged by or through PRAPAC and CIP. These backstopping visits provide more than adequate technical support to national programs. However, the volatile political situation does affect the backstopping visits at times.

National programs have provided considerable effort for strengthening not only the network member national programs, but also their own in-country institutional partners. National programs have contributed to strengthening their institutional partners through providing in-country training in relevant areas of potato production, protection, and storage techniques, as well as making advisory visits to farmers and rural development project sites.

Staff of national potato programs are well

aware of the need for strong linkages between research and extension and development organizations. The creation of linkages is one of the objectives of PRAPAC and is strongly supported by CIP and USAID. Discussions with national program leaders as well as visits to farmers and development project sites has convinced the evaluation team that working relationships exist between research and extension and development projects in Burundi, Rwanda, and Uganda. The strategies applied in such linkages are joint-planning meetings, in-country training, on-farm demonstrations, and technical advisory visits by research staff. These efforts need to be intensified, especially between the research and extension services, to not only make research relevant but also to encourage feed-back to further identify and prioritize research topics.

The PRAPAC network has made positive progress towards attaining its intended objectives. Foremost among this is the linking of four independent national research programs into a coordinated system of research planning and execution at a regional level. This has enabled the sharing of knowledge and experiences as well as the transfer of improved germplasm across political boundaries. Although PRAPAC may be considered as a model for other networks in Africa for the future, continual refinement is essential to address the dynamics of network institutions. Nevertheless, the evaluation team highly recommends that USAID continue to support the efforts of the PRAPAC network and CIP in the development of a strong and self-sustaining network.

Recommendations

Considerable progress has been made by all parties—NARS, CIP, and donors—towards the development of a strong and self-sustaining network. The Directors' Committee, cognizant of the current and potential benefits that can accrue from this network, decided to further expand its coverage by including two additional countries (Ethiopia and Kenya) and one other commodity (sweet potato) in the next phase of the project. With further understanding and experience in coordination, it is entirely conceivable that the network may include other eastern and southern African countries and other commodities/disciplines of mutual interest to all members. This, of course, calls for improved organizational structures and broader outlook in project conceptualization and management.

Despite its positive impact, the network has room for improvement. The following recommendations are made with the intention of improving the network and the national program performance in this phase as well as the next phase of the project. These recommendations can be categorized into three broad groups—regional coordination, strengthening member national programs, and technical issues.

Network Coordination

The effectiveness and efficiency of the network is heavily influenced by the technical and managerial competence, flexibility, and dynamism built into it. Therefore, the following are recommended to help achieve these goals:

- *The Network Coordination Office.* The network coordinator and her/his staff play a central and deciding role in planning and execution of regional collaborative activities. It is, therefore, recommended that the coordinating office be strengthened by staffing it with competent and dynamic personnel and by providing it with funds and other resources to facilitate its performance.

- *Research Mandates.* The main aim of the network is to optimize the use of scarce resources available in member countries national programs. Thus, it is necessary to rationalize the mandates assigned to each national programs. It is recommended that the Directors' Committee, supported by its

executive committee, reassess the capabilities of member national programs and reassign mandates on the basis of comparative advantage and national strength.

- *Germplasm Exchange.* To make the network effective, it is necessary to facilitate the transfer of segregating populations as well as advanced germplasm among member countries. However, this essential activity may be constrained by political sensitivities, quarantine regulations, and other factors. Burundi and Kenya, and in a short period Rwanda, have sanitary facilities for producing materials with thermotherapy, meristem culture, and freedom of PSTV (checked in Lima) and PLRV, PVY, PVX, and PVS. It is, therefore, recommended that the Directors' Committee and the network coordinator assess the member countries' positions on these issues and develop ways and means, including establishing minimum quarantine requirements, to further facilitate germplasm exchanges among member countries. In addition, it is highly recommended that the Directors' Committee reach an agreement about the free interchange and utilization of the advanced genetic materials developed by the network countries.

- *Local Consultancy.* One of the possible benefits accruing from this network should be the building up of regional capability to solve local as well as regional problems in the production and protection of commodities of interest. Among other things, this should mean the use of qualified staff from member countries in consultancy and advisory work for the region. For example, Rwanda has expertise in late blight technologies, seed production technologies, rapid multiplication techniques, and germplasm management, which in reality is available to the rest of network. It is, therefore, recommended that the network coordinator initiate and maintain an updated data base on scientists in member national programs.

- *Documentation of Activities.* Although some effort towards improving the overall documentation process of the PRAPAC network has been made, documentation of activities remains inadequate. Therefore, the evaluation team recommends that PRAPAC hire sufficient personnel to adequately document PRAPAC activities as well as NARS potato program activities. This documentation, whether in the form of research proposals, research and trial progress/final reports, NARS country reports and/or minutes of PRAPAC executive and director committee meetings, should be available to all participating programs, as well as to CIP and donors.

- *Information Exchange.* Network collaboration can be greatly improved through the timely transfer of research and development information among member countries. This definitely calls for increased attention by and publishing capability of the network coordination office. It is, therefore, recommended that the network coordinator take immediate and appropriate steps that would facilitate the gathering, publishing, and transmitting of progress reports, annual reports, and other publications to member national programs on a regular and timely basis.

- *Training.* This is an activity that has a long-term impact. Staff training in various disciplines, including scientific writing, is required to improve performance. In addition, upgrading staff skills in computerized data management to handle experimental results and develop sound data bases is needed desperately. Therefore, it is recommended that the network coordinator in consultation with national programs initiate further training programs. As much as possible, such training be carried out in member countries.

National Programs

The strength of the regional network is very much defended on the strength of member national programs. The network can never hope to be effective if one or several of its members are weak. It is to the mutual advantage of all to take all measures necessary to strengthen the capability of member national programs. Especially, governments of member countries as well as donors should be solicited to provide support to build up national programs. The following recommendations are meant to address this issue.

- *Human Resources Development.* The availability of qualified and motivated staff is central to the development of an effective national program. It is recommended that governments of member countries give urgent attention to the building up of a "critical mass" of scientists and technicians for each of the commodities covered in the next phase of the regional network. In this respect, continuity of trained personnel is vital.

- *Developing Leadership.* The sustainability of a national program is determined by the quality of technical and managerial competence available to it. It is necessary that there must be trained leaders to set long-term objectives and design the strategies to attain them. Training, certainly, is the basis for such development. It is, therefore, recommended that training be designed to result in the accumulation of a "critical mass" of scientists M.Sc. degree or above) to lead national programs. It is further recommended that national governments provided suitable incentives to retain qualified scientists in national research systems.

- *Infrastructure Development.* The concept of networking is based on dividing research mandates on the basis of comparative advantages. No national program can hope to meet its obligations without adequate facilities. It is, therefore, recommended that national governments give urgent attention to the development of required infrastructure—i.e., laboratory, screenhouse, and storage facilities and seed farms to guarantee high sanitary standards in the production of pre-basic and basic seed, for their respective national programs. It is further recommended that national governments seek donor(s) support for this purpose.

- *Funding.* The current PRAPAC network is seriously constrained by lack of funds, especially in some of the member countries. This, of course, has severely handicapped the performance and output of the affected national programs. It is, therefore, recommended that member governments take urgent steps to alleviate these constraints.

Technical Issues

- *Screening of Germplasm.* To strengthen the impact of new varieties, it is necessary to maintain the emphasis in the selection process for late blight resistance, and at the same time it is desirable to further emphasize the screening for bacterial wilt resistance. The land scarcity may exacerbate the potato monoculture and/or the lack of sufficient crop rotation that might limit the effectiveness of the integrated bacterial wilt control. CIP's pathologist stationed at Nairobi should provide the network countries scientific support to expedite the process for multiple-criteria selection. During the process of pre-basic and basic seed production, it is recommended that samples of the produced seed be tested for viruses. These tests should screen for the main potato viruses PLRV, PVY, PVX, and PVS.

- *Seed Multiplication and Distribution System.* The present production of basic seed at PRAPAC NARS follows an extremely effi-

cient scheme with a solid output. However, from the moment the basic seed is distributed to the national seed services for further multiplication, the entire process becomes thin and somewhat informal. There are no standards for seed multiplication, nor are there guidelines for the number of time basic seed should be multiplied. In these circumstances there might be the temptation for the research program leaders to take a step forward past the production of basic seed to give an additional cycle of multiplication. Under their control, they would be able to produce larger volumes of high quality seed of elite seed category. Even though this additional cycle of multiplication could shorten the route for providing good quality seed to the farmers, it would have a very negative effect on the research program *per se* and its expected output.

Therefore, the evaluation team recommends that the PRAPAC potato research programs concentrate their efforts on producing only sufficient quantities of high-quality basic seed and initiate a major dialogue with the seed multipliers, both government and private sector, to establish guidelines and standards for the multiplication of basic seed and develop an information system to monitor the requirements of basic seed. Concomitantly, it is recommended that the research programs transfer the responsibility of further seed multiplication cycles to government or private sector institutions that will have the responsibility for distribution of the seed to the farmers.

It is highly recommended that the PRAPAC network countries implement these seed multiplication and distribution systems as soon as possible to help increase the amount of good-quality seed reaching the fields of the ware potato producing farmers.

- *Variety Dormancy Period.* It is highly recommended to emphasize the selection of varieties with a shorter dormancy period to better fit the farmers production period—i.e., in the sequence of long rains, short rains, swamp growing seasons.

- *True Potato Seed Technology.* It is highly recommended to emphasize the use of TPS as a complementary route to producing potatoes at a lower cost. Since the potato production in the PRAPAC countries is mainly rainfed, the use of seedling tubers produced in seed beds for ware potato production is the best alternative. The TPS progenies to produce seedling tubers should combine resistance to late blight and bacterial wilt. If adequate progenitors are not available in the PRAPAC countries, these could be made available by CIP-Lima or CIP-Nairobi.

Glossary of Acronyms and Abbreviations

AFR	Bureau for Africa (USAID)
ARTS/FARA	Office of Analysis, Research, and Technical Support / Division of Food, Agriculture, and Resources Analysis (USAID/AFR/; now SD/PSGE)
ANR	Agriculture and Natural Resources
BW	bacterial wilt (*Pseudomonas solanacearum*)
CIP	International Potato Center
DLS	diffused light storage
EC	European Community
EEC	European Economic Community
ELISA	Electro Phoretic Immuno Sorption Assay
EPR	End-of-Project Review
FBU	Burundian franc
GOB	Government of Burundi
GOR	Government of Rwanda
GOU	Government of Uganda
GOZ	Government of Zaire
IARC	International Agricultural Research Center
INERA	National Institute for Agronomic Researcn and Studies, Zaire
IPM	integrated pest management
ISABU	National Institute for Agricultural Research, Burundi
ISAR	National Institute for Agricultural Research, Rwanda
KARI	Kenyan Agricultural Research Institute
LB	late blight (*Phytophthora infestans*)
m.a.s.l.	meters above sea level
NARS	National Agricultural Research System
PLRV	potato leaf role virus
PNAP	National Potato Program (Rwanda)

PRAPAC	*Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Centrale*, or the Regional Potato Improvement Program for Central Africa
PSTV	potato spindle tuber virus
PTM	potato tuber moth
PVS	potato virus "S"
PVX	potato virus "X"
PVY	potato virus "Y"
REDSO/ESA	Regional Economic Development Support Office / Eastern and Southern Africa (USAID), Nairobi, Kenya
RFMC	Regional Financial Management Center (USAID)
SAARFA	Strengthening African Agricultural Research and Faculties of Agriculture
SD/PSGE	Office of Sustainable Development / Productive Sector Growth and Environment Division (USAID/AFR; formerly ARTS/FARA)
SWRARP	South West Region Agricultural Rehabilitation Project
TPS	true potato seed
TR	Office of Technical Resources (pre-10/91 USAID/AFR organization, now SD/PSGE)
UGS	Ugandan schillings
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture

Introduction

Background

Potatoes (*Solanum tuberosum*) are an important crop in the highlands of central Africa in areas above 1,800 meters on both slopes of the Zaire/Nile ridge in Burundi, eastern Zaire, Rwanda, and western Uganda. Introduced by European missionaries and colonists starting in the late 19th century, potatoes are now widely grown by small farmers, both for home consumption and for sale in regional and national markets. Yields in farmers' fields average from four to seven metric tons per hectare, well below the thirty to forty metric tone average of developed countries. High yields have been limited by severe pressure of two major diseases: late blight (*Phytophthora infestans*) and bacterial wilt (*Pseudomonas solanacearum*).

In the years before Rwanda, Burundi, and Zaire gained independence in the early 1960s, Belgian researchers introduced European varieties and carried out experiments on cultural practices. Subsequently, for nearly 20 years after independence, the disease resistance of the available varieties degenerated.

In response to farmers' needs, national potato research programs in Burundi, Rwanda, and Zaire were organized in the early 1980s with the support of the Regional Office of the International Potato Center (CIP-Nairobi). PRAPAC (*Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Centrale*, or the Regional Potato Improvement Program for Central Africa) was established in 1982. Presently, this potato research network composed of four countries: Burundi, Rwanda, Uganda, and Zaire; Uganda joined the network in 1987. CIP provides backstopping in the areas of research, training, information, and project management. To help establish these research programs, CIP posted scientists from its own staff in Rwanda between 1979 and 1986, in Burundi from 1983 to the present, and in Uganda from 1987 to the present. The network is headquartered in Rwanda, where the PRAPAC Coordinator, a member of CIP's staff, is based. CIP's regional office is located in Nairobi.

Advanced breeding work for the benefit of the PRAPAC network is carried out by CIP in collaboration with the Government of Kenya at KARI's station in Muguga. From this Regional Germplasm Distribution Center, improved varieties combining various resistances, adaptation, quality factors, and produced under strict quarantine conditions are distributed to the National Agricultural Research System (NARS).

The general objective of the network is the improvement of potato production through the support of the NARS. The four countries share a common environment and many of the same problems. The network promotes intercountry collaboration to share scarce resources to meet common goals. This involves training to enhance institutional capacity, joint research planning to avoid duplication of effort, and the publication and sharing of results for adoption by other members

Security concerns in Rwanda since early 1990 and Zaire since mid-1991 have imposed some limitations on network activities, as well as on research activities within these countries. Land borders between Rwanda and Uganda, Rwanda and Burundi, Rwanda and Zaire, and Burundi and Zaire are closed either permanently or for unspecified intervals, although air traffic continues between the capital cities.

Project Description

In February 1986, USAID's Regional Economic Development Support Office / Eastern and Southern Africa (REDSO/ESA) awarded a five-year, $1.6 million grant to CIP to continue and expand the PRAPAC potato improvement research network. In June 1991, the grant was extended until September 28, 1992, and $655,000 in funding was added.

Additional funding has been provided over the life-of-project through Mission bilateral activities to support the potato research programs in the participating countries. A summary of these "buy-ins" is provided below.

Project Number:
623-0435-G-00-6006-00

Title: PRAPAC Network: Programme Regional d'Amelioration de la Culture de la Pomme de Terre en Afrique Central (Burundi, Rwanda, Uganda, Zaire).

Cost:

	Ext. USD
Regional Coordination Budget (REDSO/ESA):	2,212,000
USAID-Burundi "buy-in": (PL 480: FBU 49,502,062)	317,000
USAID-Rwanda "buy-in":	301,000
USAID-Uganda "buy-in": (PL 480: UGS 80 million)	288,000
USAID-Zaire "buy-in":	314,700

Life-of-Project:
January 14, 1986–September 28, 1992

PACD:
September 28, 1992

The ultimate goal of the network is to make available to farmers disease-resistant, high-yielding varieties accompanied by other technologies. The network's strategy to achieve this is to strengthen research capacity in the national programs through coordinated research, training, information exchange, and institutional support. The intermediate goals of PRAPAC can be summarized as follows:

- Develop a functional, institutional sustainable research network with demonstrable gains in efficiency, compared to what the programs could achieve working in isolation.
- Improve capacity to evaluate and select improved genetic material both on-station and in farmers fields, leading to the release of improved varieties as a regular output of the research programs.
- Increase the efficiency with which a range of production, pest management, and post-harvest technologies are introduced, tested, and transferred to farmers.
- Develop improved systems for the production, multiplication, and distribution of high-quality planting material.
- Provide training to researchers and extensionists efficiently on a network basis, and encourage on-farm research and other linkages for the benefit of the farmers.
- Improve the capacity for the monitoring and evaluation of research and transfer of technology to farmers.

Assessment of Progress

Performance and Measurable Impacts

This End-of-Project Review (EPR) provides an opportunity to assess how effectively the four national potato research programs have worked with each other and with the International Potato Center (CIP) to achieve common goals. In addition the EPR team here evaluates how effectively the donor funding in support of the network has been utilized.

Progress of Research Carried Out within the Framework of the Network in the Development of Improved Varieties and Other Potato Technologies

The ultimate goal of the PRAPAC network is to make available to farmers disease-resistant, high-yielding varieties and other technologies. The network's strategy to achieve this is to strengthen research capacity in the national programs through coordinated research, joint research planning to avoid duplication of effort, and information exchange.

Introduction, screening, and evaluation of genetic materials for release as new varieties in network countries is a complex process. Materials introduced from the network from CIP-Lima are in the form of segregating populations (tuber families and true potato seed progenies) and selected clones (Table 1). Selection is carried out in terms of high yielding capacity, late blight (*Phytophthora infestans*) resistance, bacterial wilt (*Pseudomonas solanacearum*) tolerance, virus resistances, and tuber quality.

Most of the advanced potato breeding work is carried out by CIP-Lima. However, the PRAPAC network also benefits from the advanced breeding work carried out by CIP in collaboration with the Government of Kenya at the Kenya Agricultural Research Institute's Muguga station. From this Regional Germplasm Distribution Center (CIP-Nairobi), improved varieties combining various resistances, adaptation, and quality factors are distributed to the National Agricultural Research System (NARS) under quarantine regulations. In addition, improved germplasm exchange occurs among PRAPAC countries (Table 2).

Rwanda

In the period 1980–1990, the total potato production in Rwanda increased by 47.5 percent and the yield went up by 20 percent (Table 3). These increases were the consequence of the research conducted in PNAP (the Rwandan National Potato Program), which permitted to develop a technological package including several components:

- The introduction of new varieties with high yield and stability of performance and some of them with a certain level of resistance to late blight;
- Improved sanitary conditions of seed tubers by the implementation of a seed production technology that minimized the infection of seed by bacterial wilt;
- Improvement of the seed management technology by the use of diffused light seed storage facilities that permitted planting in the next season with seeds in a better physiological condition and an adequate sprouting stage;
- Improvement in the management of late blight chemical control by the use of adequate fungicides, opportunity, frequency, and methodology of spraying;

Table 1. International Potato Center Distribution of Potato Germplasm

Year	Clones (Tubers) Units	Clones (Tubers) Accs.	In-Vitro (Plantlets) Units	In-Vitro (Plantlets) Accs.	In-Vitro (Tuberlets) Units	In-Vitro (Tuberlets) Accs.	Tubers (Families) Units	Tubers (Families) Accs.	True Seed (Families) Units	True Seed (Families) Accs.	TPS (Progeny) Units	TPS (Progeny) Accs.
Rwanda												
1984	324	34					918	120				
1985												
1986	110	22					5,634	226	10,400	52	224,400	9
1987			12		4		1,330	30	5,400	27		
1988	2,052	159	6	3	140	2	5,373	211				
1989	231	21									10,000	20
1990	3,792	184	50	22			2,062	60	200	1		
1991	4,555	404	84	32			614	15			25,000	5
Total	*11,064*	*824*	*152*	*61*	*140*	*2*	*15,931*	*662*	*16,000*	*80*	*259,400*	*3*
Burundi												
1984							857	119				
1985	310	35	2	1								
1986	586	170	15	5			2,768	162	7,049	39	150	1
1987			27	10			875	106	7,049	39	150	1
1988	355	21	50	18	345	12	1,169	35	3,500	35	100	1
1989	1,330	146	32	13			1,810	36			10,000	20
1990			76	23								
1991	679	134	87	23					2,400	24	18,000	18
Total	*3,260*	*506*	*289*	*93*	*345*	*12*	*7,479*	*458*	*19,998*	*137*	*28,400*	*41*
Zaire												
1986							123	7				
1987	60	20					123	7				
1988	318	11					1,096	105				
1989	231	21			300	3					9,000	18
1990	173	33										
1991	150	30										
Total	*932*	*115*	*0*	*0*	*300*	*3*	*1,342*	*119*	*0*	*0*	*9,000*	*18*
Uganda												
1988	296	30										
1989	561	87					1,059	169	1,000	10	119,000	37
1990	889	172					2,351	59	8,000	1	200,000	12
1991	1,635	150					409	7			381,000	24
Total	*3,381*	*439*	*0*	*0*	*0*	*0*	*3,819*	*235*	*9,000*	*11*	*700,000*	*73*

Table 2. Exchange of Germplasm in the Network

Year	Origin	Destination	Material	Quantity	Reference
1980	Rwanda	Zaire	Varieties	5	Atzimba, Sangema, Montsama, Condea, Marilahinda
1983	Rwanda	Zaire	Varieties	5	Gahinga, Kinigi, Nseko, Petero, Gasore
1988	Rwanda	Zaire	Seed	3 MT	Sangema, Cruza, Kinigi
1988	Rwanda	Zaire	Seed	3.3 MT	Sangema, Montsama, Seseni
1988	Rwanda	Uganda	Seed	10 MT	Sangema, Cruza
1989	Rwanda	Zaire	Vitroplants	2 Tubes	Sangema, Cruza
1990	Rwanda	Uganda	Plantlets	150 Pots	Sangema, Cruza
1990	Burundi	Zaire	Seed	50 50	Sangema Ndinamagara
1990	Burundi	Uganda	Seed	100 50	Uganda 11 Ndinamagara
1991	Rwanda	Burundi	Vitroplants	50	Ndinamagara
1991	Burundi	Uganda	Seed	50 50	Uganda 11 Ndinamagara
1991	Burundi	Zaire	Vitroplants	10 5 5 10	Ndinamagara Perricholi Sangema Advanced Clones
1991	Burundi	Rwanda	Vitroplants	20 Tubes	Sangema, Cruza, Muruta. Perricholi
1991	Uganda	Rwanda	Clones	8 Genotypes	Advanced Clones

- Improved crop management technology that included agronomic practices, use of manure and fertilizers, and crop rotation; and
- Training of scientists, technicians, and farmers that permitted that the technological package developed by the research staff at PNAP and other PRAPAC countries could be successfully transferred to the farmers fields.

