CIP 1992

ANNUAL REPORT

On the Cover

Tomasa Quispe is a farmer and self-educated plant breeder who uses true potato seed (TPS) for potato propagation in the tiny community of Olones, in the province of Cusco, Peru. She originally learned to produce TPS from an elderly peasant visiting from a more remote community in the highlands. Today Quispe is one of a handful of farmers in the Andean agroecosystem who use the TPS technique and recognize the value of the high-quality planting material it produces. Quispe has several types of potatoes in her germplasm collection. Having grown seed tubers from TPS over many seasons, she shares some of her potato selections with family and community members who do not know how to produce TPS themselves.

In using TPS, Quispe is carrying on a centuries-old Andean tradition of protecting the genetic diversity of the potato, one of the International Potato Center's mandate crops and a fundamental source of sustenance in this complex agroecosystem.

Photograph by Yolanda Kodelja, during an interview in 1991 by the International Potato Center's Gisella Orjeda for the IBPGR publication Geneflow.

CIP is grateful to Minka and Jorge Leon for granting permission to use their drawings of the Andean crops which appear on our cover. These drawings originally appeared in Lost Crops of the Incas, *National Academy Press, Washington D.C., 1989.*

Cover design: Cecilia Lafosse

International Potato Center

Annual Report 1992

International Potato Center
Apartado 5969, Lima, Peru

1992

The **International Potato Center (CIP)** is a not-for-profit, autonomous scientific institution established in 1971 by agreement with the government of Peru. The Center develops and disseminates knowledge to facilitate use of the potato and sweetpotato as basic foods in the developing world. CIP is one of 16 international research and training centers supported by the Consultative Group for International Agricultural Research (CGIAR). The CGIAR is sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the United Nations Development Programme (UNDP), and the International Bank for Reconstruction and Development (World Bank), and comprises more than 45 countries, international and regional organizations, and private foundations.

In 1991, through the CGIAR, CIP received funding from the following donors: the Australian Development Assistance Bureau; the Canadian International Development Agency; the CGIAR Secretariat Stabilization Fund; the Chemical and Mining Society of Chile; the Danish International Development Agency; the European Economic Community; the German Agency for Technical Cooperation; the Inter-American Development Bank; the International Development Research Centre, Canada; the Japan Economic Cooperation Bureau; the Kellogg Foundation; the OPEC (Organization of Petroleum Exporting Countries) Fund for International Development; the Rockefeller Foundation; the Scottish Crop Research Institute; the Swedish Agency for Research Cooperation; the Swiss Development Cooperation and Humanitarian Aid; the UNDP; the Overseas Development Administration, United Kingdom; the United States Agency for International Development; the World Bank; and the governments of Austria, Belgium, Brazil, Finland, France, Germany, India, Italy, Korea, Mexico, the Netherlands, Norway, the People's Republic of China, the Philippines, and Spain.

The *Annual Report CIP 1992* is published in English and Spanish by the International Potato Center; it covers the period from January 1, 1991 to December 31, 1991.

Mention of specific products by trade names does not imply endorsement of or discrimination against such products by CIP.

Citation:
International Potato Center, 1992. Annual Report CIP 1992. Lima, Peru. 254 p.

Printed by the International Potato Center
Apartado 5969, Lima, Peru, August 1992.
Copies printed: 3,800.

Managing editor
Christine Graves

Editors
Melissa Anderson
Princess Ferguson

Process support
Ximena Ganoza
Emma Martinez
Hernán Rincón

Photography
Jesús Chang
Magiorio Espinoza
Raymundo Medina
Abel Mondragón

Text processing/layout
Pilar Bernui
Fernando Jurado
Aida Nagata
María del Carmen Prieto
Rosario Reyes
Marco Sheen
Ivonne Valdizán

Art
Cecilia Lafosse
Víctor Madrid
Anselmo Morales
Christy Zevallos

Photomechanics
Rufino Failoo

Printing
Víctor Ayme
Ramón Barrientos
Pedro Chávez
Godofredo Lagos
Héctor Rojas
Reiser Ruiz

Contents

Foreword	ii
Board of Trustees	iv
Approaching Sustainability	vi
CIP's Decentralized, Collaborative Research Structure	x
Global Contact Points	xvi
The CGIAR: A Global Agricultural Research System	xviii
CIP in the News: Debut for the Hairy Potato	xx
A Research Overview	xxv
The Research Programs	
1. Production Systems	1
2. Germplasm Management and Enhancement	27
3. Disease Management	51
4. Insect and Nematode Management	81
5. Propagation and Crop Management	103
6. Postharvest Management, Marketing	125
Training	151
Information	157
CIP Publications	A-1
Research Projects and Contracts	A-23
CIP Staff	A-39
Financial Statement	A-47
Abbreviations and Acronyms	A-56

Foreword

In our annual report of 1972, Dr. Richard L. Sawyer, CIP's founder and first Director General, spoke of establishing a center that would bring the potato to a hungry world. Dr. Sawyer retired in May 1991 following 20 years of distinguished service. It was my privilege to succeed him and to join a center with an excellent scientific record, an outstanding research staff, and a unique client orientation.