Selection of High Performing:
New Varieties with Resistance to Late Blight

Each year PNAP introduces advanced genetic materials from CIP-Lima and CIP-Nairobi for testing and selection of clones which show adequate adaptation, stable yield, late blight resistance, good tuber quality attributes, and adequate agronomic characteristics related to length of growing period and plant vigor, and good storability. Since bacterial wilt is also a problem in Rwanda, the selection process also evaluates the behavior of the material to the bacterial disease.

The introduced materials are planted in the field at the PNAP's Ruhengeri station for exposure to a heavy late blight epiphytotics. In the early stage of selection, 8 to 10 percent of the materials are retained for further evaluation. The proportion of retention of materials increases as the process of evaluation progresses. After six to seven seasons of evaluation in Rwanda, a reduced number of clones that survived the process of selection are proposed to be released as new varieties.

The materials received from CIP include advanced late blight resistant clones and advanced populations in the form of tuber families that segregate for late blight, bacterial wilt and virus resistances, and yield and tuber quality attributes (Table 1).

Historically, before the establishment of PNAP in 1979 the varieties cultivated in Rwanda were a group composed mainly by Muhabura and Bufumbira introduced from Uganda and the European's Condea, Utila, Anette, Julvanette, Mariline, and a few others. In the early 1970s, a group of Mexican varieties such as Montsana, Atzimba, and Sangema where introduced by the Rwandan Institute of Agricultural Sciences (ISAR). When PNAP was established with the collaboration of CIP scientists, several of the existing varieties were subjected to positive and negative selection (rogueing), then were cleaned up from diseases at CIP - Lima and were extensively distributed by PNAP between 1980 and 1982.

Since 1979, PNAP introduced advanced genetic materials from CIP-Lima and from 1982 onwards new varieties characterized by high yield, late blight resistance and some level of tolerance to bacterial wilt started to be considered for release. Gahinga, Gasore, Petero, Nseko, and Kinigi came in 1984. From 1984 to the present, additional advanced material was introduced, evaluated, and selected. Several high performing, late blight resistant and some with a certain tolerance to bacterial wilt, new varieties have been released. The varieties Mabondo and Kirundo were selected from crosses made in the early 1980s by PNAP using CIP's progenitors. A list of the new varieties is presented in Table 4.

The varieties released by PNAP have proven to be popular because consumers appreciate their floury taste. The most spectacular case is that of Cruza 148 (CIP 720118) a variety that despite showing a purple vascular ring in its

Table 3. Rwanda: Potato Production (Metric Tons)

Year	Production (000)	Area Planted (000 Ha)	Average Yield (MT/Ha)
1980	217.0	34.2	6.3
1983	296.1	41.0	7.2
1986	310.5	42.0	7.4
1990	320.0	43.0	7.5

Source: Rwanda Ministry of Agriculture.

Table 4. Rwanda: Varieties Released, 1984 –1992.

Variety	Year of Release	Attributes[1]
Gahinga	1984	LB
Gasore	1984	LB
Nseko	1984	LB, BW
Petero	1984	LB, BW
Kinigi	1984	LB, BW
Cruza	1985	LB, BW
Mabondo	1988	LB, BW
Kirundo	1989	LB, BW
Ngunda	1992	LB
Mizero	1992	LB, BW
Gikungu	1992	LB, BW
Mugogo	1992	LB
Nderera	1992	LB, BW
Kigega	1992	LB

[1] LB = Resistant to late blight, BW = Tolerant to bacterial wilt.

Table 5. Rwanda: Distribution of Varieties by Zone, 1992
(Percent of Varieties Reported in Each Zone)

Variety	Volcanic Soils, Mutura	Highland Crest, Mudasomwa	Highland Crest, Ramba
Sangema[1]	74	35	56
Cruza[1]	2	43	26
Mabondo[1]	16	20	5
Montsama[1]	5	0	4
Kinigi[1]	0	0	7
Muhabura[1]	1	0	4
Gasore	0	1	1
Gahinga[1]	1	1	0
Satuma	2	0	0
Rubengera	0	0	2
Bakou	1	0	0
Kruger	0	1	0
Mariline	1	0	0
	103	101	105

[1] Variety released by national program.
Sample Size = 325:
Volcanic Soils/Mutura= 125;
Nile-Zaire Crest/Mudasomwa= 100;
Nile-Zaire Crest/Ramba = 100

flesh is acceptable to farmers because of its performance. Its yielding capacity combined with its resistance to late blight and bacterial wilt and its short dormancy permit it to fit well in the bimodal cropping calendar. That variety has become dominant in the southern part of Rwanda.

The results obtained from the germplasm screening carried out at PNAP have been transferred to other countries of the PRAPAC network where the varieties have been evaluated and adopted.

The PNAP varieties have practically replaced the old materials that were cultivated in Rwanda. In a recent survey (1991–1992) carried out on a sample of 325 farmers, it was found the Sangema, Cruza, and new variety Mabondo are the ones by far the most cultivated in the various agro-ecological zones of Rwanda (Table 5).

In the last 12 years PNAP has carried out a significant amount of research in the areas connected to the control of late blight and bacterial wilt both from the point of view of selection of resistant materials, as well as chemical and integrated disease control. Table 6 shows on a year basis the experiments carried out in these areas that help to explain in part the success that the newly developed varieties are having in this country.

A significant activity in the process of development of the technological package accompanying the new varieties has been the research carried out in related areas which has taken place not only at the experiment station level but also at the farmer level during the process of transfer of technology. A variety of activities carried out at the farmer level is presented in Table 7. Worth noting is the fact that ISAR has dropped its on-farm research activities due to funding constraints. Thus, the

Table 6. Rwanda: Experiments in the National Potato Program

Year	Breeding: Late Blight Screening	Breeding: Bacterial Wilt Screening	Other Evaluations	Total Breeding	Late Blight Chemical Control	Bacterial Wilt Cultural Control
1980	1	1	1	3	3	1
1981	4	1	1	6	3	3
1982	5	2	2	9	3	2
1983	9	0	2	11	2	2
1984	17	2	2	21	0	2
1985	6	2	4	12	0	3
1986	5	1	3	9	2	2
1987	4	0	3	7	1	1
1988	3	3	7	13	1	0
1989	7	2	6	15	6	1
1990	2	5	9	16	1	0
1991	7	1	4	12	0	0
Total	70	20	44	134	22	17

progress that has been made in the past will be constrained if only station research is carried out.

Experiments on late blight control have shown the effectiveness of fungicide utilization. Seven to eight applications per season provide an optimum control even for susceptible varieties, while three to four sprayings are sufficient when resistant varieties are grown under the heaviest late blight infection season. Besides late blight control, other technologies related to the agronomic management and use of diffused light storage technologies have been tested in farmers' fields with a considerable rate of adoption (See Table 7).

PNAP's success in introducing new potato varieties into cultivation has been very important. However, considering that PNAP presently is not generating its own genetic materials and given the importance of bacterial wilt, it would be recommendable that CIP emphasize combining resistances to late blight and bacterial wilt race 3 for future shipments of material for variety selection, release, and adoption.

Basic Seed Production and Seed Potato Technology Development

The objective of this subproject, which is shared with Uganda, is to produce "clean" (disease-free) basic material for seed production.

Seed Agronomy and Cropping Systems

- Agronomic trials on seed management showed that seed size (20–30 mm, 30–45 mm, and 45–60 mm) resulted in statistically equal yields when planted at the same seed rate per hectare—i.e., 1.0, 1.5, 2.0, 2.5, or 3.0 metric tons per hectare. However, yield increased with the increasing of plant density for each seed size. Agro-economically, it has been found that 2.5 metric tons per hectare of seed was optimal.
- In NPK fertilizer trials, the rate of 50, 100, and 200 kilograms per hectare respectively are optimal on volcanic soil. On alluvial and lateritic soils, the optimum is 100-200-200 kilograms per hectare.

Table 7. Rwanda - Technologies Tested in Farmers' Fields

Technology	Number of Trials	Positive Effects (No.)	Accepted by Farmer
Introduced Varieties (Montsama, Sangema)	52	31	+ +
Newly Selected Varieties (Nseko, Kinigi, Gahinga)	28	27	+ +
New Varieties with use of Compost	14	12	+ +
Compost Broadcast	8	1	-
Compost Localized	31	13	+
Selected Seed from Previous Harvest	8	5	-
Selected Seed and Compost	8	6	+
Late Blight Control with Fungicide	19	14	+ +
Chemical fertilizers	4	2	?
Seed Storage in Diffuse Light	10	1	-
Total	*182*	*112*	

- There is no effect from fertilizer if no late blight control is applied (i.e., late blight damage severely effects yields) and the potato response is much better in the rainy season than in the dry one.
- Desprouting seed decreases remarkably the total yield compared with normally sprouted seed tubers but increases the number of tubers per plant—i.e., improves the seed tuber yield.

PNAP-PRAPAC have organized two in-country training courses on optimization of potato agronomy in seed production, which have resulted in increased fertilizer utilization in the country.

Potato Seed Production and Distribution in Rwanda

Potato seed production in PNAP aims: (1) to produce enough basic seed to supply the seed multiplication services, (2) to disseminate the newly selected varieties, and (3) to increase yield. Seed growers multiply this basic seed several times before the production is sold as ware potatoes. One of the major contributions of PNAP-PRAPAC has been the consistency in the distribution of good quality seed. Figure 1 shows the flush-out seed production scheme used in Rwanda to produce high-quality pre-basic and basic seed, which includes a green-house and field production phases.

The major factor limiting seed quality in Rwanda is bacterial wilt. An important component for improved seed quality has been the production of stocks of pre-basic seed starting on tuberlets or minitubers that were produced in the screenhouses from in vitro materials. The comparison in Table 8 illustrates the highly significant gain in seed quality by using green-house-produced minitubers directly form in vitro cultures in contrast with ordinary tubers.

The outcome of the basic seed production system has been important. The rapid multiplication has taken place in the screenhouse at the

Figure 1. The Flush-Out Seed Production Scheme Used in Rwanda

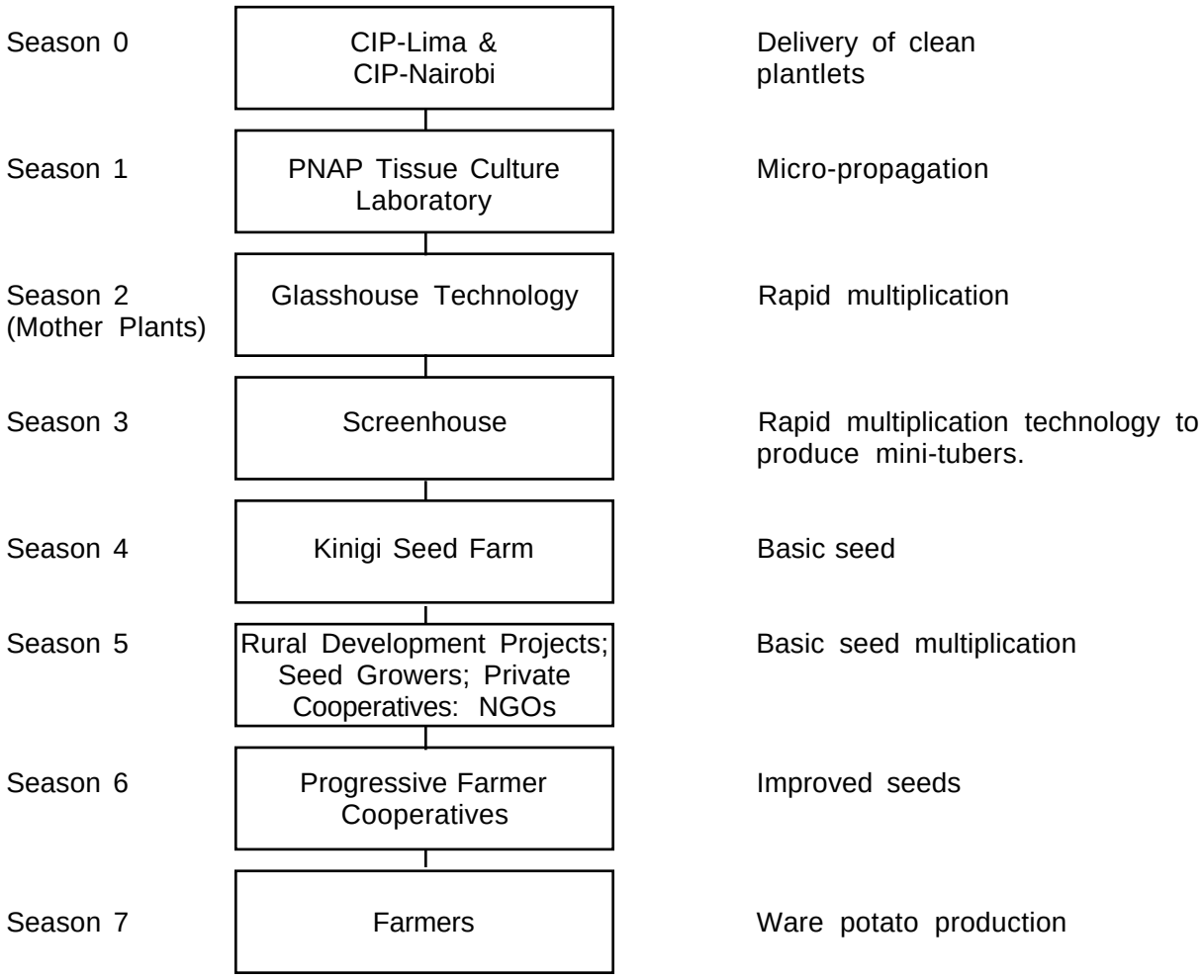

Table 8. Rwanda: Bacterial Wilt Infection in Seed Crops

Year	Number of Wilted Plants per Hectare: Crop from Mini-Tubers	Crop from Ordinary Tubers
1986	7	441
1987	3	703
1988	0	507
1989	13	806
1990	0	600

Table 9. Rwanda: Distribution of Basic Seed, 1980–1991

(Metric Tons)

Year	Quantity Distributed	Cum. Total Distributed
1980	23	23
1981	99	122
1982	143	265
1983	186	451
1984	218	669
1985	320	989
1986	212	1,201
1987	202	1,403
1988	560	1,963
1989	808	2,771
1990	638	3,409
1991	662	4,071

Ruhengeri station and then the basic seed production at the fields at Kinigi farm to be flushed-out for further multiplication. The Kinigi farm has 60 hectares of good volcanic soil with adequate texture and structure for potato production. The quantities of basic seed produced at PNAP which have been passed on to the seed multiplication service from 1980 to 1991 are presented in Table 9.

The production of pre-basic and basic seed at PNAP is an efficient process that delivers high-quality product in adequate quantities. The evaluation team had the opportunity to visit a pre-basic seed crop at the Kinigi farm and found that the plant vigor, uniformity, and health condition of the crop were excellent.

However, there is little information about the quantities of seed available for distribution from seed multiplication once the basic seed has been delivered from PNAP to the national seed service and/or further down the seed multiplication system to the farmers for additional cycles of multiplication for ware potato production. The team visited farmers multiplying seed and producing ware potatoes, but data on how much or where the seed is being distributed is not being collected. This lack of information made it difficult for the team to evaluate the overall impact of the basic seed production and its contribution to increasing national productivity.

Burundi

Available statistics, up to 1988, show that Burundi had a national average potato yield of 3.7 metric tons per hectare. This low yield reflects the effects of several constraints which impact on the potato crop. However, encouraging research results obtained by the national programs, and within the PRAPAC network, should contribute significantly to increasing the average national yield.

Bacterial wilt and late blight are serious yield constraints in Burundi. Bacterial wilt alone is estimated to cause from 25 to 30 percent losses in yield. This percentage could increase if inadequate integrated disease control measures are not taken. On the other hand, late blight could also produce serious losses if susceptible varieties are not protected by fungicides.

Within the PRAPAC network, Burundi is responsible for two subprojects: (1) bacterial wilt control and selection of germplasm for resistance; and, (2) improved storage of both seed tubers and ware potatoes. The progress achieved in these two subprojects is encouraging for the following reasons:

Control of Bacterial Wilt

- *Evaluation of Advanced Materials for Wilt Resistance.* Since 1983, tuber families and advanced clones introduced from CIP-Lima have been tested for resistance to race 3 of bacterial wilt. These materials were evaluated in a naturally infected soil at Gisozi. Table 10 shows the number of materials introduced from CIP-Lima. Among all these materials, some clones were selected and released. The clone CIP 720118 (Cruza 148) introduced in 1984 has shown in all the phases of its evaluation to be resistant to bacterial wilt. It also has resistance to late blight and has been diffused in Burundi under the name “NDINAMAGARA.”

  Other selected varieties such us Uganda-11, Kinigi, Muziranzara, and Muruta are susceptible to bacterial wilt. Promising clones under evaluation which are being tested in multilocation trials in collaboration with rural development projects are 382195.21, 381381.26, 381381.9, 382147.18 and 374080.5 (P.3). The performance of these materials in the late blight resistance trials can be seen in Table 11.

  A survey of 325 farmers in Burundi indicated that Ndinamagara was by far the most cultivated variety (88 percent of the cases), followed by Muruta and Uganda 11. Muruta, which represents about 15 to 20

Table 10. Burundi: Testing for Resistance to *Pseudomonas solanacearum*

Year	Number Families	Number Tubers	Number Clones	TPS Progenies
1983			18	
1984	17	497		
1985			68	
1986			8	
1987			20	
1988	10	360		
1989			26	
1990			30	22
1991			27	

Table 11. Burundi: Evaluation for *Phytophthora infestans* Resistance, 1990B and 1991A

Season	Clones	Late Blight Score (DAP) 30	45	60	75	90	Yield (MT/Ha)
1990B Clonal	384578.4	1	1	1	2	3	22.2
1990B Varietal	382195.21	1	1	1	3	5	17.5
	381381.9A	1	1	1	3	4	16.4
1990B Multi-Locational	381381.26A	1	1	1	2	3	22.0
	382147.18	1	1	1	2	4	22.8
1991A	BU 86022	1	1	3	4	4	23.3
	374080.5	1	1	2	3	4	28.4
	381381.9	1	1	1	2	3	31.3
	381831.26	1	1	1	2	3	36.5
Checks	Ndinamagara	1	1	3	3	3	25.8
	Muruta	1	1	4	6	6	12.4
	Kinigi	1	2	4	6	8	11.7

Notes:

- During the 1990B (February–May) season 10 tons of manure and no chemical fertilizer was applied to all trials. During the 1991A (September–January) season chemical fertilizer (60-90-60) was applied.
- Late blight is scored on a scale of 1 (absolute absence) to 9 (death of plant). DAP = Days after planting.

Table 12. Burundi: Experiments in the National Potato Program

Breeding Year	Late Blight Screening	Late Bacterial Wilt Screening	Other Evaluations	Total Breeding	Blight Chemical Control	Agronomy	Storage
1983	5			5		1	
1984	7	2	3	12		2	2
1985	3		2	5		5	3
1986	4		4	8	1	5	
1987	1		7	8	4	1	
1988	5		5	10	2	2	
1989	3	2	5	10	1	4	7
1990	2			2	1		
1991	4	3	9	16	3	2	
Total	*34*	*7*	*35*	*76*	*9*	*23*	*14*

percent of the total production, is a high yielding variety that, despite being susceptible to both bacterial wilt and late blight is particularly well adapted for growing in the swamp area during the dry season. The old potato varieties grown in Burundi are in process of being abandoned by the farmers. The main causes for these varieties to be abandoned have been slow germination and susceptibility to late blight and bacterial wilt. All these characteristics are highly correlated to low yield.

The introduction of new varieties in Burundi, as in Rwanda, has been accompanied by a technological package including use of good-quality seed, adequate seed storage techniques, chemical control of late blight, agronomic technology related to fertilizer use, crop rotation, etc. The on-farm trials have had a significant effect in the progressive adoption of the new technology. Table 12 provides information on aspects involved in the development of the technological package.

In conclusion, the introduction of new varieties with resistance to either late blight or bacterial wilt or both has already had a positive effect in replacing the old low-yielding materials with new high-performing varieties which can increase potato production nationwide and the incomes obtained by the potato-producing farmers.

- *Bacterial Wilt Control by Cultural Practices.* The bacterial wilt present in Burundi is caused by the race 3. The main sources of infection are contaminated seed and infected soil. Appropriate crop rotation can reduce the wilt inoculum in the soil. A series of experiments on crop rotation, conducted since 1983, included potatoes followed by natural fallow after which the land is cleared with herbicides followed by buckwheat, maize, wheat, peas, or beans. Recent experiments have shown that wheat planted after potatoes reduces the incidence of bacterial wilt.

- *Control of Bacterial Wilt by Production of Clean Seed.* Within the integrated bacterial wilt control strategy, which includes use of tolerant or moderately resistant varieties (since varieties with high resistance have not been found), new crop materials, and use of clean seed, a new seed production system was developed 1987. This system

has been called the "flush-out" system. The process is based on the use of pathogen-free in-vitro material, which is propagated using tissue culture techniques in laboratories of simple construction. The single node cuttings are then grown in sterilized soil within insect-proof screenhouses at the Gisozi station. At harvest, the "minitubers" produced in the screenhouses are bulked for later planting in an area of 1 to 1.5 hectares at the Munanira station (2,150 meters above sea level). This total production process constitutes the production of pre-basic seed which is further multiplied in an area of 8 to 10 hectares per season at the Mwokora station (2,200 meters above sea level). This phase of the seed production process gives the basic seed. During the process of producing pre-basic and basic seed, the application of negative selection occurs, which consists of rogueing out the diseased or atypical plants as well as the four neighboring plants.

The use of manure from animals maintained on the same farm improves the soil physical conditions and at the same time eliminates the risk of contamination by using manure collected outside the farm. Adequate procedures for the control of late blight are carried out during production to maximize productivity. The crop rotation system of growing potatoes in the same soil every five seasons has given an excellent result—i.e., potatoes followed by wheat and then three seasons of the *Pennisetum* grass known as setaria (Table 13).

The entire process of the flush-out system including the flow of the basic seed to the national seed service, rural development projects, and farmers is presented in Figure 2. The production of both pre-basic and basic seed has steadily increased from 1985 to 1991 and the effect of the flush-out seed production system has dramatically reduced the bacterial wilt seed infection at the Mwokora farm (Table 14).

Latent infection by bacterial wilt could be a shortcoming in the integrated disease control—i.e., apparently healthy tubers produced by normal looking plants when planted under environmental conditions adequate for disease development would give raise to infected plants. To cope with this problem, a system to detect latently infected tubers is being implemented.

Techniques to further improve integrated bacterial wilt control are being investigated—i.e., the use of plastic sheets to "solarize" the soil before planting.

The conclusion on the integrated bacterial wilt control is that the progress has been very significant. This PRAPAC subproject could be utilized as a model to be followed by other eastern and central African countries where bacterial wilt is a serious constraint for potato production. The evaluation team recommends that both CIP-Lima and CIP-Nairobi provide more advanced genetic materials with joint resistance to bacterial wilt and durable resistance to late blight. Since these two diseases are major constraints in the PRAPAC countries, greater attention should be given to the resistance component.

The quantitative aspects of basic seed distribution for further multiplication and distribution to farmers either for additional cycles of seed multiplication or ware production is not well documented. Mwokora staff provided data on distribution of basic seed and these are included in Table 15.

At this point, an important issue should be underscored. The production of basic seed follows an extremely efficient scheme with a solid output. However, from the moment the basic seed is distributed to the national seed services for further multiplication, the entire process becomes thin and somewhat informal. There are no standards for seed multiplication, nor are there guidelines for the number of times basic seed should be multiplied. In addition, information on national seed supply (i.e., intermediate production of seed) and demand is nil. Therefore, the team recommends that the Burundi potato research program initiate a major dialogue with the seed multipliers, both govern-

Table 13. Burundi: System of Rotation with Potatoes

	Year 1		Year 2		Year 3		Year 4		Year 5	
Field	**SA**	**SB**	**SA**	**SB**	**SA**	**SB**	**SA**	**SB**	**SA**	**SB**
1	P	W	S	S	S	P	S	S	S	S
2		P	S	S	S	S	P	W	S	S
3			P	W	S	S	S	P	S	S
4				P	S	S	S	S	P	W
5					P	W	S	S	S	P

SA = Cultural Season A (September - January); SB = Cultural season B (February - June); P = Potato; W = Wheat; S = Setaria

Figure 2. ISABU Potato Program Potato Seed Production Scheme

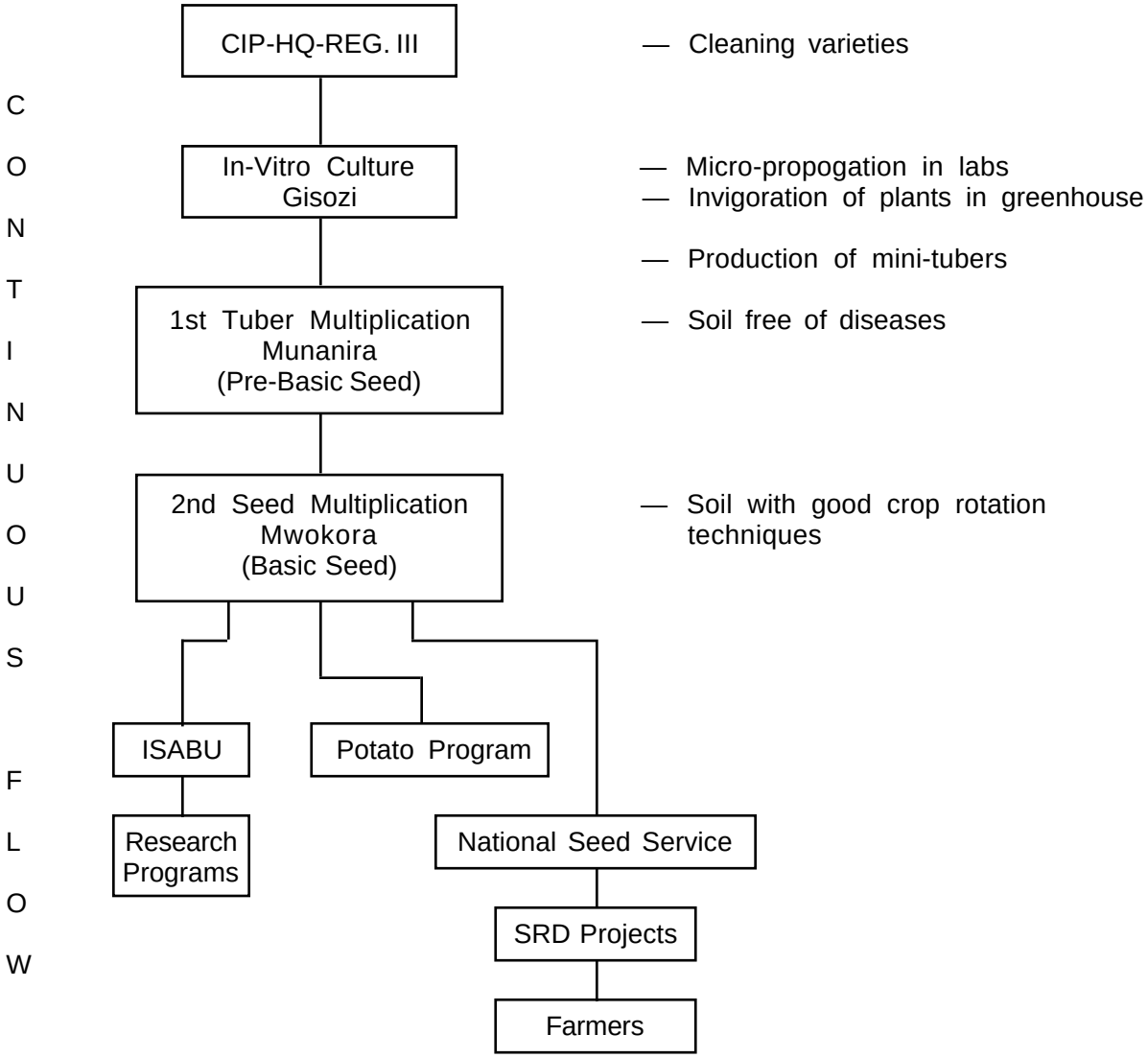

Table 14. Burundi: Potato Seed Production

Year	Munanira[1] Pre-Basic Seed Production Metric Tons	Munanira[1] Bacterial Wilt %	Mwokora[2] Basic Seed Production Metric Tons	Mwokora[2] Bacterial Wilt %
1985	33.3	0.2	105.2	—
1986	48.2	1.2	191.2	64.1[3]
1987	50.2	3.1	150.1	65.8
1988	47.6	2.9	160.2	14.5
1989	49.9	1.2	266.9	0.8
1990	68.8	0.7	295.6	0.9
1991	68.6	0.5	377.5	0.7

[1] Munanira—2,150 meters above sea level; 1 to 1.5 hectares per season from in-vitro material coming from Gisozi.
[2] Mwokora—2,200 meters above sea level; 8 to 10 hectares per season with planting material coming from Munanira.
[3] In 1986–87, Uganda 11, Sangema, Muruta, and Kinigi percentage of wilting was 4.1 and 5.8, respectively. Kenya Baraka and Muziranzara varieties had more than 60 percent wilting plants; production from these was marketed for consumption.

ment and private sector, to establish guidelines and standards for the multiplication of basic seed and develop an information system to monitor the requirements of basic seed.

In these circumstances, there might be the temptation for the research program leaders to take a step forward past the production of basic seed to give an additional cycle of multiplication. Under their control, they would be able to produce larger volumes of high-quality seed of elite seed category. Even though this additional cycle of multiplication could shorten the route for providing good-quality seed to the farmers, it would have a very negative effect on the research program *per se* and its expected output. If a potato program with scarce scientific and technical human resources dedicates an important part of its time to technology promotion activities, its research efficiency may decline.

The evaluation team recommends that the potato research programs concentrate their efforts on producing only sufficient quantities of high-quality basic seed. The revenue obtained from selling the seed should contribute to their operative budget increasing the sustainability of the program when funds are scarce.

Concomitantly, it is recommended that the research program transfer the responsibility of further seed multiplication cycles to government or private-sector institutions that will have the responsibility to convey the seed to the farmers.

Improved Storage of Both Seed Tubers and Ware Potatoes

- *Improved Storage Techniques.* The potato program has developed improved storage techniques and contributed to the transfer of this technology to the farmers principally by on-farm research and training. The positive results obtained in this subproject are linked to an improvement in the health status of the crop as a consequence of crop rotation, planting good quality seed, high-performing varieties, and relatively recent introduced materials, adequate late blight

Table 15. Burundi: Distribution of Foundation Seed, 1991
(Metric Tons)

Clients	Ndinamagara	Uganda 11[1]	Muruta	Kinigi	Sangema	Clone (374080.5)[2]	Total
CVHA	60.0	19.0	0.0	0.0	0.0		79.0
Bututsi Project	14.5	13.0	0.0	0.0	0.0		27.5
Kajondi Project	81.0	12.0	0.0	0.0	0.0		93.0
Muyinga Project	3.0	0.0	1.5	0.0	0.0		4.5
Buyenzi Project	3.0	0.0	0.0	0.0	0.0		3.0
Rutana Project	4.5	0.0	0.0	0.0	0.0		4.5
Kirimiro Project	9.5	0.0	0.0	0.0	0.0		9.5
Park Zuace	2.0						2.0
Cankuzo Project	2.0	0.0	0.0	0.0	0.0		2.0
Buragane Project	3.0	0.0	0.0	0.0	0.0		3.0
Mumirua Project	3.0	1.0	0.0	0.0	0.0		4.0
ACF Project	0.0	0.0	3.5	0.0	0.0		3.5
Action Aid	1.0	0.0	0.0	0.0	0.0		1.0
ISABU (Programs)	8.0	13.8	2.5	4.0	3.0		31.3
Other	6.0	5.5	3.5	3.3	6.5		24.8
Total	200.5	64.3	11.0	7.3	9.5	0.0	292.6
Percent	68.5	22.0	3.8	2.5	3.2	0.0	100.0
Percent of production	99.4	50.6	84.0	97.3	64.2	0.0	77.6

[1] Uganda 11 from Season B (harvested July 1991) not yet distributed.
[2] (3374080.5) is a new clone to be released by the National Seed Council.

control, etc. The improved health status of the material to be stored, either for seed or consumption, has therefore helped to attain good storage results.

Low-cost diffuse light storage technology developed by CIP in the late 1970s and early 1980s was the subject of successful adaptive research. On-station and on-farm research permitted transfer of the technology of building low-cost storage facilities with materials readily available to farmers. Seed tubers stored in these simple structures are kept in optimal conditions from harvesting to next planting. Diffuse light inhibits excessive sprout growth and instead promotes limited but vigorous growth of multiple sprouts. This type of seed when planted gives a faster, uniform, and vigorous emergence with a high plant stand. Insect damage by tuber moths during seed storage has been decreased by the use of leaves of the common aromatic weed *Lantana camara*. The use of this method of tuber moth control has spread among the farmers in Burundi, Rwanda, and Zaire.

- *Storage of Potatoes for Consumption.* Methods of ware potato storage have been developed to extend the storability of potatoes mainly for household consumption. Boxes built with wood, locally adapted baskets woven from bamboo, and naturally ventilated stoves constructed with wood have been used for storage. The capacity of these

storage containers varies between 500 to 1,000 kilograms. After a period of storage, tubers in these containers did not show greening or shrinking and exhibited a limited degree of sprouting. The best method was found to be a naturally ventilated store that maintained the lowest internal temperature (16 degrees centigrade). In the boxes, it was from 18 to 22 degrees centigrade, while in the baskets it was the highest (31 to 32 degrees centigrade). These storage technologies have been successfully transferred to farmers in Burundi. PRAPAC sponsored training programs are being used to diffuse this technology to other network countries.

Uganda

Within the PRAPAC network, Uganda has responsibility for four subprojects: (1) breeding and germplasm maintenance; (2) potato production using true potato seed (TPS); (3) seed production technologies; and (4) integrated pest management.

Research in the Ugandan Potato Program is conducted at the main experiment station, Kalengyere, and several other experimental sites whose agroecological characteristics are indicated in Table 16. The experimental sites located at various altitudes present a wide range of variation in precipitation, mean temperatures, soil pH, and major constraints effecting potato yields. These experimental sites represent the highlands, which account for 80 percent of the potato production and the lowlands, which produce the remaining 20 percent. Despite this important difference in distribution of potato production between the highlands and the lowlands, the Government of Uganda is actively promoting increased potato production in the lowlands. The government's interest was clearly indicated by the Minister of Agriculture in a meeting with the review team in Entebbe. One of the main reasons for this decision is that cassava, a very important food crop in this agroecology, is being seriously affected by the dieback disease (mosaic), and the potato is an excellent alternative crop.

However, the extension of potato production to lower altitudes will subject the crop to greater pressure from bacterial wilt, heat stress, Verticillium wilt, and potato tuber moth. As a consequence, the genetic materials need to have a wider adaptability to biotic and abiotic stresses. In addition, increasing potato production in warmer areas nearer to the major market in Kampala requires research on seed supply, agronomic management, and integrated pest and disease control.

The evaluation team travelled to Kabale, where the most important potato production area is located. Population density (350 persons per square kilometer) is extremely high in this area. We first visited Kalengyere, the 240-hectare highland experimental station, which became fully operative in 1989. In this station, research is carried out on root and tuber crops, vegetable seed production, soil and water conservation, and soil fertility. One function of this station is to transfer technology to farmers.

The Kalengyere station concentrates on the following research activities: (1) germplasm maintenance and evaluation; (2) TPS research; (3) basic-seed production including rapid multiplication leading to pre-basic seed production; (4) bacterial wilt management; (5) agronomy trials; (6) postharvest research; and, (7) on-farm research. The progress achieved in Uganda's research activities is the following:

Breeding and Germplasm Maintenance

Potato research in Uganda has been in the process of being reestablished after a long period of disruption. Many of the varieties still grown by farmers were introduced between 1968 and 1974 through a program funded by the Rockefeller Foundation. Those varieties are Marilahinda, Rutuku, Nyabwishenya, Lubega, Kachwekano, Wurster, and Muhabura.

In 1989, 10 tons of seed of the varieties

Table 16. Uganda: Characteristics of the Experimental Sites

Site	Altitude (Meters)	Rainfall (Millimeters)	Mean Temperature (Degrees Centigrade)	pH	Major Constraints
Kalengyere	2,500	1,550	15	4.0–5.0	LB, PTM
Kachekano	2,000	1,040	18	3.5–4.0	LB, BW, PTM
Buginyanya	1,990	1,200	24	5.4–5.5	LB, BW, PTM
Rubare	1,510	1,200	21	5.3–5.6	LB, BW, PTM
Mityana	1,250	1,400	21	5.3–5.6	Verticillium, LB, BW, PTM, Stress Conditions
Kabanyolo	1,250	1,440	22	5.5–5.7	Verticillium, LB, BW, Stress Conditions

LB = Late Blight; BW = Bacterial Wilt; PTM = Potato tuber moth

Cruza and Sangema were introduced to Uganda from the National Potato Program of Rwanda (PNAP) through the PRAPAC network. These two varieties have been rapidly disseminated among the farmers of the most important potato producing areas.

From 1988 to 1991, an increasing amount of genetic material from CIP-Lima, such as clones, tuber families, and true seed, were introduced to Uganda (Table 1). These materials are in process of being evaluated and are at different stages in the selection process. A group of 755 clones and 2,593 single tuber progenies belonging to 87 families with a widely diverse background were tested during three crop seasons from 1989–1990. This material was grown during the rainy and dry seasons and exhibited a wide range of genetic variability and adaptability. A number of genotypes with varying agronomic and economic characters have been identified. Listed below are the outstanding genotypes identified.

- *Late blight resistant, high yield, and wider adaptability.* 381381.20, 381379.9, 575049 CEW-69.1, 374080.5 P-3, 381382.34, 381388.34, 382732.23, 381381.9, 381372.22, 381379.15, 381403.1, 381174.15, 381381.13, 381163.9, 381406.7, 381403.8, 381397.25, 381403.10, 381178.4, 382255.8, 382146.15, 382155.2, 382171.4, 387097.3, 387098.31, 387210.21.

- *Late blight plus bacterial wilt resistance, high yield, and wider adaptability.* 388571.16, 388572.2, 388572.4, 388571.8, 388572.10, 388572.15, 388572.14, 388572.17, 388574.8, 388574.19, 388575.1, 388575.13, 388575.14, 388575.11, 388575.8, 388575.17, 388576.10, 388578.3, 388579.2B, 388579.17, 388580.4, 388705.3, 388718.13, 678011 (BL2.9).

- *Early and drought resistant with high yield.* 387092.5, 387092.7, 387094.3, 387094.4, 387094.5, 387098.20, 387197.2, 387194.19, 387197.24, 387201.42.

- *Early, bacterial wilt and Verticillium resistant for lowland adaptations.* 800746, 800947, 379706.34 (LT-9), 800938 (AVRDC 1287-19), Caxamarca, Piratini 381379.9. Also, the clones 381381.20, 381379.9, 575049 (CEW-69.1), 374080.5 (P-3), 381382.34, 381388.34, 382732.23, 381174.15, and 678011 (BL-2.9) are in advanced variety trials.

The team visited the field multiplication of both the new varieties that are being introduced—i.e., Sangema and Cruza (Ndinamagara in Burundi)—and also the new selections under multiplication that will be released as new varieties and already have received tentative names—i.e., Victoria (381381.20), Kabale (374080.5), and Kisoro (381379.9). The performance of these clones is presented in Table 17.

The data presented in Table 17 also shows the very high yield potential of the clones 381381.20 (Victoria) and 381379.9 (Kisoro), as well as their high level of late blight resistance even in the absence of fungicide application. Their yields are remarkable when compared to the checks.

The evaluation team also visited a large field, ready for harvest, where clones selected out of tuber families were under evaluation. The number of evaluation trials on advanced genetic materials at Kalengyere is impressive. Also, the commitment of the national program scientific and technical staff, under the leadership of the experienced and energetic breeder Dr. Lyle Sikka, involved in the program is commendable.[1]

The team fully recognizes the outstanding effort over a short period, two years, required to develop a large evaluation and selection program oriented towards the release of high-yielding and late blight-resistant varieties. Despite this outstanding effort, the evaluation team makes these two suggestions to further improve the outcome of the program.

The first suggestion is related to bacterial wilt and Verticillium wilt resistances indicated for a large number of promising clones. It would be advisable to reconfirm these resistances in systematic studies, preferably using artificially inoculated fields to achieve a relatively even distribution of the pathogens in order to minimize the risk of "escapes" during the evaluation

1. Unfortunately, Dr. Sikka could not accompany the team due to an accident from which he was still recovering.

Table 17. Uganda: Performance of Genotypes in Advanced Variety Trials

Genotype	Mean Yield (MT/Ha)	Mean Number Tubers Per/Hill	Mean Tuber Weight (Grams)	Late Blight Score + Spray	Late Blight Score - Spray
381381.20 – Victoria	60.3	12	91	2	4
381379.9 – Kisoro	55.1	14	71	2	6
Maris Peer	53.7	11	88	3	6
Monserrate	53.7	10	97	4	7
387711.5	50.3	14	65	3	6.5
575049 – CEW69	48.8	12	73	3	5
800945 – AL-204	46.6	12	70	7.5	9
374080.5 – Kabale	42.9	9	86	2	7
720049 (Montsama) (800258) (K. Jyoti)	40.3	11	66	4.5	6
	39.6	7	102	7.5	9
Check Varieties					
Cruza	11.0	20	49	3	4
Sangema	35.4	9	74	5	9

Late Blight Score: 1 = No damage; 2 = Dead plant

process. Another approach would be to request the assistance of CIP's pathologist in Nairobi to implement a screenhouse reconfirmation test.

The second suggestion is to significantly reduce the number of clones selected and retained in the very early stages of selection—i.e., make the selection stiffer. A more manageable number of clones would be kept, both in the field and in storage, which would simplify the process of evaluation and further selection, as well as facilitate the production of seed.

The replacement of the old varieties by the CIP materials introduced through PRAPAC is taking place at a fast pace (Table 18). The dissemination of Cruza has been fast and this is due to the combined resistances to late blight and bacterial wilt as well as to its relatively short dormancy period, which makes this variety easily adaptable to the sequence of growing seasons. The varieties Kabale, Kisoro, and CEW 69.1 appear to be more adapted to the warmer lowlands than the old varieties Rutuku and Marilahinda.

More recent research results indicate that the clone CIP 379706.34 (LT-9) on the basis of performance in the last four cropping seasons can be considered for release for the agroclimatic conditions and agronomic systems of the lowlands tropics (1,000–1,200 m.a.s.l.).

These results indicate that the progress achieved in Uganda in identifying high yielding materials able to replace the older less performing varieties has been very effective. It is hoped that an enhanced effort to select more bacterial wilt-resistant clones could accelerate the adaptability of the materials to warmer conditions in support of the government's efforts to expand production in the lowlands.