During these past 20 years, international centers have benefitted greatly from the development of more sophisticated tools and the evolution of stronger, better equipped national programs. These advances have helped us achieve our goal of bringing more food to more people at an affordable price. During this period, however, we have also been asked to take up many new challenges. Today, CIP works with six of the lesser-known Andean root and tuber crops, as well as with sweetpotato. In addition, we now evaluate our work with an increasing regard for the sustainability of agriculture, for the protection of the natural resource base, and for the well-being of farmers and consumers.

The past year was devoted to setting a course that will help us achieve these goals. In October 1991, we presented to the CGIAR a long-term strategy that outlines the main elements of our research plan for the future. The strategy builds upon CIP's accomplishments and strongly emphasizes the Center's hallmarks of decentralization and partnership. It puts a renewed and stronger focus on our work in the Andean ecoregion. At the same time, the number of regions and research Programs (previously Thrusts) has been reduced to streamline and further integrate the Center's activities.

Toward the end of the year, with help from the International Service for National Agricultural Research (ISNAR), we began a priority-setting exercise. One of the first products of this activity will be the phasing out by 1993 of all low-priority research projects, about 15% of the current total. In addition, this exercise has helped establish guideposts for the development of a five-year work plan and budget to come into effect in 1994. By then, the new project-based management system and the key elements of our board-approved reorganization plan will be in place. Among the fundamental elements of this reorganization are the recent appointments of Dr. José Valle Riestra as CIP's Deputy Director General for Administration and Finance, and of Dr. Peter Gregory as our Deputy Director General for Research. Dr. Gregory will be responsible for all Center research and training programs. He will work closely with Dr. Valle Riestra, who will oversee the integration of Center administration and finances. Dr. Ken Brown, formerly our Director of Regional Programs, will serve as Senior Advisor for Management and International Cooperation. The Board of Trustees has also been restructured as a result of a recent self-study exercise. Two new committees—Audit and Nominations—join the Board's Executive and Program committees for the more efficient guidance of Center activities.

Within this new management structure, day-to-day responsibility for research will rest with the Leaders of the six new research Programs. The Program Leaders will work with some 25 project coordinators who are responsible for overseeing work in one or more major areas of research, as well as with Department Heads for disciplinary coordination. Training and information functions will be integrated within the Programs as project components.

These changes in operations and job responsibilities are designed to increase the Center's effectiveness in responding to the shifts taking place in agriculture, and also to help us adjust efficiently to difficult financial circumstances. Although donor support to CIP remains strong, all CGIAR centers have experienced drops in funding. In CIP's case, this is compounded by extremely challenging economic and social conditions in our host country. I am pleased to report that progress is being made in dealing with this situation. We have scaled back, and new accounting systems have helped us to gain flexibility in the way we manage and finance our programs. In addition, new sources of funding are beginning to open up, a trend which we hope will continue.

I feel confident that CIP can look forward to an easier road ahead. Because of our strengthened decentralized structure and well established client orientation, we are able to respond quickly to new situations and opportunities. The CIP model provides an excellent framework for determining ongoing global commodity activities as well as increased responsibilities in natural resource management, especially at the eco-regional level. Additionally, our flexible structure helps us respond to changing social circumstances both at headquarters and in the regions.

At this time, as CIP prepares itself for a new medium-term plan, I am confident that our technologies will play a major role in helping farmers expand production and improve their management of natural resources. As we move forward, we acknowledge the achievements of the past as well as the challenges that lie ahead. In the future, CIP will strive to make the most of its institutional model and the flexibility it provides for achieving innovation and, ultimately, impact in farmers' fields.

Hubert Zandstra
Director General
August 1992

Board of Trustees

Executive Committee

Chairperson: DR. LINDSAY INNES

DR. LINDSAY INNES
Deputy Director
Scottish Crop Research Institute
Invergowrie
Dundee DD2 5DA, United Kingdom

DR. LANDER PACORA
Sta. Carmela Calle 1, No. 162
Surco
Lima, Peru

Program Committee

Chairperson: DR. STACHYS MUTURI

DR. DURWARD BATEMAN
Dean
College of Agriculture and Life Science
North Carolina State University
Box 7601
Raleigh, NC 27695-7601
USA

DR. KLAUS RAVEN
Coordinator
Regional Development Institute
Universidad Nacional Agraria
La Molina
Av. La Universidad s/n, La Molina
Lima, Peru

Audit Committee

Chairperson: DR. LANDER PACORA

DR. AURELIANO BRANDOLINI
Director General
Istituto Agronomico per L'Otremare (IAO)
Via A. Cocchi 4
Florence 50131, Italy