Table 18. Uganda: Varieties Cultivated by Farmers (Percent)

Varieties	Districts Kabale (Highlands)	Districts Mbarara (Lowlands)
New Introductions		
Cruza	40	40
Sangema	7	—
381381.20 – Victoria	12	—
374080.5 – Kabale	2	22
381379.9 – Kisoro	1	16
575049 – CEW69	1	11
Total	*63*	*89*
Old Varieties		
Rutuku	22	—
Marilahinda	8	—
Other (13 varieties)	7	11
Total	*37*	*11*

True Potato Seed (TPS)

Twenty TPS progenies, including three open pollinated ones, were tested as seedling tubers and as transplants for the production of ware potatoes, and for their breeding potential for variety selection. Almost all the progenies are adaptable for raising seedling tubers and as transplants.

The mean yield of TPS progenies ranged from 4.6 to 6.0 kilograms per square meter for the production of seedling tubers. Twelve TPS progenies obtained yields between 3.7 and 9.4 kilograms per square meter. A significant finding was that two open-pollinated progenies, yielding 7.4 and 7.5 kilograms per square meter, compared favorably with the top ranking hybrid progenies. Additionally, the results from two on-farm trials obtained yields of 4.9 to 5.7 kilograms per square meter.

Mean yields of transplants were 79.9 to 99.5 metric tons per hectare (MT/ha) planted in high hills compared to 35.4–54.7 MT/ha in two improved check varieties. The yields of nine TPS progenies were between 18.2 and 78.0 MT/ha with the mean of 49.2 MT/ha. An open-pollinated progeny (CIP 782002) ranked the highest. A number of single plant selections (191), made to measure their breeding potential for future variety development, yielded between 1.3 and 1.6 kilogram per plant.

Seedling tubers of promising TPS progenies

(F1 C2) were evaluated as planting material against check varieties. First-generation seedling tubers were very productive despite their small size. Random checking by Electro Phoretic Immuno Sorption Assay (ELISA) revealed no virus infection in the TPS population. A major advantage of TPS is that most of the common viruses cannot be transmitted through the seed.

In conclusion, the use of TPS as a route of propagation shows great promise relative to costly propagation by seed tubers. In addition to reducing the problems of tuber- and soil-borne pathogens, TPS can provide potato growers with a simple method of producing high-quality seed themselves. Alternatively, the production of seedling tubers could be integrated in the national seed program. The cost of transportation and storage would be greatly reduced because of the small size of seedling tubers. However, it would be highly recommendable to select late blight-resistant TPS families. During the visit to the Kalengyere, the team could see serious late blight damage in TPS progenies.

Basic Seed Production

The process of reestablishing a basic seed program was launched in 1989 with the introduction into Uganda of 10 tons of basic seed tubers of the varieties Cruza and Sangema from PNAP in Rwanda facilitated by the PRAPAC network. This material was first multiplied through an out-growers scheme and then taken to the Kalengyere station, where a three-stage evaluation program has been implemented. The initial seed stocks are produced by two different schemes:

- *From seed stocks of a given variety*—i.e., Cruza, Sangema, and Rutuku—apparently healthy single-hill selections are performed (positive selection). These plants are inspected three times, during the growing season, for varietal purity and virus contamination. Additionally, all plants selected from single hills are tested for viruses by ELISA. Negative selection (rogueing) is also practiced when bacterial wilt infected plants are detected. The evaluation team was informed that viruses X and S have been found by serological testing, although the percentage found was relatively low. No presence of PLRV or PVY has been reported. From September through April, the aphid population is extremely low.

  With large tubers from the selected single hills, a clonal selection is initiated for a pedigree-like or genealogical process. The tubers from the single hills will give origin to the A clones whose bulked tubers will produce the B clones that at harvest will be bulked to give basic seed. At present, there are 10 hectares of pre-basic seed crops at Kalengyere station under production in different stages of the multiplication process.

- *Pathogen tested minitubers* from CIP/Nairobi, Burundi, or in-vitro tuberlets from CIP/Lima are used. These materials are from adapted varieties or from promising clones and are planted in isolated rustic shelters as mother-plants from which stem cuttings will be obtained. The tubers from the 8,000 to 10,000 stem cuttings are planted in the following season as pre-basic seed and subsequently as basic-seed. The area devoted to pre-basic seed is about 6,000 meters squared.

The amount of basic seed production in 1989–1990 was approximately 25 MT in the short rains season and 50 MT in the long rains season—i.e., a total of about 75 MT per year. In 1990–1991, 120 MT were produced. Most of this seed was of the varieties Cruza, Sangema, and Rutuku. In addition, the evaluation team was informed that basic seed for the three new varieties Victoria, Kabale, and Kisoro was also produced in the amounts of 2,000, 2,800, and 1,250 kilograms, respectively.

A clear picture of the seed multiplication and distribution system beyond the stations was

not available. The evaluation team was informed that, after the basic seed is obtained at Kalengyere, an additional cycle is performed at the seed farms at Buginyanya, Mityana, Rubare, and Kachekano. After this multiplication, the intent is to pass the seed on to contract growers for further multiplication and then distributed to potato-producing farmers. A national seed potato production and distribution system has been planned by the government, but at the time of the review it did not appear that it had been implemented. Therefore, the team considers that it is highly recommendable for the authorities of the Uganda Ministry of Agriculture to develop a functional system of seed multiplication and distribution, outside of the research system, primarily in the private sector that ensures that farmers fully benefit from the potato research program by obtaining an adequate supply of seed of the new varieties that have been introduced or selected at Uganda.

Management of Bacterial Wilt

The evaluation team was informed that studies on the effects of cultural practices for the control of bacterial wilt demonstrated the importance of minimum operations in the growing crop. No hilling (i.e., planting on the flat) or complete earthing up as soon as plant emergence was started in combination with the use of resistant varieties gave better control of bacterial wilt. However, at the time of our visit no differences among treatments were apparent.

In another trial at Kachwekano, clean seed from locations free from bacterial wilt planted in a field in which potatoes had not been grown during the last two years, showed practically no incidence of bacterial wilt. Encouraged by these results, an area of 1 hectare was planted with foundation seed for multiplication into basic seed; so far, no incidence of bacterial wilt had been reported.

Results from an experiment on the effect of intercropping with maize, beans, and garden peas using one resistant and one susceptible variety were not conclusive. Similarly, no benefits were obtained from strip planting alternating with maize, cowpeas, and garden peas verses sole planting either on ridges or mounds. It appears that experiments using cut seed should be discouraged as this technique favors the enhancement of bacterial wilt infection.

Agronomic Research

Studies on interrelationship of seed size, spacing, and fertilizer requirements in the previous two crop seasons yielded useful information. Plant densities of 47,619 to 71,428 per hectare obtained the highest yields. Medium-sized tubers (50 grams) planted at spacing of 70 x 20 cm or 90 x 20 cm are ideal for maximizing potato yields with a large proportion of seed sized tubers.

The results from fertilizer trials from the previous two crop seasons emphasized the need for balanced fertilization. The best treatments were N100-P50-K50, (kg/ha) and N100-P100-K50 (kg/ha). However, given the low pH of the soils at Kalengyere (4.0–5.0) and Kachwekano (3.5–4.0), some liming experiments are recommended.

Development of Post-Harvest Technology

Tubers from 10 TPS progenies of three different grades were studied for storage behavior in diffused light stores. Results indicated that all the TPS progenies, with the exception of CIP 982002 (OP), remained in good physiological condition during a storage period of 120–130 days. Sprout development was balanced with strong and sturdy sprouts. Weight loss was 5.3 to 11.0 percent. This material has been planted in an experiment to study its comparative performance as influenced by diffused light storage. Recognizing the usefulness of low cost methods for seed storage, diffused light stores with some modifications have been adapted at three research stations.

On-Farm Research

About 7 on-station and 13 on-farm trials have been conducted with four candidate varieties to study their adaptability in different agroclimatic regions. A team of three scientists from Kawanda Research Station, as representatives of the Variety Release Committee, inspected these trials during the first week of February 1991. The positive results obtained from these trials form the basis for the release of three new varieties in Uganda.

PRAPAC's Success in Strengthening the Member National Programs and Their Institutional Partners

The general objective of the PRAPAC network is the improvement of potato production through support to the NARS. The network's strategy to achieve this involves training to enhance institutional capacity, institutional support, the publication and sharing of results for adoption by other network members, and the sharing of scarce resources to meet common goals. Discussions follow on each of the PRAPAC member institutions.

Rwanda

Strengthening the National Program

The following criteria are used in assessing the strengths of the national potato research program (PNAP) of Rwanda.

- *Human Resources Development.* The number and qualification of the research and technical staff are among the important indications of strength. In this respect, the following can be said of PNAP:
  - Currently, PNAP has a technical staff of three scientists and four technicians, excluding the five technicians undergoing long-term but nondegree training. In terms of academic qualifications, one holds a Ph.D. degree, two have B.Sc.'s and the technicians are at post-secondary diploma level. Thus, compared to 1986, the current (1992) personnel situation (Table 19) has dropped both in terms of quantity and quality.
  - One of PRAPAC's activities in strengthening the national program is through training, both in-country and abroad. Table 20 shows PRAPAC sponsored training in Rwanda during 1986–1991. During this period, a total of 63 persons received short-term training in nine areas of specialization.
- *Infrastructure Development.* The headquarters of both PNAP and PRAPAC Coordination are located in the same compound at

Table 19. Rwanda: Personnel in PNAP, 1986 and 1992

Qualifications	1986	1992
Ph.D.	3	1
Ing. Agr.	2	1
B.Sc.	—	1
Tech. Agr. A2	3	2
Tech. Agr. A3	2	2
Total	*10*	*7*

Table 20. Rwanda: PRAPAC Sponsored Training, 1986–1991

Subjects	Participants
APA meetings	4
Germplasm management	4
Late blight	22
Post-harvest	3
Rapid multiplication	2
Seed production	18
Seed system	2
Tissue culture	7
TPS	1
Total	*63*

Ruhengeri. Most of the field research and seed multiplication activities of PNAP are carried out at Kinigi farm. The following facilities are available at the headquarters or the Kinigi farm:

- *Land:* The 60 hectares presently available at Kinigi farm are being expanded to 200 hectares. This large area permits a long crop rotation and improves the soil sanitation.
- *Research and Support Buildings:* Several buildings provide space for offices, rooms for tissue culture and related activities, screenhouses, stores for germplasm and other items, a small library, and a workshop. Conversion of one of the stores into a laboratory is planned for the immediate future. One of the major contributions of PRAPAC in this respect is the financial support for the construction of the training complex made-up of classrooms, dormitory rooms, a kitchen and dining facility, and the residence of the PRAPAC coordinator, as well as for the construction of three screen-houses.
- *Equipment and Supplies:* Most of the available office and laboratory equipment and supplies required for research, training, and seed multiplication activities have, to a large extent, been provided through the PRAPAC bilateral funding. The only items that need urgent attention are reported to be air conditioners for the tissue culture rooms.
- *Vehicles and Farm Machinery:* There are some vehicles and farm machinery, although their adequacy to meet the needs of PNAP are questionable.

- *Funding.* The annual budget of PNAP is reported to be about 40 million Rwandese francs (approximately US$ 330,000). According to the program leader (station director), a quarter of this budget is obtained from the PRAPAC (bilateral) allocation. The remaining amount is obtained from the Government through the Rwandan National Institute for Agricultural Research (ISAR) (50 percent) and from station produce sales (25 percent).

- *Technical Assistance.* The research, training, and seed multiplication activities of PNAP are greatly strengthened by technical support provided by consultants arranged by or through PRAPAC. First of all, the PRAPAC coordinator based at Ruhengeri provides technical advice and support in addition to a number of experts from various organizations, including CIP, which come to the station to advise on the various activities in the relevant disciplines. Table 21 shows details of consultancies to PNAP during 1982–1987. This list does not include all the visits made by CIP-Region III staff based in Nairobi, Kenya.

Strengthening Institutional Partners

PNAP has developed working relationships with rural development projects, private farmers, cooperatives and nongovernmental organizations (NGOs). PRAPAC, through PNAP, has done a commendable job of strengthening the national partners through providing in-country training in potato production, protection and storage techniques. PNAP organized in-country training activities for 10,384 participants during the period 1980–1990 (Table 22). The majority of the trainees were farmers. PNAP scientists work closely with farmers through on-farm research activities and also provide advice to their institutional partners when requested to do so. Table 22 also shows the number of persons trained from the PRAPAC network member countries during the same period.

Table 21. Rwanda: Visits by International Scientists to PNAP, 1983–1992

Date	Name	Institution	Purpose
2/83	M. Potts	CIP - Burundi	PRAPAC meeting
4/83	G.L.T. Hunt	CIP - Nairobi	Storage research
6/83	P. Schmiediche	CIP - Lima	Breeding research
8/83	C.D. van Loon	Netherlands	Agronomy research
3/83	G. Scott	CIP - Lima	Marketing study
3/84	J. Valle Riestra	CIP-Lima	PRAPAC
3/84	S. Nganga	CIP - Lima	PRAPAC
5/84	L. Turkensteen	CIP/IPO	Late blight research
5/84	P. Accatino	CIP - Lima	Seed program
5/84	E. French	CIP - Lima	Bacterial wilt seminar
5/84	A. Ramos	NAL - Kenya	Bacterial wilt seminar
7/84	G. Fourge	Belgium	Seminar
1/85	R. Contant	ISNAR	Research management
1/85	M. de Lattre	ISNAR	Research management
6/85	P. Accatino	CIP - Lima	Germplasm management course
6/85	G. Robertson	CIP-Lima	Germplasm management course
6/85	J. Landeo	CIP-Lima	Germplasm management course
6/85	S. Nganga	CIP-Nairobi	Germplasm management course
6/85	G.L.T. Hunt	CIP-Nairobi	Germplasm Management course
10/86	Italian team		Potato storage
10/87	H.M.Kidanemariam	CIP-Nairobi	Breeding research
10/87	G.L.T. Hunt	CIP-Nairobi	Storage research
10/87	B. Parker	CIP-Nairobi	Entomology research
10/87	D.D.de Gembloux		
5/88	L. Turkensteen	CIP/IPO	Late blight seminar
5/89	P. Roche	Consultant	Agronomy research
5/89	P. Bockstegen	FAO/WorldBank	Agronomy research
7/89	J. Landeo	CIP-Lima	Breeding research
7/89	H.M.Kidanemariam	CIP-Nairobi	Breeding research
4/90	L. Skoglund	CIP-Nairobi	Pathologist research
6/91	C. Carli	CIP-Nairobi	Seed production
6/91	F. Salas	CIP-Lima	Information services
11/91	P.T. Ewell	CIP-Nairobi	Monitoring and evaluation
2/92	H.M.Kidanemariam	CIP-Nairobi	Variety release
4/92	L. Skoglund	CIP-Nairobi	Late blight research

Burundi

Strengthening the National Program

The set of criteria applied to assess the Rwanda national program can also be used to assess the Burundi program.

- *Human Resources Development.* The currently available technical manpower in the national potato program under Burundi's National Institute for Agricultural Research (ISABU) is shown in Table 23. As can be seen, the personnel status in the potato research program has remained almost the same since 1986. There are currently four scientists and six technicians dealing with the research and seed multiplication activities. There is also a CIP staff member based in Burundi. Although there is a justified

Table 22. Rwanda: Persons Trained at PNAP, 1980–1990

Year	PNAP Staff	Projects & Co-ops	PRAPAC Programs	Academic Students	Farmers[1]
1980	3	3	3	2	208
1981	2	10	12	2	501
1982	1	21	4	2	793
1983	3	87	20	4	428
1984	3	37	2	6	741
1985	4	21	17	9	53
1986	4	30	19	7	914
1987	6	22	32	7	173
1988	8	41	46	9	1,704
1989	7	78	34	12	3,396
1990	3	111	12	3	748
Total	*44*	*461*	*201*	*63*	*9,659*

[1] Note: Includes mainly extension type training through demonstrations and field days.

need for additional technical manpower, the research and basic seed multiplication activities are adequately handled with the present manpower level.

During the 1986–1991 period, 79 staff underwent short-term training in relevant disciplines (Table 24). These PRAPAC sponsored training activities were carried out both in-country and abroad.

- *Infrastructure Development.* Six stations and ten substations are employed for research and seed multiplication activities at ISABU. Of these, 2 stations, Gisozi and Mahwa, and 2 substations, Munanira and Mwokora, are used for potato research and seed multiplication activities. The research facilities at these sites can be summarized as follows:
  - *Land:* The total area under these stations and substations is 47 hectares, and is considered adequate for the needs of the potato program.
  - *Research and Support Buildings:* The program is considered to have adequate facilities and structures at the four sites. These include office and laboratory space, rooms for tissue culture and related activities, screen houses, stores, etc. The PRAPAC network has made a significant contribution in making these facilities available to the national program.
  - *Equipment and Supplies:* The program appears to have adequate supply of necessary items to carry out its activities.
  - *Vehicles and Farm Machinery:* The evaluation team did not receive any reports regarding the inadequacy of the currently available vehicles and machinery.
- *Funding.* The budget for the potato program comes from several sources. The Government, through ISABU, provides funds for staff salaries and wages and for the development of many of the civil structures. Recurrent operating funds are made available through Belgian aid and from PRAPAC (bilateral, includes USAID local currency and dollars) funding. PRAPAC also finances some of the training activities. In addition to these, the stations produce sales (primarily seed sales) that generate up to 20 millions Burundian francs, which can

Table 23. Burundi: Personnel in the National Potato Program, 1986 and 1992

Qualifications	1986	1992
Ph.D.	1	—
M.Sc.	—	1
Ing. Agr.	2	3
B.Sc.	—	—
Tech. Agr. A2	1	1
Tech. Agr. A3	5	5
Total	9	10

Table 24. Burundi: PRAPAC Sponsored Training, 1986–1991

Subjects	Participants
APA meetings	5
Germplasm management	6
Late blight	7
Post-harvest	3
Rapid multiplication	4
Seed production	44
Seed system	2
Tissue culture	7
TPS	1
Total	*79*

Table 25. Support to National Potato Programs[1]

Country	National Budget	PRAPAC	Basic Seed Sales	Other
Rwanda	50	25	25	
Burundi	4	33	35	28
Zaire	N/A	N/A	N/A	N/A
Uganda	N/A	N/A	N/A	N/A

[1] Percent contributed to program budget

Table 26. Burundi: In-Country Training Organized by the National Program

Year	Subject	Participants
1983	Potato Seed Production	18
1984	Potato Seed Production	22
	In-vitro Techniques	1
1985	Potato Seed Production	12
	Potato Crop Management	15
1986	Potato Crop Management	15
1987	Bacterial Wilt	12
	Journee "Porte Ouverte"	20
1988	Potato Storage	1
1990	Seed Production	15
	In-Vitro Culture	7
1992	Potato Pests and Diseases	21
Total		*160*

be used to finance capital development projects. The budget allocations for a given year are shown in Table 25.

- *Technical Assistance.* As indicated earlier, the national potato program is supported by CIP presence in the person of Donald Berrios. As in Rwanda, staff from CIP-Lima and CIP-Nairobi made regular visits to interact with national staff and provide advice and guidance in the potato research and seed multiplication activities.

Strengthening Institutional Partners

The national potato program, with the support of PRAPAC and CIP, provides training for staff in organizations related to its program. The type of training and the associated participants during the years 1983 to 1992 are shown in Table 26.

Zaire

Strengthening the National Program

Despite serious attempts, the evaluation team was unable to cross the Rwanda-Zaire border and visit the Zairian National Potato Program. As a result, it is not possible to assess progress made as the team does not have adequate information and data at its disposal. The limited information presented below reflects what was available in the regional office of CIP in Nairobi as well as interviews with the program leader from Zaire.

Table 27. Zaire: Personnel in National Potato Program, 1986 and 1992

Qualifications	1986	1992
Ing. Agr.	1	4[1]
License	—	1
Tech. Agr. A1	2	1
Tech. Agr. A2	1	6
Tech. Agr. A3	2	2
Total	*6*	*14*

[1] One is the Program Leader.

- *Human Resources Development.* Table 27 shows the research and technical support staff of the National Potato Program under Zaire's National Insittute for Agrarian Research and Studies (INERA). Currently, the program has a total staff of 14, made up of 5 scientists and 9 technicians, all Zairian nationals. All the scientists are below the M.Sc. levels. In terms of number, Zaire has scored a rapid increase in personnel compared to 1986, when there were only 6 researchers. The distribution among the scientists and technicians by discipline also appears satisfactory.

  The other aspect of human resources development is related to training in various specializations. Staff in the national potato program have participated in a large number of training activities sponsored by PRAPAC and by CIP (Table 28). Overall, there have been 57 participants in nine areas of specialization since 1986.

  Thus, if other resources are not limiting, the Zairian National Potato Program appears to be reasonably well staffed to undertake research and seed multiplication activities in potatoes.

- *Infrastructure Development.* The Zaire National Program carries out its research and seed multiplication activities in one research station (Mulungu), established in 1980, and two substations (Nikoa and Kipopo). The evaluation team cannot provide detailed information on infrastructure available at these stations. However, according to the national program leader, there is not much infrastructure to talk about at any of them.

- *Funding.* The budget for the Zairian national potato program is supposed to come from two sources—i.e, the Government and USAID through a bilateral grant arrangement. The Government covers salaries of staff and such other facilities as land and office space, etc. The planned contributions of USAID for the years 1990–1992 is shown in Table 29.

  According to the Zairian national program leader, the Government has so far provided only salaries for staff and virtually nothing for operational expenses. USAID canceled all grants to the program after the initial payment in 1990 due to the political uprising in Zaire resulting in the U.S. Government's cancellation of all USAID programs in Zaire. Therefore, the program is seriously constrained by lack of funds—so much so, in fact, that the program leader has been unable to visit the two substations in the last two years because of lack of funds.

Table 28. Zaire: Staff Training in National Potato Program, 1986–1991

Subjects	PRAPAC Sponsored	CIP Sponsored	Total
APA meetings[1]	3	—	3
Disease management	15	—	15
Bacterial wilt	—	1	1
Germplasm management	3	—	3
Late blight	3	—	3
Post-harvest	3	—	3
Rapid multiplication	2	—	2
Seed production	17	1	18
Seed system	2	—	2
Tissue culture	7	—	7
Total	*55*	*2*	*57*

[1/] Jointly sponsored by PRAPAC and CIP, but shown here only under PRAPAC for convenience.

Table 29. Zaire: USAID Bilateral Funds Allocated to Potato Program
(in thousands of U.S. dollars)

Category	1990	1991	1992	Total
Technical assistance	25.0	26.2	27.5	78.7
Equipment				
Vehicles	22.0	—	—	22.0
Motorcycles	12.0	6.0	—	18.0
Laboratory equipment	10.0	10.0	—	20.0
Operations				
Fuel	20.0	20.0	20.0	60.0
Vehicle maintenance	10.0	10.0	10.0	30.0
Travel	12.0	12.0	12.0	36.0
Construction	40.0	10.0	—	50.0
Total	*151.0*	*94.2*	*69.5*	*314.7*

Table 30. Zaire: In-Country Courses through PRAPAC Funds

Date	Location	Number of Participants	Remarks
February 1983	Mulungu (Sud-Kivu)	25	Technicians
July 1983	Tubers (Nord-Kivu)	15	Technicians
August 1986	Mulungu (Sud-Kivu)	23	Technicians
April 1987	Butembo (Nord-Kivu)	14	Technicians
July 1988	Mulungu (Sud-Kivu)	15	Technicians
December 1991	Mulungu (Sud-Kivu)	23	Farmers

- *Technical Assistance.* According to the national program leader, CIP staff from the regional office have made numerous visits to the main station, but details on the kinds of activities undertaken and frequencies of such visits are not available.

Strengthening Institutional Partners

The Zairian national program actively participates in network activities and tries to contribute its share in strengthening its network partners. Because of resources limitations, it may not have been able to contribute as much. However, the Zairian program transferred selected clones to the Burundi and Uganda national programs in 1991.

Within Zaire, the national potato program has contributed to strengthening its institutional partners through multiplications and distribution of "basic" seed (about 20 to 30 metric tons per year), conducting in-country training (Table 30), and providing advisory services when conditions and resources permit.

Uganda

Strengthening the National Program

Uganda has had a functioning potato research program since 1968. However, the political turmoil in the country during the 1970s and early 1980s seriously disrupted this activity. The research effort was reinitiated in 1986, and the Ugandan National Potato Research Program joined the PRAPAC Network in 1987. Since then, significant effort and resources have been mobilized to rehabilitate the program. The achievements of the program since 1987 can be summarized as follows:

- *Human Resources Development.* The scientific and technical manpower assigned to the National Potato Program is shown in Table 31. As can be seen, a total of seven scientists and seven technicians are engaged in potato research and seed multiplication activities. All except one are Ugandan nationals. In terms of academic qualifications, there are three with M.Sc.'s, four with B.Sc.'s, six with diplomas, and one with a certificate. The expatriate, a CIP staff member, has an M.Sc. with extensive experience in the field. It should be noted, however, that most of the national staff in the program have only a few years of experience in potato research and seed multiplication activities.

  As noted elsewhere in this report, one of PRAPAC's main objectives is to strengthen national programs by providing training to research workers in several areas of specializations. As can be seen from Table 32, there have been several such opportunities for staff of the Uganda's National Potato Program. Of the 63 staff trained since 1986, PRAPAC and CIP have sponsored 57 and 6 respectively, while 4 are jointly sponsored by PRAPAC and CIP to attend the annual planning meetings held in 1987 and 1990. Also notable in the table is the relevancy of the nine areas covered in the training to potato research and seed multiplication activities.

- *Infrastructure Development.* The Ugandan

Table 31. Uganda: Personnel in the National Potato Program, 1992

Qualifications	1992
M.Sc.	1[1]
M.Sc.	2
B.Sc.	4[2]
Diploma	6
Certificate	1
Total	*14*

[1] Expatriate
[2] One is the Program Leader and one is in training.

National Potato Program carries out its research and seed multiplication activities in its main research station at Kalengyere, the substation at Buginyanya, the trial-site at Kachekano and the collaborative sites at Rubare (with the South West Region Agricultural Rehabilitation Project, SWRARP) and Mityana and Kabanyolo (both with Makerere University). The evaluation team, during its stay in Uganda, visited the Kalengyere station and the Kachekano substation. The following comments on infrastructure development are based on visits to these two stations and reports (both oral and written) obtained from the program staff.

- *Land:* The land area under the Kalengyere main station is 240 hectares. The trial site at Kachekano is actually located on an 86-hectare property belonging to a public rural development project, which has allocated about 6.5 ha to the National Potato Program. Thus, the land available to the program is more than adequate to meet its immediate needs.
- *Office and Laboratory Space:* There are only two metal structures being used as offices and no laboratory facilities to speak of at the main station. Conditions at other sites can only be expected to be worse. Therefore, office and laboratory facilities are extremely inadequate.
- *Screen-Houses:* Currently, the research staff use small temporary (makeshift) plastic frames (three of them) as screen-houses. However, the evaluation team was informed that a modern screen-house structure has been received at the station and will soon be installed to ease their problem. No such facilities were reported to exist at the other sites.
- *Stores:* There are some old-fashioned stores both at Kalengyere and Kachekano. But the staff feel that these are inadequate and need improvement. Additional modern/improved technology stores are also required.
- *Residences:* Currently staff (including the expatriate) at both Kalengyere and Kachekano live in Kabale township, which is 48 kilometers from the main station. There is now a three-bedroom house under construction (funded by European Economic Community) at the

Table 32. Uganda: Short-Term Training for Staff in the National Program, 1986–1991

Subjects	PRAPAC Sponsored	CIP Sponsored	Total
APA meetings[1]	4	—	4
Bacterial wilt	—	2	2
Germplasm management	2	2	4
Late blight	4	—	4
Post-harvest	4	—	4
Seed production	12	1	13
Seed system	3	—	3
Tissue culture	3	—	3
TPS	25	—	25
Vegetative production	—	1	1
Total	*57*	*6*	*63*

[1]Jointly sponsored by PRAPAC and CIP, but shown here only under PRAPAC for convenience.

main center. Therefore, there is virtually no housing for research staff, except the station director, at Kalengyere.

- *Office and Laboratory Equipment:* Very little, if any, exists to speak of. However, some equipment, chemicals and other supplies had been ordered using PRAPAC (bilateral) funds and should have arrived soon, according to reports from the program staff.
- *Vehicles and Farm Machinery:* There are few vehicles (two four-wheel drive vehicles and two motorcycles) at the main station, but reports indicated that these vehicles were provided by other programs at the station, although used by the staff of the potato program. There is no farm machinery at the station at this time. The program coordinator reported that several vehicles (a truck, a pickup and a tractor) had been ordered. It must, of course, be mentioned that the National Program Coordinator and the expatriate consultant each have vehicles at their disposal, presumably provided through PRAPAC project funds.

- *Funding.* According to the PRAPAC Phase I Progress Report made available for the evaluation team, the Ugandan National Potato Program is funded by the Ugandan Government and the USAID/Uganda through a bilateral grant arrangement. The following has been provided to the program since 1987:
  - *Government of Uganda:* Has made available funds totaling over UGS 80 million for salaries, wages, buildings, transport, and input supplies.
  - *USAID/Uganda:* Has provided over US$ 170,000 and UGS 90 million. Presumably, the USAID dollar contributions have been used for procurement of equipment and supplies from abroad.

  The above progress report does not mention the contribution of PRAPAC as far as funding is concerned. It is, however, necessary to mention that the expatriate consultant with the Ugandan National Program salary and other personal costs are provided from PRAPAC coordination funds provided by REDSO/ESA. The total amount of this funding is not included in the above report.

Strengthening Institutional Partners

The Ugandan National Program plays an active role in network activities, mainly in germplasm exchange with network member countries. Although relatively young, the program shares its experiences with the other member countries to support their effort in building their national programs. Within Uganda, the program provides technical and material (germplasm) support to rural development organization. The following have been accomplished to date:

- *Germplasm:* Clean (basic) potato seed is provided every year.
- *Training:* Three in-country training courses have been provided to staff of development projects in TPS production, farmer's tuber seed production, and pathology of potatoes and Irish potato.
- *Demonstrations:* Farmer field days are organized regularly, sometimes in collaboration with other organizations such as the Makerere University.
- *Technical Assistance:* The research staff make direct contact with development projects and farmers to help improve their production activities.

PRAPAC'S Progress in Strengthening Linkages Between Research Programs and Extension Development Agencies

Rwanda

PNAP staff are well aware that effective linkage of their program to the national extension

Table 33. Burundi: National Institutions Involved with Potato

Project/ Institution	Research	Seed Production	Seed Distribution	Extension	Input Supply	Training	Commercial Production
CVHA—High Altitude Crops	+ +	+ + +	+ + +	+ + +	+ + +	+	
Bututsi Project	+ +	+ + +	+ + +	+ + +	+ + +	+	
Kajondi Project	+ + +	+ + +	+	+		+	
Muyinga Project	+ +			+ +	+	+ +	+ +
Buyenzi Project	+	+ +	+ +	+ +	+	+	
Rutana Project	+ +	+	+ +	+ +	+	+ +	
Kirimiro Project	+ +	+	+ +	+ +	+	+ +	
Cankuzo Project	+		+	+	+	+	
Buragane Project	+		+	+	+	+	
Mumirwa Project	+		+	+	+	+	
Kirundo Project	+		+	+	+		
ACF Project	+ +					+ + +	

service, as well as to the many rural development agencies, is a prerequisite to the generation and effective transfer of appropriate potato production and plant protection technologies. This has been emphasized in the meetings the review team had with the Director General of ISAR and also with leader of the national potato program. The strategy adopted to attain this includes the following:

- *Joint Planning Meetings:* These meetings are held twice a year both to assess in part research results and to develop research plans for the next season. Staff from the National Extension Service, National Seed Service, and rural development projects are invited to attend such meetings.
- *In-Country Training:* As indicated earlier in this report, PNAP organizes in-country training on priority topics every year. Staff members from relevant national development organizations participate in these training activities.
- *On-Farm Demonstrations:* On-station tested technologies are verified on selected farmers' fields as part of the on-farm research and demonstration activities of PNAP. This provides unique opportunities to create useful linkages with the participating farmers as well as with rural development agents.
- *Advisory Services:* PNAP scientists/technicians make field visits regularly to monitor potato production activities and to provide on site technical advice. This is a sure method of creating useful linkages.

Burundi

The Burundi national potato program has a clear understanding of the need to create a strong and effective linkage with the relevant public organizations, private groups, and farmers to accelerate the adoption of improved technologies. Among its major partners are the National Seed Service and the National Extension Service, both under the Ministry of Agriculture. In addition, there are at least 12 rural development projects involved with potato activities in one way or another (Table 33).

The national potato program has direct contact with the national seed and extension services and rural development projects. Farmers are reached mainly through what is known as "Ateliers." An "Ateliers" is a farming systems

research/extension area in which 50 farmers are selected for on-farm research. The "Ateliers" are actually organized under ISABU and one "Atelier" is assigned to each "natural zone" in Burundi. Currently, five "Ateliers" are in operation. The evaluation team had a chance to visit one such program operating in the Bututsi region. Operationally, the "Ateliers" are the interface between research and extension and serve as a bridge in the technology transfer process.

Among the linkage mechanisms adopted by the national program are joint planning meetings, training, and consultancy advisory services.

Zaire

According to the Zairian national program leader, the research system has only limited linkages with the national extension service. This limited linkage is the result of the fact that INERA is under the Ministry of Science and Higher Education while the national extension service is under the Ministry of Agriculture.

The national potato program approaches development agencies and NGOs through the Farming System Unit under INERA. In this context, the national program organizes joint planning meetings, conducts in-country training, and implements on-farm trials as well as demonstration plots both on-station and on farmers' fields.

Uganda

Staff of the National Potato Program have made close contact with many of the national rural development organizations. It should be noted that at the present time research and extension are both under the same umbrella organization, the Ministry of Agriculture. This makes communication and coordination easier. Other rural development organizations also have close linkages with the Ministry of Agriculture. Special efforts are made by the program staff to assure closer working relationships with farmers. The evaluation team had the opportunity to visit development projects and farmers to get a feeling for such linkages and was gratified to note that indeed close linkages have been established.

According to the program coordinator, the following strategies are applied to create improved linkages:

- *Joint Planning Meetings:* Such meetings are held every year with extension and rural development project staff to discuss research needs and available technological options.
- *In-Country Training:* Training services are provided by research staff, as and when called upon.
- *On-Farm Trials:* Research, extension, and rural development project staff work together in planning and executing trials on farmers' or project fields. Research information and data are provided to research staff and other NARS for processing and recommendations.
- *Advisory Services:* Both the expatriate consultant and national staff use a good portion of their time in visiting farmers and development project to provide technical advice and support.

Progress Towards the Development of a Strong and Self-Sustaining Network

The PRAPAC network is taking the lead as a model for strong and sustainable networks. During this phase of the project, there has been a graduation from PRAPAC being a donor / International Agricultural Research Center (IARC)-driven network to a NARS-driven network. Illustrative of this change are the terms of reference that were developed for the different constituents—i.e., the Director's Committee, the Executive Committee, the PRAPAC coordinator, and the IARC (CIP) (See Appendix C). The Director's Committee, which is made up of the NARS Directors of Agricultural Research of the participating countries, is charged with the overall management responsibility, including

financial management, of the network. The significance of this change is noticeable in that the Coordinator may be nominated by CIP, but the selection process is carried out by the Director's Committee. It is the reviewer's understanding that this also applies to other PRAPAC positions such as the administrative assistant and the deputy coordinator.

Where is this leading to? During the Executive Committee meeting held in February 1992, a proposed follow-on activity was drafted encompassing the potato and sweet potato program activities in the participating countries. The Executive Committee then submitted this draft proposal to the Director's Committee for review and approval, which included discussions with CIP regarding the technical backstopping of the network activities. Fundamental changes in the network should be noted:

- Two more countries, Ethiopia and Kenya, were accepted into the network;
- Sweet potatoes were added in addition to Irish potatoes; and
- The name was changed from PRAPAC to PRAPACE (*Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Centrale et de l'Est*), thus encompassing east and central Africa.[2]

In addition to the fundamental changes that occurred, the Director's have also clarified activities to be considered as network or bilateral. Noteworthy is the funding of long-term resident technical assistance for individual countries, which is now being considered a bilateral activity and not a network activity. The fine line here is that short-term technical assistance backstopping for the network is to be provided by CIP. Therefore, the necessity for the network to fund full-time technical assistance for individual NARS programs is not needed.

The movement of germplasm among PRAPAC countries demonstrates the strength of the network for utilizing the available resources (Table 2). This is definitely a positive indication that the technologies being developed are being shared.

2. For consistency and ease of understanding, the acronym PRAPAC is used throughout this report for all references to the network, including actions taken and recommendations for action after the adoption of this name change.

CIP's Backstopping of PRAPAC

CIP's backstopping to the network has been provided in numerous forms—e.g., provision for germplasm from Lima and/or Nairobi, technical assistance, personnel for bilateral technical assistance and coordination, and personnel for network coordination. In general, CIP's backstopping has been good, although some clarification is necessary.

The weak link in the CIP backstopping evolves from the PRAPAC coordination office. Whether the coordinator's terms of reference were poorly defined or not satisfactorily carried out left serious questions with the members of the Director's Committee as to who "the boss" really is. However, this dilemma has now been resolved through the tabling of terms of reference for the coordinator detailing not only the coordinator's responsibilities but also who he is answerable to. Nevertheless, what the team observed supported communication problem between NARS scientists and the coordinator. This problem has surfaced from two points of view—first, by the number of trips/visits (after factoring in the impact of the volatile political situation in the region) the coordinator made to the participating country potato programs, and second, in terms of the contacts made in the NARS.

Coordination and Utilization of Donor Support

The International Potato Center (CIP) PRAPAC project is a subproject of the Strengthening African Agricultural Research and Faculties of Agriculture (SAARFA) umbrella project. Overall project management responsibility has been with USAID/AFR/SD/PSGE. However, implementation and monitoring of the subproject was delegated to USAID's Regional Economic Development Support Office / Eastern and Southern Africa (REDSO/ESA). Hence, a large amount of project management assistance has been provided by REDSO/ESA during the life of the project due to the location of the project (Rwanda, Burundi, Zaire, and Uganda), the CIP Region III office, and the REDSO office.

Personnel have been in place in REDSO to provide both technical and administrative management services for the project since 1986. REDSO's main communication link with the project has been with the PRAPAC coordinator in Kigali, Rwanda,[1] although the CIP regional director, located in Nairobi, provides the linkage with CIP headquarters in Lima, Peru. Most project implementation decisions, including negotiating grant agreement amendments, therefore, have been made by the field officers. This arrangement has worked in a timely and efficient manner and both CIP and the PRAPAC directors wish to continue this relationship in the future.

The Regional Financial Management Center (RFMC) located within REDSO/ESA is responsible for the financial disbursement of project funds. Project costs are normally receipted and forwarded to the PRAPAC coordination office for recording and transmission to CIP headquarters in Lima, Peru. CIP headquarters prepare a funds reimbursement voucher for services rendered, which is submitted to RFMC. The REDSO project officer provides administrative approval before reimbursement against actual project expenditures is made by RFMC. Payment is made directly to CIP headquarters.

All national potato research programs in PRAPAC countries have been receiving additional funding, either counterpart funding and/or hard currency, to support their research programs. This funding is used mainly for improving facilities (greenhouses, laboratories), vehicles (including tractors and other implements), and inputs for on-farm trials and seed production. Although the funds disbursed through the network program are monitored by the PRAPAC coordinator and CIP scientists working in the program, coordination and monitoring of the bilateral funds is done by the national director of research and the leader of the potato research program. This dual mechanism for monitoring and coordination of funds has led to some inefficiencies such as Uganda's potato research program only recently receiving screenhouses, when the screenhouses are an essential element in the potato research program. Thus, the evaluation team recommends that future programming and monitoring of bilateral funding should be done in coordination with the PRAPAC network.

1. The PRAPAC Coordinator was formerly located at PNAP in Ruhengeri, Rwanda. He moved to Kigali when security in the Ruhengeri area deteriorated, and eventually out of the country after the April 1994 political and ethnic uprising.

Development of Flexible Systems for Monitoring and Evaluation within PRAPAC

One of the covenants in the grant amendment of July 1991 (See Appendix I, number 4) stated that "CIP/PRAPAC will gather information and establish a baseline data on the status of potato research, production, marketing, storage, economics, diseases and consumption since the start of the project so as to enable the end of project evaluation to determine the impact of project activities"—i.e., establish a monitoring and evaluation system. To initiate this effort several activities were undertaken:

1. A research associate was hired on a short-term contract to:
   a. Collect and organize secondary data from the National Agricultural Research Systems (NARS), rural development projects, and other institutions;
   b. Organize small, focused surveys in collaboration with national institutions for a few selected topic areas; and
   c. Assist in data entry, analysis, and write-up.

2. A consultant was hired to assess the potato research and seed programs in Uganda. Since Uganda is a relatively new member of PRAPAC, a specialized study was considered which would produce useful information as an *ex ante* evaluation of the program, particularly the effective implementation of the seed program.

3. A workshop is planned to assess the information which has been collected and to develop guidelines for analysis and presentation of the data.

The evaluation team was impressed with the progress made in the development of a monitoring and evaluation system within PRAPAC. The data collected by the research associate, in collaboration with the CIP Regional Social Scientist and the PRAPAC Coordinator, for Rwanda, Burundi, and Zaire was extremely useful in carrying out the evaluation. In fact, discussions the team held with the NARS scientists from Rwanda, Burundi, and Zaire bore out the level of participation/collaboration that took place during the data collection effort. The scientists *knew* about the details regarding basic seed production and additional information needed which they felt could help explain certain parameters in their seed production programs.

On the other hand, the consultants report on the Uganda potato program, although only a snapshot in time, was illustrative but did not provide sufficient supportive data to draw the conclusions obtained. Partially the fault lies in the fact that the consultant had little, or no, background in potato technologies and/or production. This resulted in his assuming the information provided by local collaborators as being "gospel." Nevertheless, this study did provide some useful feedback on the Uganda program, especially in regards to seed production and dissemination. In addition, the lessons learned will be useful in conducting similar studies for other country programs in the future.

The secondary and survey data provided to the evaluation team had only passed through a preliminary analysis, and many of the questions the team had regarding the data will be clarified through further analysis. The workshop planned with the NARS and CIP scientists will also help to make the data set a PRAPAC

effort. Some questions remain, however, as to whether comparable data has been collected for the Uganda program. Thus, the team recommends that PRAPAC retain a research associate to collect secondary data and conduct specific surveys in collaboration with national scientists and institutions for Uganda, Ethiopia, and Kenya as early in the "new" project phase as possible.

PRAPAC's Financial Management

CIP/PRAPAC expenditures for the 1986 to 1991 period are provided in Appendix J. The budgetary position as of December 31, 1991 (Table 34), indicates that with the approval of the workplan for the January to September period, there is an unprogrammed balance of approximately $198,000. "Training and training materials" is the line item with the largest balance, due in part to the decreased use of the Ruhengeri training facility.

Ten percent is a large amount to be left unprogrammed, and whether the responsibility lies with the PRAPAC Coordinator or CIP, either headquarters or the Region III office, an explanation for not programming the amount is necessary. The evaluation team noted earlier in the report that several of the NARS bilateral programs are seriously underfunded (i.e., Zaire), and have been for some time. There is virtually no funding available to carry out research in Zaire's potato program at this time, and with a little forward planning by the PRAPAC Coordinator and CIP, this acute problem might have been averted.