Nominations Committee

Chairperson: DR. LANDER PACORA

DR. K. L. CHADHA
Deputy Director General (Horticulture)
Indian Council for Agricultural Research (ICAR)
Krishi Bhavan
Dr. Rajendra Prasad Rd.
New Delhi 110 001, India

Vice Chairperson: DR. LANDER PACORA

DR. STACHYS MUTURI
Agricultural Consultant
P.O. Box 25033
206 Jacaranda Avenue
Lavington Green
Nairobi, Kenya

DR. HUBERT G. ZANDSTRA
Director General
International Potato Center (CIP)
Apartado 5969
Lima, Peru

DR. FRANZ WINIGER
Head
Department of Potato Production
FAP Zarich Rechenholz
Postfach 8046
Zurich, Switzerland

DR. SETIJATI SASTRAPRADJA
Botanist
National Centre for Research
in Biotechnology
Indonesian Institute of Sciences
Jl. Juanda 18
Bogor 16122, Indonesia

DR. TOSHIHIRO KAJIWARA
Japan Plant Protection Association
Komagome, 1-43-11
Toshima-ku
Tokyo 170, Japan

DR. SHEN JINPU
Deputy Director
Chinese Academy of Agricultural Sciences (CAAS)
Bai Shi Qiao Road No. 30
West Suburb of Beijing
Beijing, People's Republic of China

Approaching Sustainability

Technology has provided alternatives for this mother's generation—faced with land scarcity, poverty, and population pressure—allowing potato production to be to introduced into reclaimed swampland in Burundi, where good yields were obtained in a short period of time. Sustainability involves consolidating and enhancing these gains for her child's generation, and for those to come.

The following article is based on the CGIAR publication entitled "Preserving the Options: Food Productivity and Sustainability." [1] *In this paper, the CGIAR sets forth the evolution of its approach to sustainability, since the Group's outset in 1972 to the moment of the preparations for the 1992 UNCED Earth Summit in Rio de Janeiro. As chairman of the CGIAR's sustainability committee, our Director General, Dr. Hubert Zandstra, outlines the strategy that must be followed to strike the balance between production, conservation, and equity for future generations.*

Food is Not a Matter of Choice[2]

The "rules of the road" by which agricultural researchers measure the impact of their work are being restudied. The first conclusion is that it is impossible to choose between food needs today and food needs 100 years from now. Somehow, the global food production system must keep pace with the demand that 90 million new mouths place on it every year. Second, the natural resource base—land, water, and plant species—must be preserved, and eventually upgraded, to fuel the agricultural giant that will have to satisfy the food demands of the future.

In the 1950s, before anyone gave much thought to environment, experts predicted that developing countries would eventually run out of food. While pockets of famine did occur, widespread starvation was averted by the introduction of high-yielding crop varieties that were resistant to pests and diseases and could tolerate wide swings in weather. Today, the Third World produces three to four times as much food as it did in 1950, but a predicted doubling of demand over the next 30 years will put extreme pressure on developing countries where birthrates are highest and resources fewest. Just to keep even, farmers must increase production 2.5% each year for the foreseeable future, a considerable task. If they succeed, however, the environmental costs could be high.

The impact of population on land resources was noted in a recent study by the International Maize and Wheat Improvement Center (CIMMYT). The center estimated that the amount of cropland per person worldwide

1. Available from the CGIAR Secretariat, 1818 H St. NW, Washington, DC 20433, USA.
2. This article first appeared in the May 1992 CGIAR Highlights.

declined 25% between 1950 and 1975, and will likely drop another 15% by the year 2000. The center put the annual loss of arable land through desertification at 6 million hectares (15 million acres) with another 1 to 1.5 million hectares (2.5 to 3.9 million acres) lost through waterlogging and salinity. The net topsoil loss through erosion is estimated at 26 billion tons a year.

Scientists are also predicting significant climate changes. Rising temperatures due to atmospheric buildup of carbon dioxide and other greenhouse gases have serious implications for agriculture. Furthermore, a thinning of the earth's protective ozone layer is allowing harmful ultraviolet radiation to strike the earth's surface. Agriculture therefore faces a double challenge—not only to increase productivity to meet food needs, but also to assure that the resource base is preserved for the future.

Not the Status Quo

Dr. Hubert Zandstra, Director General of the International Potato Center (CIP) in Lima, Peru and presently chairman of the CGIAR committee on sustainability, believes that agricultural sustainability goes beyond preserving the environmental status quo.

"It doesn't mean that the choices we make today about using resources are permanent," he says. "The job of today's researcher is to make sure that society has the same number of choices a hundred years from now. Today's scientist must be as concerned with the environment as the last generation of researchers was with increasing crop production."

But increases in food production, cannot be achieved by research alone, Zandstra says. Economic and social conditions, and especially government policies, are limiting factors. Many governments still believe they cannot afford to conserve soil, water and forests, and fail to recognize that the cost of protecting resources now is cheaper than the cost of trying to restore them later. Yet Zandstra is confident that national agricultural policymakers are slowly becoming more sensitive to the consequences.