In general PRAPAC and CIP have programmed the PRAPAC activities with the expenditure limitations of the grant. However, the evaluation team recommends that the PRAPAC coordinator pay more attention to the financial aspects of future grants to allow expenditures to occur in a timely manner.

Table 34. CIP/PRAPAC Budget as of December 31, 1991
(US $)

Line Item	LOP Allocation	Total Expenditure	Balance Available	Workplan 1/1–9/30/92	Balance Remaining
Coordinator position	1,493,300	1,237,776	255,524	210,000	45,524
Training and materials	386,500	293,750	92,750	25,000	67,750
Consultants					
Training	44,000	26,503	17,497	15,000	2,497
Seed and diseases	70,000	7,846	62,154	30,000	32,154
Agronomy and varieties	54,000	10,962	43,038	20,000	23,038
Cold storage equipment	32,000	13,289	18,711	0	18,711
Baseline data	40,000	0	40,000	40,000	0
Evaluation	25,000	0	25,000	25,000	0
Contingencies	27,200	18,838	8,362	0	8,362
NFA Audit	40,000	0	40,000	40,000	0
Total	*2,212,000*	*1,608,975*	*603,035*	*405,000*	*198,036*

Extent to Which Previous Recommendations Have Been Implemented

Recommendations from the midterm project evaluation conducted from March 14 to April 2, 1989, are presented in Appendix H. Thirty-eight recommendations were proposed. Those recommendations addressed to PRAPAC specifically (19 in total) were designed to use research resources more efficiently and to strengthen research collaboration, monitoring, and reporting.

For most of the recommendations addressed to PRAPAC, some action has been undertaken or completed. However, several of the recommendations that require substantial oversight and input from the coordinator, such as a consolidated report on subprojects (#2), a report for the study undertaken on fungicide use (#6), summary reports for the consultant activities (#9), and the improvement of research proposal and reports (#14), have not been satisfactorily implemented. Although some effort towards improving the overall documentation process of the PRAPAC network has been made, documentation of activities remains inadequate. Therefore, the evaluation team recommends that PRAPAC hire sufficient personnel to adequately document PRAPAC activities as well as NARS potato program activities. This documentation, whether in the form of research proposals, research and trial progress/final reports, NARS country reports, and/or minutes of PRAPAC executive and director committee meetings should be available to all participating programs, as well as to CIP and donors.

In summary, most of the recommendations from the midterm evaluation were implemented to some degree. One outstanding issue remaining, in addition to the documentation issue presented above, is in regards to the need for NARS to assess short- and long-term undergraduate and graduate level training required for the potato research programs (#30). The evaluation team recommends that the long-term Ph.D. training issue should be addressed by the PRAPAC directors as a network issue, since one of the tenets of the network is to better utilize available resources (which includes personnel) and/or to supplement those areas where there are shortfalls by the most efficient means.

Extent to Which Project Goals, Purpose, and Outputs Have Been Achieved

Considerable progress has occurred towards achieving the project goal and purpose over the life of the project. During the current phase of the project, more than 15 new varietal releases were made in the network countries. This provides only a minuscule example of the network productivity in the development, transfer, and adaption of improved varieties. Several thousand units of new material received by the network countries from CIP (Table 1, p. 4) have included advanced late blight resistant clones, advanced populations in the form of tuber families that segregate for late blight, bacterial wilt and virus resistance, and yield and tuber quality attributes. The selection process, given that in PRAPAC countries two to three seasons per year can be used for potato production, takes up to seven years before a new variety is released. The new releases in the network have been possible as a result of the collaborative efforts of the potato research programs in the network countries and the free exchange among network countries of advanced germplasm.

Strengthening of the potato research programs of the PRAPAC countries has also occurred through the training of over 200 staff members. The majority of the training was short-term on priority topics of interest to the network.

The PRAPAC network is taking the lead as a model for strong and sustainable networks. PRAPAC graduated from being a donor / International Agricultural Research Center (IARC)-driven network to a NARS-driven network. Terms of reference were drafted by the Directors' Committee for the different constituents—i.e., the Directors Committee, the Executive Committee, the PRAPAC coordinator, and the IARC (CIP) (See Appendix C). The Directors Committee—i.e., the NARS Directors of Agricultural Research of the participating countries—is charged with the overall management responsibility, including financial management, of the network. Applicants for positions may be nominated by CIP and/or the donor, but the selection process is carried out by the Director's Committee. The evaluation team considers these initial changes in the PRAPAC management to be a significant effort towards sustainability.

Conclusions

In Rwanda, Burundi, and Uganda, the success of the initial introduction of varieties and later on the selection of new varieties showing a better adaptation and a higher level of resistance to late blight is evident. There has been an active interchange of advanced materials in the network as indicated in Table 2 (p. 5). This shows that the variety development technology has been actively shared among the PRAPAC network countries.

With the exception of Cruza-148 (Ndinamagara in Burundi), all the other potato varieties are susceptible to bacterial wilt which along with late blight are the major enemies of potato production in the PRAPAC countries. Given the high pressure for land utilization, the potato monoculture is helping to increase the danger of bacterial wilt attack. It seems necessary, therefore, to place more emphasis on selecting for combined resistance to late blight and bacterial wilt.

The "true potato seed" (TPS) technology has been showing promising results, particularly in Uganda. Rwanda results indicate that TPS technology helps in areas where potato production systems are not well established. However, the progenies need higher resistance levels to late blight to make this technology more viable.

The development of an efficient basic seed production scheme based on the use of rapid multiplication on a flush-out system combined with other measures for the integrated bacterial wilt control (soil rotation, agronomic practices, etc.) have given very good results. However, it appears in the three countries visited that a solid and well organized system for further seed multiplication and distribution is not in place. The implementation of a seed multiplication and distribution system is very important for the new varieties to achieve a greater measurable impact in the short to medium term.

The facilities for basic seed production (seed farms, greenhouses, laboratories, seed storage) are adequate in Rwanda and Burundi. In Uganda, there is an urgent need for one or two greenhouses and laboratories to further improve the process of pre-basic and basic seed production. Furthermore, in Uganda the evaluation team found that the personnel at the research stations have limited means of transportation, which decreases their effectiveness in conducting research at several sites.

The technology for diffuse light seed storage appears well developed in Rwanda and Burundi, but needs continued effort in Uganda since the potato research program has only recently restarted during the last 2½ to 3 years.

All PRAPAC countries, with the exception of Rwanda, have improved their personnel status, both in quantity and quality, compared to 1986. However, Rwanda has shown a decline not only in number but also in quality of staff. An area of concern to the evaluation team is the dependency of the Rwandan National Potato Program on a single, admittedly competent person. Although the network as an entity can be considered reasonably well staffed, it is difficult to say the same about each national program in the network. For the most part, the manpower situation in each national program is tenuous at best. Hence, it is necessary for PRAPAC to double its efforts to create a critical mass of at least 5 scientists at M.Sc. or higher levels and 10 to 15 support staff below that grade to ensure adequate leadership and technical competence in each national program.

Both PRAPAC and CIP have done a com-

mendable job in organizing training for the research staff. However, most of the training is limited to short courses designed to import skills in specific areas. PRAPAC and/or CIP should consider providing opportunities for degree-level training at Ph.D. and M.Sc. levels to ensure adequate leadership skills in the network. Degree-level training, for economic reasons, will continue to be limited, although it is essential for leadership potential.

Short-term training activities need to continue, but must be more selective not only in topic areas but also in reference to staff nominated for training. There is not much to be gained by having one individual participating in several courses, or in the same course more than once as a trainee, unless it is absolutely essential. This may rationalize the cost of short-term training and allow for the savings to be used to fund advanced degree training.

There is a large degree of variability among the member countries in terms of infrastructure development. Perhaps Uganda is the poorest of the lot in this respect, since it currently has very little in the way of developed infrastructure (except for land). Reports have been made indicating possible improvements in the immediate future, but the evaluation team (and indeed the National program staff) believes that a lot more effort (and funding) is needed to make the programs more effective and efficient, as well as to keep up staff morale. It would seem that Zaire is not in much better shape. The situation in Zaire is made even worse by lack of donor support, as USAID has canceled all grants in Zaire. The level of infrastructure development in Burundi and Rwanda is comparatively better, although there is room for improvement in both cases.

Data on available funding in the network is not complete. However, it is very clear from discussions with national program leaders that there is a big disparity among national programs with respect to funding. On one end of the scale, there are Burundi and Rwanda with reasonably adequate levels of funding and good donor support, while at the other extreme, there is Zaire, which faces extreme shortage of funds. In fact, the Zairian national program leader indicated that he had not visited his two substations at Nioka and Kipopo for the last two years because of lack of funds. The Ugandan national program leader also indicated inadequate funding for his program, although it cannot be as severe as in Zaire. Funding is a real constraint for the efficiency and effectiveness of the national programs and, therefore, requires urgent attention by both the national governments and donors.

The technical and managerial support made available to the national programs by or through PRAPAC and CIP is very important. Currently, the national programs in Burundi and Uganda have full-time consultants assigned to the programs, and the network coordinator is based in Rwanda. The staff of the CIP regional office make frequent visits to all national programs. These are supplemented by visits by experts from CIP-Lima and from other organizations arranged by or through PRAPAC and CIP. These backstopping visits provide more than adequate technical support to national programs. However, the volatile political situation does affect the backstopping visits at times.

National programs have provided considerable effort for strengthening not only the network-member national programs, but also their own in-country institutional partners. National programs have contributed to strengthening their institutional partners through providing in-country training in relevant areas of potato production, protection, and storage techniques, as well as making advisory visits to farmers and rural development project sites.

Staff of national potato programs are well aware of the need for strong linkages between research and extension and development organizations. The creation of linkages is one of the objectives of PRAPAC and is strongly supported by CIP and USAID. Discussions with national program leaders, as well as visits to farmers and development project sites, has con-

vinced the evaluation team that working relationships exist between research and extension and development projects in Burundi, Rwanda, and Uganda. The strategies applied in such linkages are joint-planning meetings, in-country training, on-farm demonstrations, and technical advisory visits by research staff. These efforts need to be intensified, especially between the research and extension services, not only to make research relevant but also to encourage feedback to further identify and prioritize research topics.

The PRAPAC network has made positive progress towards attaining its intended objectives. Foremost among this is the linking of four independent national research programs into a coordinated system of research planning and execution at a regional level. This has enabled the sharing of knowledge and experiences as well as the transfer of improved germplasm across political boundaries. Although PRAPAC may be considered as a model for other networks in Africa for the future, continual refinement is essential to address the dynamics of network institutions. Nevertheless, the evaluation team highly recommends that USAID continue to support the efforts of the PRAPAC network and of CIP, in the development of a strong and self-sustaining network.

Recommendations

Considerable progress has been made by all parties, National Agricultural Research Systems (NARS), the International Potato Center (CIP), and donors, towards the development of a strong and self-sustaining PRAPAC network. The Directors' Committee, cognizant of the current and potential benefits that can accrue from this network, decided to further expand its coverage by including two additional countries (Ethiopia and Kenya) and one other commodity (sweet potato) in the next phase of the project. With further understanding and experience in coordination, it is entirely conceivable that the network may include other eastern and southern African countries and other commodities/disciplines of mutual interest to all members. This, of course, calls for improved organizational structures and broader outlook in project conceptualization and management.

Despite its positive impact, the network has room for improvement. The following recommendations are made with the intention of improving the network and the national program performance in this phase, as well as the next phase, of the project. These recommendations can be categorized into three broad groups—i.e., regional network coordination, strengthening member national programs, and technical issues.

Regional Network Coordination

The effectiveness and efficiency of the PRAPAC network is heavily influenced by the technical and managerial competence, flexibility, and dynamism built into it. Therefore, the following are recommended to help achieve these goals:

1. *The Network Coordination Office.* The network coordinator and her/his staff play a central and deciding role in planning and execution of regional collaborative activities. It is, therefore, recommended that the coordinating office be strengthened by staffing it with competent and dynamic personnel and by providing it with funds and other resources to facilitate its performance.

2. *Research Mandates.* The main aim of the network is to optimize the use of scarce resources available in member countries' national programs. Thus, it is necessary to rationalize the mandates assigned to each national programs. It is recommended that the Directors' Committee, supported by its executive committee, reassess the capabilities of member national programs and reassign mandates on the basis of comparative advantage and national strength.

3. *Germplasm Exchange.* To make the network effective, it is necessary to facilitate the transfer of segregating populations as well as advanced germplasm among member countries. However, this essential activity may be constrained by political sensitivities, quarantine regulations, and other factors. Burundi and Kenya, and, in a short period, Rwanda have sanitary facilities for producing materials with thermotherapy, meristem culture, and freedom of PSTV (checked in Lima) and PLRV, PVY, PVX, and PVS. It is, therefore, recommended that the Directors' Committee and the network coordinator assess the member countries' positions on these issues and develop ways and means, including establishing minimum

quarantine requirements, to further facilitate germplasm exchanges among member countries. In addition, it is highly recommended that the Directors' Committee reach an agreement about the free interchange and utilization of the advanced genetic materials developed by the network countries.

4. *Local Consultancy.* One of the possible benefits accruing from this network should be the building up of regional capability to solve local as well as regional problems in the production and protection of commodities of interest. Among other things, this should mean the use of qualified staff from member countries in consultancy and advisory work for the region. For example, Rwanda has expertise in late blight technologies, seed production technologies, rapid multiplication techniques, and germplasm management that in reality is available to the rest of network. It is, therefore, recommended that the network coordinator initiate and maintain an updated data base on scientists in member national programs.

5. *Documentation of Activities.* Although some effort towards improving the overall documentation process of the PRAPAC network has been made, documentation of activities remains inadequate. Therefore, the evaluation team recommends that PRAPAC hire sufficient personnel to adequately document PRAPAC activities as well as NARS potato program activities. This documentation, whether in the form of research proposals, research and trial progress/final reports, NARS country reports and/or minutes of PRAPAC executive and director committee meetings, should be available to all participating programs as well as to CIP and donors.

6. *Information Exchange.* Network collaboration can be greatly improved through the timely transfer of research and development information among member countries. This definitely calls for increased attention by and publishing capability of the network coordination office. It is, therefore, recommended that the network coordinator take immediate and appropriate steps that would facilitate the gathering, publishing, and transmitting of progress reports, annual reports, and other publications to member national programs on a regular and timely basis.

7. *Training.* This is an activity with long-term impact. Staff training in various disciplines, including scientific writing, is required to improve performance. In addition, upgrading staff skills in computerized data management to handle experimental results and develop sound data bases is needed desperately. Therefore, it is recommended that the network coordinator in consultation with national programs initiate further training programs. As much as possible, such training should be carried out in member countries.

National Programs

The strength of the regional network is very much defended on the strength of member national programs. The network can never hope to be effective if one or several of its members are weak. It is to the mutual advantage of all to take all measures necessary to strengthen the capability of member national programs. Especially, governments of member countries as well as donors should be solicited to provide support to build up national programs. The following recommendations are meant to address this issue:

1. *Human Resources Development.* The availability of qualified and motivated personnel is central to the development of an effective national program. Governments of member

countries should give urgent attention to the building up of a "critical mass" of scientists and technicians for each of the commodities covered in the next phase of the regional network. In this respect, continuity of trained personnel is vital.

2. *Developing Leadership.* The sustainability of a national program is determined by the quality of technical and managerial competence available to it. Trained leaders are necessary to set long-term objectives and design the strategies to attain them. Training, certainly, is the basis for such development. It is, therefore, recommended that training be designed to result in the accumulation of a "critical mass" of scientists (M.Sc. degree or above) to lead national programs. National governments also should provide suitable incentives to retain qualified scientists in national research systems.

3. *Infrastructure Development.* The concept of networking is based on dividing research mandates on the basis of comparative advantages. No national program can hope to meet its obligations without adequate facilities. It is, therefore, recommended that national governments give urgent attention to the development of required infrastructure—i.e., laboratory, screenhouse, and storage facilities and seed farms to guarantee high sanitary standards in the production of prebasic and basic seed—for their respective national programs. In addition, national governments should seek donor(s) support for this purpose.

4. *Funding.* The current PRAPAC network is seriously constrained by lack of funds, especially in some of the member countries. This, of course, has severely handicapped the performance and output of the affected national programs. Member governments therefore should take urgent steps to alleviate these constraints.

Technical Issues

1. *Screening of Germplasm.* To strengthen the impact of new varieties, it is necessary to maintain the emphasis in the selection process for late blight resistance and, at the same time, to further emphasize the screening for bacterial wilt resistance. Land scarcity may exacerbate the potato monoculture and/or the lack of sufficient crop rotation that might limit the effectiveness of the integrated bacterial wilt control. CIP's pathologist stationed at Nairobi should provide the network countries scientific support to expedite the process for multiple-criteria selection. During the process of pre-basic and basic seed production, it is recommended that samples of the produced seed be tested for viruses. These tests should screen for the main potato viruses PLRV, PVY, PVX, and PVS.

2. *Seed Multiplication and Distribution System.* The present production of basic seed at PRAPAC NARS follows an extremely efficient scheme with a solid output. However, from the moment the basic seed is distributed to the national seed services for further multiplication, the entire process becomes thin and somewhat informal. There are no standards for seed multiplication, nor are there guidelines for the number of times basic seed should be multiplied. In these circumstances, research program leaders might be tempted to take a step forward past the production of basic seed to give an additional cycle of multiplication. Under their control, these leaders would be able to produce larger volumes of high quality seed of elite seed category. Even though this additional cycle of multiplication could shorten the route for providing good quality seed to the farmers, it would have a very negative effect on the research program *per se* and its expected output.

   Therefore, the evaluation team recom-

mends that the PRAPAC potato research programs concentrate their efforts on producing only sufficient quantities of high quality basic seed and initiate a major dialogue with the seed multipliers, both government and private sector, to establish guidelines and standards for the multiplication of basic seed and to develop an information system to monitor the requirements of basic seed. Concomitantly, it is recommended that the research programs transfer the responsibility of further seed multiplication cycles to government or private sector institutions that will have the responsibility for distribution of the seed to the farmers.

It is highly recommended that the PRAPAC network countries implement these seed multiplication and distribution systems as soon as possible to help increase the amount of good quality seed reaching the fields of the ware potato producing farmers.

3. *Variety Dormancy Period.* It is highly recommended that PRAPAC emphasize the selection of varieties with a shorter dormancy period to better fit farmerss production period—i.e., in the sequence of long rains / short rains / swamp growing seasons.

4. *True Potato Seed Technology (TPS).* The use of TPS as a complementary route to producing potatoes at a lower cost is highly recommended. Since the potato production in the PRAPAC countries is mainly rainfed, the use of seedling tubers produced in seed beds for ware potato production is the best alternative. The TPS progenies to produce seedling tubers should combine resistance to late blight and bacterial wilt. If adequate progenitors are not available in the PRAPAC countries, these could be made available by CIP-Lima or CIP-Nairobi.

Appendixes

USAID-Funded Project on

Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Centrale (PRAPAC)

Appendix A

Terms of Reference

PRAPAC End-of-Project Review (EPR),
May 18–June 5, 1992

Section One: Activity to be Evaluated

PRAPAC (*Programme Régional d'Amélioration de la Culture de la Pomme de Terre en Afrique Centrale*, or the Regional Potato Improvement Program for Central Africa) is a potato research network composed of four countries: Burundi, Rwanda, Uganda, and Zaire. The International Potato Center (CIP) provides backstopping in the areas of research, training, information and project management. The project is based in Rwanda, where the PRAPAC Coordinator, a member of CIP's staff, is based.[1] CIP's regional office is located in Nairobi.

Advanced breeding work for the benefit of the PRAPAC network is carried out by CIP in collaboration with the Government of Kenya at KARI's station in Muguga. From this Regional Germplasm Distribution Center, improved varieties combining various resistances, adaptation, and quality factors are distributed to the NARS under quarantine regulations.

Project Number:
623-0435-G-00-6006-00

Title: PRAPAC Network: Programme Regional d'Amelioration de la Culture de la Pomme de Terre en Afrique Central (Burundi, Rwanda, Uganda, Zaire).
Ext. USD

Cost: Regional coordination budget (REDSO/ESA): 2,212,000
USAID/Burundi "buy-in": (PL 480: FBU 49,502,062) 317,000
USAID/Rwanda "buy-in": 301,000
USAID/Uganda "buy-in": (PL 480: UGS 80 million) 288,000
USAID/Zaire "buy-in": 314,700

Life-of-Project:
01/14/1986–09/30/1992

PACD:
September 30, 1992

Section Two: Purpose of the Evaluation

This end-of-project review (EPR) provides an opportunity to assess how effectively the four national potato research programs have worked with each other and with CIP to achieve common goals. The donor will also evaluate how effectively the funding in support of the network has been utilized.

PRAPAC was founded by the national programs of Burundi, Rwanda, and Zaire in 1982, and Uganda joined in 1987. The ultimate goal of the network is to make available to farmers disease-resistant, high-yielding varieties and other technologies. The network's strategy to achieve this is to strengthen research capacity in the national programs through coordinated research, training, information exchange, and institutional support. The intermediate goals of PRAPAC can be summarized as follows:

- Develop a functional, institutional sustainable research network with demonstrable gains in efficiency, compared to what the

1. The PRAPAC Coordinator was formerly located at PNAP in Ruhengeri, Rwanda. He moved to Kigali when security in the Ruhengeri area deteriorated, and eventually out of the country after the April 1994 political and ethnic uprising.

programs could achieve working in isolation.

- Improve capacity to evaluate and select improved genetic material both on-station and in farmers fields, leading to the release of improved varieties as a regular output of the research programs.
- Increase the efficiency with which a range of production, pest management, and post-harvest technologies are introduced, tested, and transferred to farmers.
- Develop improved systems for the production, multiplication, and distribution of high-quality planting material.
- Provide training to researchers and extensionists efficiently on a network basis, and encourage on-farm research and other linkages for the benefit of the farmers.
- Improve the capacity for the monitoring and evaluation of research and transfer of technology to farmers.

Section Three: Background

a. Introduction

In response to an unsolicited proposal presented to USAID by CIP and the network countries, grants were made by the Africa Bureau and by the bilateral USAID missions to the member countries. Project funding to the network through USAID/REDSO started on February 14, 1986. The original PACD was extended from February 13, 1991, to September 30, 1992, which corresponds with the end of the umbrella SAARFA project.

b. Project Goal and Objectives

The grant has provided support to the network through CIP to support the goals outlined above.

Section Four: Scope of Work

The evaluation team for the end-of-project review (EPR) is asked to review key areas to determine the progress and impact of PRAPAC in relation to the expected outputs of the original unsolicited proposal, the extension proposal, and the USAID Project Agreement.

Specifically, the team is asked to:

1) Assess the progress of research carried out within the framework of the network in the development of improved varieties and other potato technologies, in response to demand from farmers, consumers, and development institutions.
2) Assess progress in the development of sustainable systems for the production, multiplication, and distribution of high-quality planting material, and of their impact on the farm level.
3) Evaluate PRAPAC's success in strengthening the member national potato research programs and their institutional partners, through institution-building and manpower development.
4) Assess progress in strengthening linkages between research programs and extension and development agencies.
5) Assess progress towards the development of a strong and self-sustaining network, through the appropriate roles of the Directors' Committee, the Executive Committee, and the Coordinator.
6) Evaluate how effectively CIP's backstopping has helped PRAPAC achieve its goals.
7) Evaluate how effectively donor support from REDSO/ESA, individual USAID missions to the member countries, and other sources has been coordinated and utilized.
8) Evaluate progress in the development of flexible systems for monitoring and evaluation within PRAPAC, and make suggestions for improvements.
9) Recommend improvements which could be implemented in the next phase of the network, when it is planned to include two additional countries—Ethiopia and Kenya, and an additional crop—sweet potatoes.

10) Liaise with the audit of PRAPAC's operations, and assess how well PRAPAC's financial management has contributed to the goal a sustainable network.

Section Five: EPR Calendar, Methods, and Procedures

The evaluation will take place between May 18 and June 5, 1992. The evaluation will be based on the following:

- Visits to all four member countries, with opportunities to meet senior policy makers in the NARS, research scientists in the national potato programs, staff of affiliated institutions, field visits, and review of all appropriate records and documents.
- Meetings with PRAPAC coordinator and with the staff of CIP's regional office in Nairobi.
- A review of project documents and publications.
- The report of PRAPAC on monitoring and impact assessment, including an external consultant's report on activities in Uganda.

Section Six: Team Composition

- Humberto A. Mendoza, CIP Head of Breeding and Genetics–Lima, Technical Team Leader.
- David R. Martella, REDSO/ESA Agricultural Advisor.
- Seme Debela—General Manager, Institute of Agricultural Research, Ethiopia, NARS policy maker—Representing overview of NARS issues for Review.
- Kenneth J. Brown—Director, Regional Programs, CIP
- Mr. Hudson Masambu, REDSO/ESA, will be available to help with logistics.
- CIP Staff: S. Nganga, P. Ewell and PRAPAC Coordinator M. Soto will be available as resource persons.

In particular, Dr. Marco Soto will travel with the EPR team in Rwanda and Burundi.

Section Seven: Reporting Requirements

The EPR team will make a unified final document of Review of PRAPAC Phase 1 based on their visits, interviews, and the volumes of documents on PRAPAC Project presented to the team.

The team leader shall be responsible in the technical performance of the report. The team leader will have overall responsibility for preparing the evaluation report, which will include a synthesis of the reports prepared by other members, documenting the salient issues, progress, and constraints identified during the course of this evaluation as outlined in the scope of work.

David Martella, REDSO/ESA, shall oversee the final report in the interest of the Donor as regards the outcome and impact of the Phase 1 donor investment in PRAPAC.

The report will include the following:

i) An executive summary of three pages in length including the purpose of the evaluation and methodology used, findings, conclusions, lessons learned, and recommendations;
ii) Body of the report of not more than 30–35 pages, including a discussion of the purpose of the evaluation, the study questions, and the significance of the resulting recommendations; and,
iii) Appendices (including technical management issues raised during the evaluation requiring greater elaboration, a copy of the evaluation scope of work, a brief annotated bibliography of the documents and reports consulted, and a list of persons and agencies consulted).

Following the submission of the report, a preliminary working session will be held with the evaluation team and USAID to discuss the find-

ings and recommendations. The team leader will then incorporate in the final draft version of the report, the subsequent consideration of any questions or issues raised during this initial review meeting. The team leader will submit ten copies of the final draft report *prior to his departure from Nairobi*. The final version will be reviewed in a meeting with the REDSO/ ESA Director, the evaluation team, USAID officials, and CIP Regional office.

Appendix B

Itinerary for CIP/PRAPAC End-of-Project Review (EPR)

The EPR Team will visit the following PRAPAC member countries: Rwanda, Burundi, Zaire, and Uganda, in that order. In addition, one day will be spent in Kenya to review CIP Regional activities that relate to the PRAPAC Network. At the beginning of the review, the team will meet with REDSO/ESA management.

The calendar of events involves flexibility of the EPR team to spend a good proportion of their time to review the field activities of the PRAPAC network and to see and review the hands-on linkage activities. The EPR team will meet and interview the network coordinator, PRAPAC network policy makers and researchers, as well as the USAID bilateral Missions that are supporting the PRAPAC network.

May 18 to June 5, 1992, Tentative Schedule

Monday May 18:
- PRAPAC EPR Team meeting at REDSO.
- Meeting with Bruce Odell, Acting Director–REDSO
- Review of PRAPAC Documents and Data

Tuesday May 19:
- Fly to Kigali, Rwanda
- Meeting with PRAPAC Coordinator—M. Soto

Wednesday May 20:
- Drive to PNAP, Ruhengeri
- Meeting with Dr. P. Tegera, PNAP Coordinator
- Field visits and discussions at PRAPAC Program Headquarters.

Thursday May 21:
- Meeting with PNAP Coordinator on PRAPAC Issues
- Meeting with Dr. Ndereyehe, ISAR Director
- Drive to Kigali

Friday May 22:
- Meeting with USAID/Rwanda Director and Agricultural Development Officer
- Drive to Rubona: ISAR Headquarters
- Meeting with George Ndamage, Sweet Potato Program Coordinator
- Drive to Bujumbura, Burundi

Saturday May 23:
- Visit ISABU—Munanira/Mwokora Field Research.

Sunday May 24:
- EPR Team discussions and write-ups of drafts.

Monday May 25:
- Team visit to Gisozi ISABU Program Pomme de Terre Headquarters.

Tuesday May 26:
- Meeting with ISABU Director General
- Meeting with USAID/Burundi Agricultural Development Officer

Wednesday May 27:
- Drive to Kivu, Zaire. (**Canceled**)
- Visit INERA Zaire.

Thursday May 28:
- Return to Bujumbura (**Canceled**)

Friday May 29:

- EPR Team discussions with PRAPAC Directors.
- Fly to Nairobi, Kenya

Saturday May 30:

- Fly to Entebbe, Uganda

Sunday May 31:

- EPR Team discussions and write-up of drafts.

Monday June 1:

- Meeting with USAID/Uganda Director and Agriculture Development Officer
- Meeting with Secretary for Research and National Coordinator
- Meeting with Commissioner for Agriculture
- Drive to Kabale

Tuesday June 2:

- Visit to Potato Program Kabale

Wednesday June 3:

- Drive to Entebbe
- Fly to Nairobi

Thursday June 4:

- Meeting with CIP Regional Staff
- Team reconstruct report unification.

Friday June 5:

- EPR Document finalization and presentation
- Debriefing at REDSO Director's Office.

Saturday June 6:

- Team disbands/departs.

Appendix C

Network Coordination

The following two committees are created to facilitate and coordinate the execution of a regional program on potatoes and sweet potatoes in central and eastern Africa.

1. *Directors Committee.* Composed of:
   - Director General of ISABU, Burundi
   - Director General of ISAR, Rwanda
   - General Manager of IAR, Ethiopia
   - Director of KARI, Kenya
   - Secretary for Research, Uganda
   - President Delegate General of INERA, Zaire
   - Director of Region III, CIP

2. *Executive Committee.* Composed of:
   - National Program Leaders for Potatoes
   - National Program Leaders for Sweet Potatoes
   - Regional Coordinator for PRAPACE

The terms of reference (TOR) of the various bodies involved in the execution of PRAPACE activities are as follows:

1. *Committee of Directors*

   1.1/Take overall responsibility for the proper functioning of the PRAPACE Network and its coordinating office, including the recruitment of the Network Coordinator and ensuring the overall progress and success of the Network.
   1.2/Establish the general policies and priorities of research in potatoes and sweet potatoes in the network countries.
   1.3/Define the working relationship between CIP and PRAPACE.
   1.4/Consider and approve the annual plan of work and budget submitted to it by the Executive Committee.
   1.5/Ensure the timely preparation of progress and annual reports and approve their release for the public as well as the donors.
   1.6/Organize and implement a schedule for monitoring and evaluation of the programs.
   1.7/Appoint a chairman for the Committee of Directors to serve for a period of one year. The Chairman will be selected on a rotational basis and on alphabetical order of the name of member countries.
   1.8/Encourage the publication in refereed journals of research results by national scientists engaged in the two programs.
   1.9/Take any other measures deemed necessary to attain the objectives of the Network.

2. *Executive Committee*

   2.1/Serve as the technical arm of the PRAPACE Network towards the attainment of its objectives.
   2.2/Prepare and submit medium- and long-term plans for potatoes and sweet potatoes research for the consideration and approval by the Committee of Directors.
   2.3/On the basis of long-term plans, prepare and submit on a timely basis annual programs and budgets for the Committee of Directors.
   2.4/Execute approved annual plans and submit progress and annual reports through the office of the Coordinator.
   2.5/Prepare new projects to further

strengthen the PRAPACE Network.

2.6/Carry out other activities when requested by the Committee of Directors.

3. *PRAPACE Coordinator*

3.1/Be responsible for the proper organization and functioning of the PRAPACE coordination office and provide dynamic and progressional service for effective and efficient implementation of its assigned responsibilities.

3.2/Serve as a facilitator in the preparation and execution of annual programs at national and regional levels.

3.3/Prepare and submit for approval by the Committee of Directors an annual work plan, including visits to member countries.

3.4/Organize or help organize training, workshops, seminars, etc., in relation to the two commodities of the Network.

3.5/Help national programs in identifying and procuring goods and services relevant for the execution of PRAPACE activities.

3.6/Organize the meetings and field visits of the Committee of Directors and of the Executive Committee.

3.7/On the basis of reports obtained from national program leaders, prepare harmonized technical and financial reports for submission to the Committee of Directors on a twice-a-year basis.

3.8/Prepare and submit, on a timely basis, an annual report of the PRAPACE Network to the Committee of Directors.

3.9/Maintain close contact with the President of the PRAPACE Network, National Directors of Research of member countries, and members of the Executive Committee.

3.10/Assemble and maintain an updated data base of Network activities.

3.11/The Network Coordinator will be appointed for a period of three years, renewable if found satisfactory.

3.12/Carry out other activities as requested by the Committee of Directors and/or President of PRAPACE.

3.13/The Coordinator will attend the Directors Committee meeting, acting as a Secretary or resource person.

4. *International Potato Center (CIP)*

4.1/Provide technical backstopping in the planning, implementation, monitoring, and/or evaluation of research programs in potatoes and sweet potatoes within the multidisciplinary teams in the Region.

4.2/Participate actively in collaborative research with NARS scientists in the two commodities.

4.3/Facilitate the implementation of training programs of Network scientists and technicians.

4.4/Make available its facilities and expertise in procuring goods and services to the Network.

4.5/Assist in identifying and recruiting a Network Coordinator as and when requested by the Committee of Directors.

4.6/Assist in any other matter that strengthens the effectiveness of the PRAPACE Network.

Appendix D

PRAPAC Country Profiles

Rwanda

Introduction

Rwanda is a densely populated country with a surface of 26,338 square kilometers and 7.2 million in habitants. The rural areas are occupied by about 92 percent of the people and the population density is near 400 habitants per square kilometer, which imposes an intensive use of agricultural land to produce the necessary food.

Official estimates indicate that the agricultural sector of the country's economy grew at about 4 percent per year. The main food commodities are bananas, cassava, sweet potatoes, potatoes, and relatively beans.

The cereals, maize, sorghum, and other grains are of relatively smaller importance (CNA 1991). Potatoes are planted in 41,000 hectares for a production of 202,000 metric tons with an average field of 4.9 metric tons per hectare (1986–1988 FAO production yearbook). The national goal for the year 2000 calls for a greater increase in potato production than in any other food growth rate. For the period 1982–1986, the average annual growth for potato production and yield was of 7.9 percent and 5.4 percent, respectively (Delepierre 1987).

Potato production increased from 60,000 to 320,000 metric tons between 1960 and 1990. Potatoes have become the countries's sixth most important crop in terms of hectarage and total production (Haugerud 1986). The national per capita potato consumption was estimated to be from 85 to 100 kilograms per year in 1980 (Poats, 1981). The Rwanda government's plan is to produce 500,000 metric tons in 50,000 hectares in the year 2000 (Ndereyehe 1992), which places a challenge to agricultural technology.

Constraints to Potato Production

- *Late blight (*Phytophthora infestans*) and bacterial wilt (*Pseudomonas solanacearum*),* diseases that cause significant yield losses to the crop. Virus diseases are present but at relatively low frequency.
- *Insufficient of good quality seed available to farmers,* and lack of quality control regulations for seed production.
- *Small farm size (0.9 hectares per farmer),* which obligates farmers to grow crops without fallow.
- *Poor agronomic practices related to crop rotation, fertilization, soil conservation, and use of seed that is improperly sprouted,* either because it is too young or too old, causing poor plant stand or lack of vigor and too many stems, respectively.
- *Losses during storage and problems during transplantation and marketing.* Often potatoes are harvested early, and tubers with peeling skin deteriorate rapidly. In other cases, recently harvested potatoes are stored without a curing period, increasing the likelihood of rots and loss. There is no organized marketing system, and variation in supply and prices are often high.
- *Extension, training, and transfer of technology,* which are insufficiently developed to further promote potato production and consumption in the country.

PRAPAC Potato Research and Training Subprojects Assigned to Rwanda

- *Study of control of late blight.* The objectives are to select genetic materials with resistance to late blight and to complement with the study of optimum chemical control measures.
- *Local training of staff and technicians*. The objectives are to provide short courses and on-the-job training for scientific staff and technicians of PRAPAC countries.
- *Basic seed production technology (subproject shared with Uganda).* The objective is to produce "clean" (disease-free) basic material for seed production.

To accomplish the objectives of these PRAPAC subprojects, the National Potato Program (PNAP) has organized its activities as follows:

- *Germplasm Management*. Introduction, screening, and evaluation of genetic materials for release of new varieties is introduced from CIP-Lima and CIP-Nairobi. The materials introduced are segregating populations (tuber families and true potato seed progenies) and selected clones mainly from CIP-Lima and CIP-Nairobi. Selection is carried out in terms of high yielding capacity, late blight resistance, bacterial wilt tolerance, and tuber quality. Selected clones after systematic testing are aimed to become new varieties for Rwanda and other PRAPAC countries if their adaptability is adequate.
- *Seed Production and Distribution*. This activity involves rapid multiplication of in-vitro stocks of germplasm.

Burundi

Introduction

Burundi is a small (27,834 square kilometers), densely populated (5.3 million population) country struggling to achieve economic development. Because of accelerating demographic growth and even higher increases in food requirements, Burundi faces a challenge to raise productivity on the large number of small farms that constitute the backbone of the largely agrarian economy. Greater productivity and more intensive use of available farmland is essential to meet the demand for basic staples, as well as to improve rural income and stimulate the growth in nonagricultural productivity.

During the past decade, Burundi has been endowed with favorable weather conditions, and yet food productivity has just managed to keep pace with population growth. A series of disturbing trends raises concern about the current delicate balance between available food supplies and the country's essential food requirement. Since 1980, the average growth rate of agricultural productivity has slowed to 1.7 percent versus 3.3 percent for the period of 1965–1980 (World Bank 1989). Just the opposite has occurred with population, as the growth rate has increased from 1.9 percent in the period 1965–1980 to 2.8 percent in 1980 (World Bank 1980). Agricultural production in Burundi during the 1980s barely maintained per capita consumption levels.

Prospects for future economic and agricultural development are further clouded by the massive public debt, as the terms of trade have sharply deteriorated (1985 = 100 vs. 1987 = 75). Consequently, debt service and the foreign trade imbalances represent a major drag on the overall economy, siphoning off resources that otherwise might be invested to improve performance in both agricultural and nonagricultural sectors.

Agricultural Goals and Strategies

The Government of Burundi's Five-Year Plan for Economic and Social Development (1988–1992) assigned a number of specific objectives for the agriculture sector, including:

- Maintenance of self-sufficiency in food production, combined with an improvement in the nutritional levels of the population.
- Increase in the monetary income of the rural population as a means of raising quality of life.

Rational speculation and, of necessity, a gradual transformation of agricultural production from a subsistence orientation to an increasingly commercial orientation are key strategies in achieving the Plan's objectives. A combination of yield-increasing technologies and improved distribution of requisite inputs (e.g., improved seed, fertilizers, pesticides) are two complimentary components of this strategy on the production side. Pressure on land will require improved productivity. Availability of technical means to increase productivity will facilitate growers' efforts to modify their cropping patterns and increase output per hectare per unit of time.

Actual Status of Potatoes

Potatoes are thought to have a great potential in Burundian agriculture for a number of reasons:

- At the farm level, growers are aware that potatoes produce a remarkable quantity of carbohydrates and protein in a short period of time (3 to 4 months, versus 12 to 24 months for cassava; 4 to 8 metric tons per hectare, versus 600 kilograms for beans). Burundian farmers are also aware that with improved seed and the use of animal manure, potato yields can reach as much as 16 metric tons per hectare or more.
- The stagnant or declining yields for maize, sorghum, and beans switch land out of those crops and into potatoes.
- The recent expansion in production is mainly due to preference for potatoes over other root and tuber crops in both rural and urban households.
- Favorable prices for potatoes also represent an added incentive to potato production.
- At the policy-making level, there is a growing appreciation of the interest of growers and consumers in the potato's particular attributes. Further, a realization also exists that the growth output to date has been achieved with only minor government support (i.e., there is no special program of support prices or government marketing schemes, as is the case for other commodities such as rice).

While potatoes receive no specific mention in the current Five-Year Plan, agricultural planners are now aware of the potato's apparent potential, which has to be considered in the future initiatives in the agricultural sector.

Constraints and Objectives

The two major biotic constraints to potato production in the country are late blight and bacterial wilt.

The shortage of improved quality seed is an important constraint to potato production. Progress has been made establishing an effective system for producing pre-basic and basic seed with CIP collaboration. The demand from rural development projects and growers for seed exceeds the available supplies.

Insufficiency in the use of fertilizers and pesticides constitutes another important constraint. The full yield potential from improved seed can be achieved only when utilizing these inputs. The supply of pesticides has improved marginally during the last decade. Fertilizer, however, continues to be extremely difficult to procure because none is produced locally and foreign exchange for importation is scarce.

Given the poor, depleted soils, fertilizer is a must for improving productivity and raising incomes.

Lack of effective extension services combined with research is also a constraint to increased potato production in Burundi. New technologies are available in the form of improved-quality basic seed and rustic storage practices. Some rural development projects have done good work in facilitating and monitoring said technologies, but others have been less successful.

On the research side, the National Potato Program is understaffed and lacking in trained personnel. The objectives of the Burundi National Potato Research Program are:

- To identify clones with late blight and bacterial wilt resistances, food production capacity, and adaption to ecoclimatic conditions of Burundi.
- To improve cultural techniques by researching and testing technologies adapted to farmers' conditions in order to increase potato production in the farmers' fields.
- To produce high quality basic seed of improved varieties and to develop appropriate methods for seed production in rural areas.

Zaire

Introduction

Potatoes were introduced into Zaire during the end of the last century. Presently, potatoes are grown in highland zones located in Haut-Zaire, Kivu (north and south), and Shaba regions. They are also cultivated in Bandundu and Bas-Zaire regions. Moreover, 50 percent of total national production is located in Kivu region.

According to the available data, potato production in Zaire rose from less than 20,000 metric tons on 1965 to over 220,000 metric tons in 1984 (Table D.1). This increase is largely due to the expansion of areas planted with potato, which rose from 3,000 hectares in 1965 to 35,000 hectares in 1984.

Potatoes play an important role in the diet of farm households in the producing areas, particularly in the high altitude (above 2,000 meters above sea level) regions of Kivu. The level of potato consumption in these areas ranges between 130 to 220 kilograms per capita per year. Unfortunately, the average yield is too low, around 5 metric tons per hectare, because of the many constraints to potato production.

Constraints to Potato Production

- *Late blight and bacterial wilt,* which are the most important diseases. They are the main cause of lower yields in farmer fields, due to the lack of resistant varieties.
- *Shortage of good quality seed.*

Table D.1. Potato Production, Area, and Yield

Year	Production (000 MT)	Area (000 Ha)	Yield (MT/Ha)
1965[1]	18.5	3.0	5.2
1966	27.0	5.0	5.4
1967	28.0	5.2	5.4
1968	29.0	5.4	5.4
1969	30.2	5.6	5.4
1970	28.4	5.2	5.5
1971	37.0	8.0	4.6
1972	45.0	10.0	4.5
1973	60.0	12.0	5.0
1974	75.0	15.0	5.0
1975	110.0	20.0	5.5
1976	120.0	22.0	5.5
1977	130.0	24.0	5.5
1978	140.0	26.0	5.4
1979	150.0	28.0	5.4
1980	165.0	30.0	5.5
1981	175.0	32.0	5.5
1982	193.0	35.0	5.5
1983	200.0	35.0	5.7
1984	220.0	35.0	6.3

[1]Average, 1961–1965.