"The CGIAR centers have put a heavy emphasis on research designed to help poor farmers," he says, "despite the evidence that returns in production are greater from research done on prime farmland. The introduction of more intensive agriculture in less favorable areas, however, frequently results in environmental damage. Subsistence farmers cannot afford conservation programs. For them the greatest concern is survival. Yet increased demand for food will have to be met where the demand exists: not by developing the most favorable environment at the expense of the less favorable, but by helping the poorest become more productive," Zandstra says.

Ecological Suicide

Traditional farming systems designed to feed small populations, Zandstra notes, are failing to meet the needs of increasing populations. Unable to increase food output from limited resources, the poor are driven to farming practices that amount to ecological suicide: shortening bush fallows, extending cultivation to forest areas, and grazing more animals than the land can support. The intensification of agricultural production to meet growing needs can have undesirable environmental or ecological consequences, he says, and is contributing to the deterioration of natural resources and living conditions in the developing world.

"There are two sides to the issue," Zandstra says. "First, we need to develop technologies that give farmers higher income and minimize environmental damage. Second, we need to produce as much food as possible on the most stable land so that people will not be literally driven into the hills because of lack of food. Experience has shown that it is possible to develop responsible agriculture."

Though worries about environment have brought about changes in the world's research agenda, reports of declining rice and cereal yields may eventually create a backlash. It is still uncertain whether a leveling off of yields is a short-term aberration due to unfavorable weather conditions, or whether it is the beginning of a long-term trend that could have disastrous consequences. The loss of production momentum in Asia and the failure under stress of traditional systems of land use, combined with the depletion of non-renewable natural resources, pose tremendous problems.

If production does not increase, Zandstra says, the implications for the future are horrendous given the problem of feeding twice as many people just a few years from now. At the same time, if we don't invest in our natural resources, we may one day lift the lid to find that the world's food basket is nearly empty.

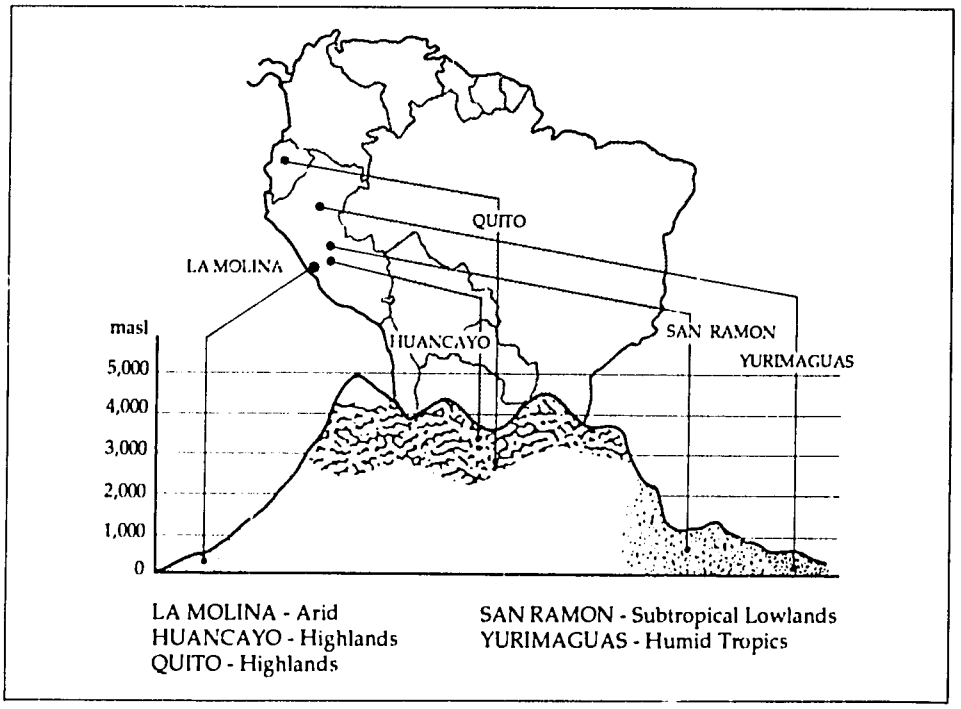
CIP's Decentralized, Collaborative Research Structure

Headquarters

CIP headquarters is located at the La Molina experiment station in the coastal desert near Lima, Peru. There are four other headquarters experiment stations—three in Peru and one in neighboring Quito, Ecuador—that together represent four of the principal agroecological regions of CIP's client countries.

The La Molina facilities include general research and administrative offices, as well as laboratories, greenhouses, refrigerated and diffused-light stores, growth chambers and experiment fields. Research at the two sites in the Amazon jungle region—mid-elevation San Ramon on the eastern slopes of the Andes and Yurimaguas in the hot, humid tropics—focuses on warm-climate potato and sweetpotato production. The two cool highland sites, Huancayo and Quito, house the primary field collections of CIP's genetic resources.

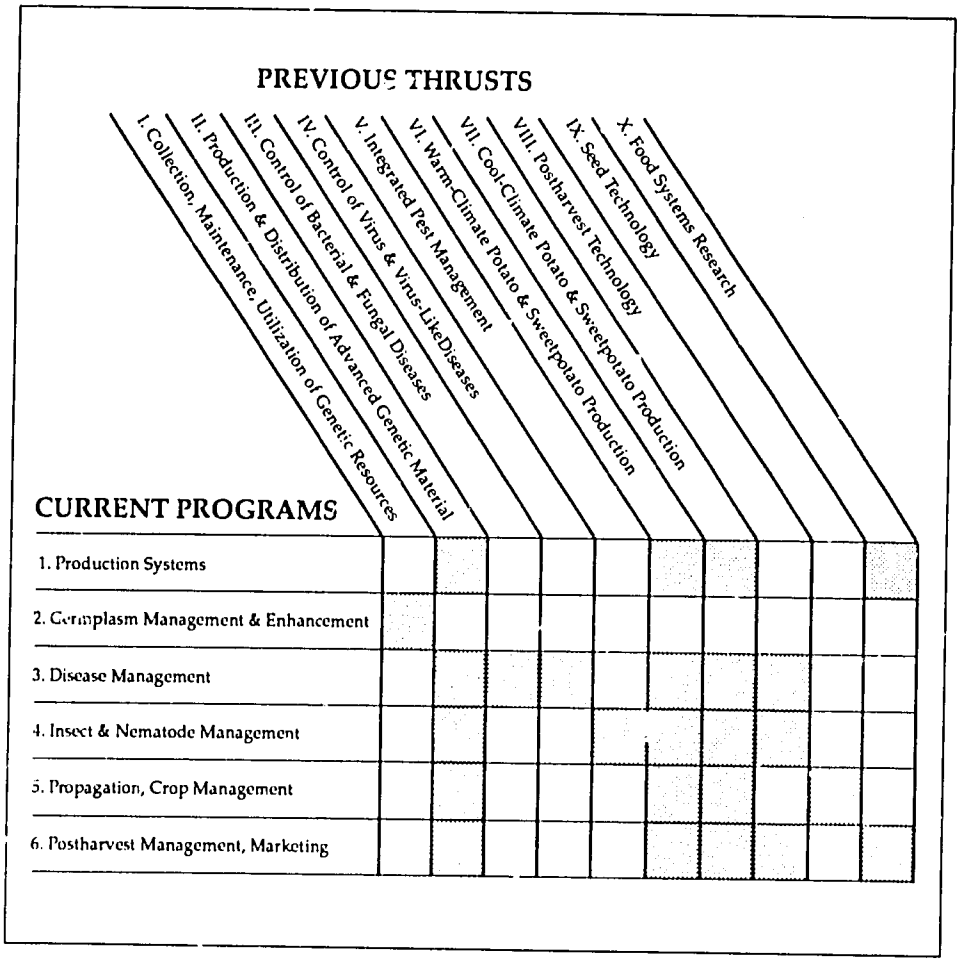
CIP headquarters staff in Peru and Ecuador comprise approximately 500 locally hired and 40 internationally hired staff.