- *Declining soil fertility*.
- *Poor agronomic practices*.

Objectives of Potato Program

- *To develop the best bacterial wilt and late blight resistant varieties* that are adaptable to different agroecological zone of growing areas.
- *To improve the yield potential of potatoes in different agroclimatic zones* by developing the appropriate agronomic techniques.
- *To strengthen on-farm research* for efficient transfer of technologies to rural areas.

PRAPAC Potato Research Activities

To overcome the problems of potato production, a National Potato Research Program was established in 1980 at Malungu Station by the National Institute for Agronomic Research and Studies (INERA) in collaboration with the International Potato Center (CIP). The Program has been a member of PRAPAC since 1982. In this network, Zaire is responsible for three research subprojects:

- Variety development for adaptation to the different climatic zones;
- Agronomy research in the different climatic zones; and
- Potato processing research.

Achievements of the PRAPAC Phase I Activities

Following is a review of the achievements during the 1980–1991 period. Because of lack of funds, almost all activities were carried out in the Malungu area only.

- *Variety Development for Adaptation.* Since 1980, more than 16,000 genotypes were introduced and tested by INERA-Malungu. These genotypes were introduced mainly from PNAP-Ruhengeri in Rwanda, CIP-Lima, and CIP-Nairobi. Up to now, INERA has already selected and diffused six varieties in the Malungu area. These varieties are Montsana, Sangema, Kinigi, Nseko, Cruza, and Gahinga. Two new clones have been selected and are going to be given variety names. The new high-performing varieties are the CIP clones 380606.6 and 380583.8 which are resistance to late blight and for medium to early maturity.

- *Agronomy Research.* The most important results that have been achieved are:
  1. The best potato planting dates in the Malungu area are from mid-September to mid-October in Season A and from mid-March to mid-April in Season B.
  2. Research on crop association indicated that potatoes intercropped with maize would be best planted at least 10 days before the planting of maize.
  3. Studies on planting methods showed that planting in the row and hilling immediately yielded better than planting flat and then hilling after emergence.
  4. Experiments on planting depth indicated that bacterial wilt infection rate was higher at 2 centimeters than at 10 centimeters in depth.
  5. A trial on crop rotation conducted for 6 seasons showed that the rotation maize-bean-potato controlled bacterial wilt infection well (1.6 percent) compared with the check potato-potato-potato (86 percent) monocropping system.
  6. A maize intercropping with three potato genotypes showed that the variety Sangema is more suitable for intercropping than Montsama and Kinigi.

- *Processing.* This research area has not been carried out because of lack of funds and trained personnel. Nevertheless, an appropriate method for the production of dehydrated potatoes has been developed.

Training and Publications

- Training took place in the form of regional courses, individual training, workshops, conferences, and in-country courses. All training program were supported either by PRAPAC or by CIP.
- In 1987, PRAPAC financed a survey on supplying, marketing, consumption, and processing of potatoes in Kinshasa.
- In 1990, PRAPAC supported a thesis research for a degree in rural development. This thesis involved a prefeasibility study for simple potato processing in the potato production area of north Kivu.
- At least eight conference papers, written by National Potato Program scientists, have been published by PRAPAC.

Uganda

Introduction

Uganda's potato research program was started in 1968 with the main aim of self-sufficiency in potato production particularly as an import substitution product. A combination of collaborative work between the Government of Uganda, United States, Makerere University, and International Potato Center, the program was able to release 11 varieties, 4 of which are still widely grown in Uganda and other PRAPAC countries. However, political turmoil and civil strife tremendously slowed down this momentum until 1987.

In June 1987, Uganda joined PRAPAC without any infrastructure, without any research staff, and without any seed potato program to talk of. The aim of joining PRAPAC was to share the scarce resources within the region and the successes accruing from it.

Goals

The main goal of Uganda's program was to conduct research on basic potato seed production in order to come out with relatively cheap high-yielding, disease-resistant adaptable varieties easily available to farmers.

Specific objectives of the program:

- *Germplasm introduction and evaluation.*
- *Importation of seed from PRAPAC countries to clean up, multiply, and distribute to farmers*, before any serious research was started.
- *Development of seed potato production technologies* leading to release of varieties suitable to different agroclimatic zones of Uganda.
- *Trials and production of ware potatoes from True Potato Seed (TPS).*
- *Training of farmers, extension workers, and researchers in potato production.*

Status

Because of the Uganda program's involvement in the PRAPAC activities, short- and long-term objectives have been realized in the last four years of its PRAPAC membership and collaboration with CIP.

- Development and release of three high-quality potato varieties.
- Importation of 10 metric tons of Sangema and Cruza seed from Rwanda, purchased by USAID/REDSO and transported by PRAPAC coordination.
- Purchase, by USAID/Uganda in collaboration with REDSO/Nairobi, of an initial 1,400 kilograms of Dithane M-45.
- Exchange of visits and experiences by PRAPAC national leaders and other scientists. Such visits and experiences have contributed substantially to the shaping of the National Potato Research and Development Program.
- Since 1989, atachment of a very senior potato scientist, Dr. L. Sikka, to Uganda by CIP as a consultant, paid for by PRAPAC and USAID/Uganda. Under his leadership

much work has been achieved in research and transfer of technology.
- Exchange of advanced clones and pathogen-tested in-vitro varieties, to our benefit of the program.
- Exchange of research findings, which also benefited the program.
- Training of staff, using PRAPAC support. Several seminars, workshops, conferences, and individual travel and training have been successfully organized.
- Increased potato production and yields, resulting in an increase of material potato production areas.

Constraints to Research on Potato Production

- Inadequate infrastructure at the Kalengyere Potato Research Station—i.e., screenhouses, electricity, and water supply;
- Inadequate seed potato storage;
- Inadequate laboratory and office facilities;
- Lack of cold room for in-vitro maintenance;
- Inadequate transportation for the staff and materials;
- Further training of all kinds.
- Need to encourage good management, high productivity, and team work.

Objectives of Potato Research Program

- Germplasm introduction, evaluation, and release of new late blight and bacterial wilt resistant varieties.
- Seed production and transfer of technology.
- Agronomic research on fertilizer use, crop rotation, and chemical control of late blight.
- Postharvest technology.
- On-farm research.
- Training.

Appendix E

Research Publications and Associated Scientists

Burundi

A) Publications

Potts, A. L., Kayitare, L., Potts, M. J. (1985). Atlas des variétés de Pomme de terre diffusées au Burundi. Fiche technique no. 005, ISABU.

Potts, M. J., L. Kayitare, L. (1988). Guide pratique pour la multiplication des semences de pomme de terre. Fiche technique no. 006, ISABU.

Scott, G. J., Muvira, C. (1990). Peasants, Potatoes and Private Sector-led Agricultural Development in Burundi. Lima: International Potato Center (CIP).

B) Reports

Berrios, D. 1991. "Controle de la bacteriose vasculaire dans des fermes semencières: cas du Burundi." Formation PRAPAC sur la gestion de germoplasme, Bukavu (Zaire).

Muvira, C., Berrios, D. (1992). "Review of PRAPAC activities."

Muvira, C., Rubirigi, A., Berrios, D. (1990). "La pomme de terre au Burundi, une contribution certaine au développement agricole du Burundi." Journées agronomiques de l'ISABU. Bujumbura.

Muvira, C., Berrios, D. (1991). "Burundi's national potato research program."

Potts, M. J., Kayitare, L. (1989). "Les aspects phytosanitaires de l'évolution de la multiplication des semences de pommes de terre au Burundi." Séminaire PRAPAC sur la production de semence de pomme de terre en lien avec la bactériose, Bujumbura.

Rubirigi A., Berrios, D. (1991). "Evaluation du germoplasme par la résistance à la bactériose vasculaire, cas du Burundi." Formation PRAPAC sur la faction de germoplasme, Bureau (Zaire), June 1991.

Rubirigi, A. (1988). Synthèse recherches sur la mildiou de la pomme de terre au Burundi: Séminaire PRAPAC sur le mildiou de la pomme de terre, Gisenyi, Rwanda, April 1988.

Rueda, J. L., Pozy, P., Muvira, C., Nzoyihera, Z., Turner, C., Niyongabo, E. (1990). "The development and acceptance of potato seed production under farmers conditions in Burundi." Mauritius, APA conference.

Rwanda

A) Publications

Bicamumpaka, M. et Devaux, A. (1984). "Programme de sélection au Rwanda pour l'obtention de variétés résistantes au Mildion et à la Bactériose." Absts. 9th Conférence EHPR (Interlaken), pp. 330-331.

Bicamumpaka, M. et Devaux, A. (1984). La sélection des variétés résistantes au Mildion et à la Bactériose au Rwanda. Note technique ISAR 5, en édition.

Bicamumpaka, M. et Haverkort, A. J. (1984). "Recherche sur la Pomme de Terre et Transfert de Technologies au Rwanda". Dans: Développement de la Culture de la production, pp. 5-7.

Bicamumpaka, M., Gatarasi, T. et Rutayasire,

C. (1984). “Flétrissement bactérien de la pomme de terre au Rwanda.” Bulletin agricole du Rwanda.

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Appendix F

NARS Potato Program Staff

1986

Name	Education	Activities
Burundi		
M.J. Potts	Ph.D.	Program Head (CIP)
G.J.H. De Vries	Ing. Agr. Ao	Agronomy (CIP/FAO)
J.L. Rueda		Seed Production (CIP)
L. Kayitare	Ing. Agr. Ao	Germplasm
E. Biranguza	Tech. Agr. A2	Technology transfer
S. Nikura	Tech. Agr. A3	Seed production
D. Simenya	Tech. Agr. A3	Seed production
A. Sinduhije	Tech. Agr. A3	Germplasm
Z. Nzoyihera	Tech. Agr. A3	Field Research
A. Buhinja	Tech. Agr. A3	Field Research
Rwanda		
P. Tegera	Ph.D.	Program Head
A. Haugerud	Ph.D.	Socio-economist (CIP)
Gatarasi	Ph.D	Pathology
M. Bicamumpaka	Ing. Agr.	Germplasm
Rutayisire	Ing. Agr.	Seed production
Munyawera	Tech. Agr. A3	Seed production
Mukamanzi	Tech. Agr. A2	Rapid multiplication
A. Kenge	Tech. Agr. A2	Gishwati farm
G. Ndagijimana	Tech. Agr. A2	Kinigi farm
E. Munyankusi	Tech. Agr. A3	Kinigi farm
Uganda		
D.R. Akimanzi		Coordinator
Zaire		
Bouwe Nasona	Ing. Agr. Ao	Program Head
Murhankikire R.	Tech. Agr. A1	Technology transfer
Ngoyi Kadiebe	Tech. Agr. A1	Breeding/selection
Tshikoli Mbusa	Tech. Agr. A2	Seed production
Mbaswa S.	Tech. Agr. A3	Seed production
Kashosi N.	Tech. Agr. A3	Post-harvest

1992

Name	Education	Activities
C. Muvira	M.S.	Program Head
D. Berrios	Ing. Agr. Ao	Advisor (CIP)
A. Buhinja	Tech. Agr. A3	Seed Production
A. Rubigiri	Ing. Agr. Ao	Breeding
A. Niyomvo	Tech. Agr. A2	
S. Nikura	Tech. Agr. A3	Seed production
D. Simenya	Tech. Agr. A3	Seed production
A. Sinduhije	Tech. Agr. A2	Tissue culture
Z. Nzoyihera	Tech. Agr. A3	Field Research
P. Tegera	Ph.D.	Program Head
P.C. Kagenzi	Ing. Agr.	Seed production
M. Habarurema	B.Sc.	Laboratory
L. Ruterana	Tech. Agr. A3	Kinigi farm
F. Uwimpaye	Tech. Agr. A2	Agronomy
A. Mukaminani	Tech. Agr. A2	On-farm evaluation
E. Munyankusi	Tech. Agr. A3	Germplasm
D.R. Akimanzi		Coordinator
L.C. Sikka	Msc.	Consultant (CIP)
R. Kankwezire	Bsc.	Seed Technology
J. Alacho	Bsc	Breeding/Agronomy
D. Rumumba	Diploma	Seed production
M. Mukandutiye	Diploma	Seed production
S. Kasule	Diploma	Virologist
J. Rubasha	Diploma	Extension
Bouwe Nasona	Ing. Agr. Ao	Program Head
Murhankikire R.	License	Technology transfer
Mutombo T.	Ing. Agr. Ao	Seed production
Phemba Phezo	Ing. Agr. Ao	Pathology
Feruzi	Ing. Agr. Ao	Post-harvest
Ngoyi Kadiebwe	Tech. Agr. A1	Breeding/selection
Mushia M.	Tech. Agr. A2	Extension
Tshikoli Mbusa	Tech. Agr. A2	Seed production, Nioka

1986

Name	Education	Activities

1992

Name	Education	Activities
Mbaswa S.	Tech. Agr. A3	On-farm research
Kashosi N.	Tech. Agr. A3	Post-harvest
Lone Buba	Tech. Agr. A2	TPS
Ngentho Ukany	Tech. Agr. A2	Breeding/selection
Nnega Fundi	Tech. Agr. A2	Selection, Nioka
M. X	Tech. Agr. A2	Selection, Shaba

Appendix G

Persons and Agencies Consulted

Rwanda NARS

Dr. Karoli Ndereyehe—Director General, ISAR, Rwanda
Dr. Pierre Tegera —Program Leader, PNAP Section/ISAR
Mr. L. Ruterana—Technician, Kinigi Farm
Mr. George Ndamage—Sweet Potato Program Leader, ISAR/Rubona
Dr. Marco Soto—PRAPAC Coordinator (CIP), Kigali

Burundi NARS

Dr. Andre Nivyobizi—Director General, ISABU, Burundi
Mr. Charles Muvira—Program Leader, ISABU
Mr. Aloys de Gonzague Habonimana—Director of Research, ISABU
Mr. Daniel Barampama—Director of Etude du Milieu et System de Production, ISABU
Mr. Donald Berrios—Advisor to National Potato Program (CIP)
Mr. Alphonse Rubirigi—Technician, Gisozi
Mr. Diomede Simenya—Technician, Munanira
Mr. Simon Nikura—Technician, Mwokora
Mr. Abraham Buhinja—Technician, Mwokora

Zaire NARS

Prof. Ndyanabo Masimango—Director General, INERA, Zaire
Mr. Bouwe Nasona wa Baseko—Program Leader, INERA/Malungu

Uganda NARS

Prof. Joseph Mukiibi—Secretary for Research, MOA
Mr. D.R. Akimanzi—Program Leader
Mr. Lyle Sikka—Advisor to National Potato Program (CIP)

CIP Region III

Dr. Sylvester Nganga—Regional Director
Dr. Peter Ewell—Economist
Dr. Hailemichael Kidanemariam—Breeder
Dr. Linnea Skoglund—Pathologist
Ms. Josephine Mutuura—Economist

USAID

Dr. Richard Edwards—Chief Agricultural and Natural Resources Division, REDSO/ESA
Mr. Bruce Odell—Acting Director, REDSO/ESA
Mr. Gary Nelson—Director, USAID/Rwanda
Mr. Kurt Fuller—Agricultural Development Officer, USAID/Rwanda
Mr. Rich Newberg—Agriculture Development Officer, USAID/Burundi
Mr. Keith Sherper—Director, USAID/Uganda
Dr. Gary Bayer—Agricultural Development Officer , USAID/Uganda

Appendix H

Mid-Term Evaluation Recommendations

For PRAPAC

1. If new subprojects are undertaken, consideration should be given to terminating others in order to not spread resources too thinly.

2. The scientist responsible for a subproject should personally report on the progress at each annual meeting.

3. Consider the appropriateness of reinitiating true potato seed (TPS) research.

4. Continue to schedule regular monitoring tours so that network participants can observe first-hand each other's experiments, trials, and research procedures, and invite donor representatives (REDSO, USAID, and others).

5. National potato programs in PRAPAC should explore ways to better involve universities in their work.

6. A study should be made of the long-term viability of fungicide use as a component for the control of late blight.

7. At the earliest opportunity, R-gene-free germplasm should be screened for blight resistance by all PRAPAC countries.

8. Research on the control of late blight, bacterial wilt, and insect and nematode pests should continue within an integrated control framework.

9. All consultants, both from CIP and from outside, should send summary reports of their findings to all of the member programs, with summaries in French and English.

10. Consideration should be given to hiring an administrative assistant to free up more of the Coordinator's time for his or her principal role as scientific advisor to the national programs.

11. The Director's Committee should develop a more explicit written job description for the Coordinator's position including percentage of time to be spent on travel status, the minimum amount of country-specific technical assistance to be provided to each country, and the priority ranking of each function the Coordinator is to perform.

12. Develop a mechanism to detail explicitly each member state's annual in-kind and/or cash contributions to PRAPAC activities.

13. Limit the number of on-farm trials, but emphasize on-farm trials in all research.

14. The quality of research proposals and research reports prepared by PRAPAC's collaborative researchers needs to be improved.

15. Consideration should be given to expanding the network.

16. PRAPAC should work within the larger structure of the agricultural sector in each country to improve the linkages between potato research and clean seed production, and the agencies responsible for seed bulk-

ing, seed distribution, and extension.

17. Collecting and monitoring of economic baseline data needs much more emphasis in the network, through end of grant, to assist member countries to focus their limited research resources on farmers' priorities.

18. The PRAPAC coordinator should travel more frequently to Uganda, and he needs to intensify his contact with the University, the Ministry of Agriculture, and the USAID Mission in Uganda.

19. The viability of potato production at mid-elevations in central Uganda and southern Rwanda should be carefully evaluated.

For REDSO/ESA

20. REDSO and the USAID missions in each country should improve their mechanisms for consultation and joint planning.

21. Funding must be found for the national potato program in Zaire, which has never received an operating budget from either INERA or the USAID country mission in Kinshasa.

22. REDSO should develop a schedule with USAID/Uganda for release of funds for Uganda potato research, and formalize these financial contributions.

23. The biennial Agricultural Development Officers' Conference should be used as a forum for reaching agreement between the REDSO Agriculture Office and USAID Missions in Rwanda, Burundi, Zaire, and Uganda on funding contributions and the scheduling of ancillary annual budget and congressional presentation inputs and obligation document presentation.

24. The REDSO Regional Pesticide Advisor should look into the use of chemical fertilizers and fungicides (primarily Dithane M45 and Rodomil 58 WP) in experimental and seed multiplication plots in Rwanda and Burundi, and a very limited use of Actellic, a low-toxicity insecticide, on seed potatoes stored on the research stations.

25. Assess the availability of funding for a Phase II of PRAPAC support, and the feasibility and cost-effectiveness of alternative ways of funding central African potato research, studies, and training.

For CIP

26. Under the present grant to PRAPAC, a detailed proposal for use of the $188,000 contingency line item needs to be prepared by CIP to meet expected shortfalls in the budget line items for the Coordinator's salary, supplies, and services.

27. CIP should request that REDSO revise its grant budget to procure for each national program one microcomputer, and a set of standard software packages.

28. A CIP scientist with a vehicle and operating budget, seconded to INERA for work in the Kivu region of Zaire, would help strengthen Zaire's potato research efforts.

29. Explore interest of USAID and other donors in funding the continuation of PRAPAC activities after the termination of the REDSO/ESA grant.

For Host-Country Collaborating Institutions

30. Assess long-term undergraduate- and graduate-level training needs for potato research and propose candidates for training to appropriate donors, including bilateral USAID Missions.

31. The Ugandan Ministry of Agriculture should consider moving the national potato program coordinator's office from Entebbe to the Kawanda research station.

32. In collaboration with Makerere University faculty members, the Ministry of Agriculture should conduct a socioeconomic survey of potato farmers and consumers.

33. Potato should be incorporated in the Uganda Government's five-year food crop research plan.

For USAID Missions

34. USAID/Burundi should consider incorporating studies on potato (e.g., production, marketing, and consumption) and support for potato research into its on-going programs: the redesign of its separate Farming Systems Research Project and/or the design of its new Agricultural Marketing Economic Policy Reform Program.

35. USAID/Rwanda should consider using project development and support funds to commission a study on the current and potential importance of potatoes in comparison with other commodity research, as input to the planned FY90 design of its new agricultural research project.

36. USAID/Zaire should consider funding the local costs of national potato research in the Kivu through PRAPAC.

37. Both USAID/Burundi and USAID/Rwanda should consider funding undergraduate and graduate level degrees for national potato researchers under the cover of their separate Human Resource development projects.

38. USAID/Uganda should consider programming at least $25,000 for immediate foreign exchange needs plus local currencies to support potato research through end of the REDSO grant.

Appendix I

Additional Covenants to the Grant Agreement

1. CIP and PRAPAC network agree to conduct an analysis of four specific policy concerns:
   (a) Cost recovery of new planting material.
   (b) Existing or potential capacity to multiply, distribute, and sell new planting material.
   (c) Existing and potential markets for seed potatoes.
   (d) Government regulations regarding marketing of agricultural inputs required for production.

   The analysis will be done with a view to forward increased participation of the private sector involvement in research, extension, and marketing in future networking activities. The analysis reports will be submitted to REDSO/ESA three months prior to the PACD of the project.

2. The CIP/PRAPAC Directors' Committee will address the question of incorporating private-sector interests into the research planning process and, specifically, review the proposal that private-sector representatives from member countries be appointed to the project executive committee directors' committee.

3. CIP will revise and submit the terms of reference for additional project technical assistance to be located in Uganda and Rwanda to establish their involvement in project implementation. The Uganda-based person should spend at least 50 percent of his time working in other participating countries in the region. The Rwanda-based person should be compensated at rates comparable to a similar position in the Rwanda NARS and not more.

4. CIP/PRAPAC will gather information and establish a baseline data on the status of potato research production, marketing, storage, economics, diseases, and consumption since the start of the project so as to enable the end of project evaluation to determine the impact of project activities.

5. CIP should make revisions in the project logframe to identify more quantifiable intermediate achievements and expected end-of-project benefits.

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