CIP Headquarters Experiment Stations

The Research Programs

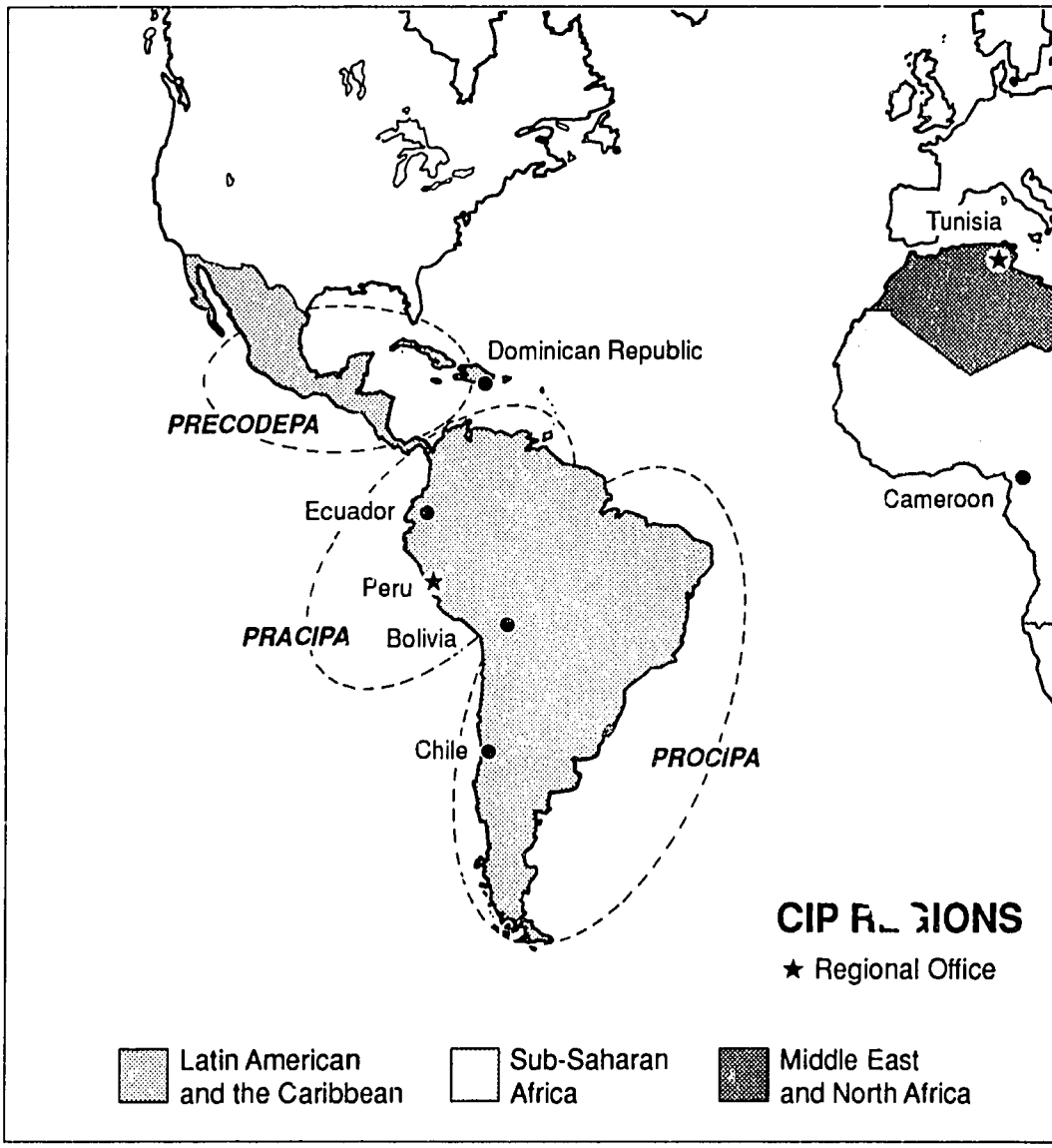
The 1990s CIP strategy also includes the focusing of research, and the strengthening of its integration. The previous ten research Thrusts have been concentrated in six Programs to ensure greater cohesiveness. Breeding and social science activities have been distributed across the Programs, and training and information functions have been included as project components.



Thrust Restructuring and Redistribution of Activities
The shaded areas indicate the distribution of previous Thrust activities within the current Programs.

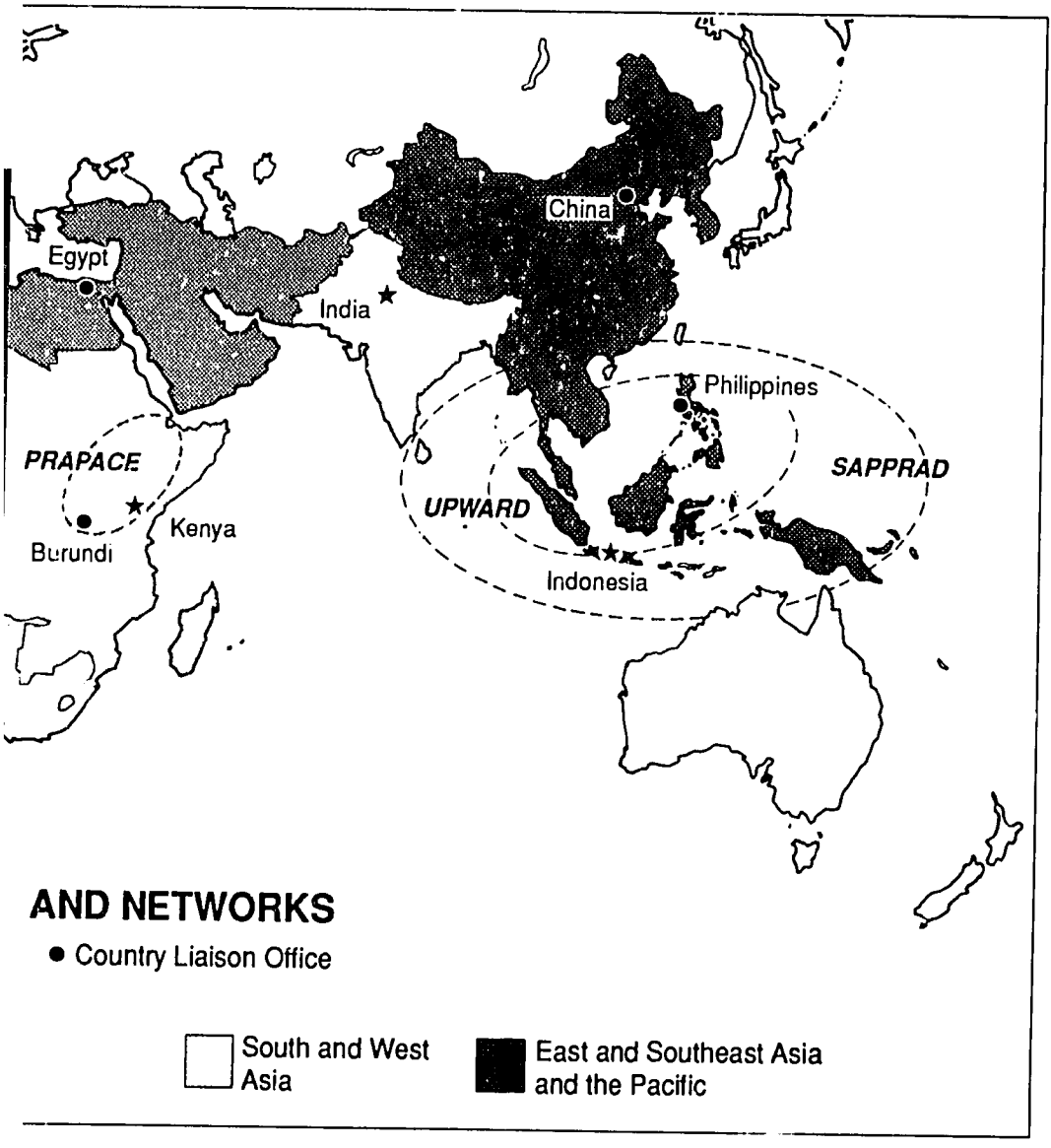
New CIP Regions

Close to 30 internationally recruited scientists work at CIP locations throughout the world. CIP's decentralized, collaborative operational structure helps ensure the relevance of research in its client countries worldwide. The global research program allows CIP and national program scientists to work together to develop and evaluate technologies under a range of local conditions. CIP's research approach takes into account the farmer as well as the consumer and the agribusiness community, seeking the user perspective at all levels of the food chain.



As part of its strategy for the 1990s, CIP will capitalize on these strengths by streamlining the management of its growing number of regional activities. This includes a reduction in the number of CIP regions from eight to five, corresponding to the major continental areas.

This consolidation, along with increased agroecological analysis in CIP's research, will provide more effective transfer of technology across and within ecoregions. At the same time, it will promote the establishment of multidisciplinary expertise in each major geographical area, the sharing of skills within and among regions, and the more efficient use of local expertise.



Networks

CIP has helped develop six unique collaborative networks that are fundamental vehicles for implementing cost-efficient research and disseminating its results among the center's clients. In these networks, countries within a geographical area share responsibilities for certain priority research, according to comparative advantage. CIP participates in the networks as an equal partner, providing technical assistance in its areas of expertise as well as administrative guidance.

PRECODEPA *(Programa Regional Cooperativo de Papa)*
Costa Rica, Cuba, the Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama

PRACIPA *(Programa Andino Cooperativo de Investigación en Papa)*
Bolivia, Colombia, Ecuador, Peru, Venezuela

PROCIPA *(Programa Cooperativo de Investigaciones en Papa)*
Argentina, Brazil, Chile, Uruguay, Paraguay

SAPPRAD *(Southeast Asian Program for Potato Research and Development)*
Indonesia, Malaysia, Papua New Guinea, the Philippines, Sri Lanka, Thailand

PRAPACE *(Programme Régional d'Amélioration de la Culture de la Pomme de Terre et de la Patate Douce en Afrique Centrale et de l'Est)*
Burundi, Ethiopia, Kenya, Rwanda,Uganda, Zaire

UPWARD *(User's Perspective with Agricultural Research and Development)*
Indonesia, Nepal, the Philippines, Sri Lanka, Thailand, Vietnam

The Networks and Their Members

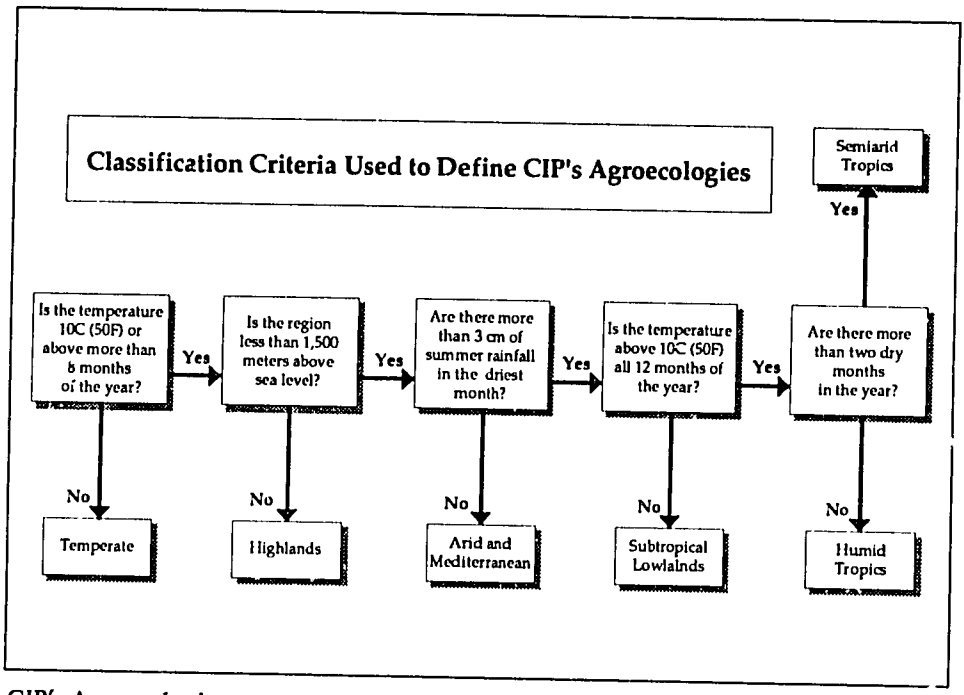
Special Country Projects

Parallel to CIP's core collaborative research with national programs in client countries, special country projects are sometimes initiated when a country has a well developed program in one or more of CIP's mandate areas. In these cases, CIP helps the country in question to seek complementary funding for a fixed time period to strengthen national capabilities in priority concerns. These projects, co-directed by CIP and national program staff members, are important mechanisms for the achievement of sustainable results at the national level. CIP's current special country projects in South America include PROINPA in Bolivia, FORTIPAPA in Ecuador, and SEINPA in Peru; there is also one special country project in Africa, in Burundi.

Agroecologies

To prioritize research and better evaluate the potential of its commodities, CIP has determined the principal agroecologies for potato and sweetpotato in its client countries. This classification is based on climatic and geographical criteria.

While the major constraints of CIP's mandate crops cut across ecoregions, agroecological analysis is a tool for better research decision-making, bringing environmental considerations to bear on priority setting and resource allocation.



CIP's Agroecologies

The Andean Ecoregion

CIP's has conducted ample research in the Andean highlands, an ecoregion of special interest. Andean farmers have domesticated some 25 species of edible roots and tubers, ranging from the potato—one of CIP's CGIAR-mandated commodities—to species about which very little is known. Because of the proven need, the Center's comparative advantage, and the outstanding support shown by donors and partners, CIP is investigating opportunities to do more research on this agroecosystem. This will involve preserving and managing the region's threatened natural resources, as well as investigation of the potential of the lesser known Andean tuber and root crops, both here and in other agroecologies.

Global Contact Points

Latin America and the Caribbean

Peru

CIP Regional Office
International Potato Center
Apartado 5969
Lima 100, Peru
Phone: (51-14) 35-4354
(51-14) 36-6920
Fax: (51-14) 35-1570
Telex: 25672 PE
Cable: CIPAPA, Lima
E-mail: 157:CGI801 or CIP
157:CGI043 or
CIP-ISD

CIP-SEINPA/INIAA Special Project
(same address as above)

Ecuador

CIP-INIAP/FORTIPAPA Special Project
Apartado 17-16-129-CEQ
Quito, Ecuador
Phone: (593-2) 554-721
(593-2) 554-726
Fax: (593-2) 562-286
E-Mail: TODOS@CIP.EC

Bolivia

CIP-IBTA/PROINPA Special Project
Casilla Postal 4285
Cochabamba, Bolivia
Phone: (591-42) 42-925
(591-42) 40-929
Fax: (591-42) 45-708
Telex: 6445 PRONAPA BV
E-mail: CGI272

Chile

CIP-Chile Liaison Office
Casilla 16487
Santiago 9, Chile
Phone: (56-2) 225-2118
Fax: (56-2) 225-8773
Telex: 242207 INIA CL

Colombia

CIP-Colombia Liaison Office
c/o ICA (La Selva)
Apartado Aéreo 128
742 Rionegro, Antioquía
Colombia
Phone: (57-4) 537-0161
(57-4) 537-0079

Su -Saharan Africa

Kenya

CIP Regional Office
P.O. Box 25171
Nairobi, Kenya
Phone: (254-2) 63-2054
(254-2) 63-2151
(254-2) 63-2206
Fax: (254-2) 63-1499
Telex: 22040 ILRAD
Cable: CIPAPA, Nairobi
E-mail: CGI265

Burundi

CIP-ISABU Special Project
B.P. 75
Bujumbura, Burundi
Phone/Fax: (257-22) 4074
(Bujumbura)
(257-44) 2103
(GS021)
Telex: 5030 BDI through
Hotel Source du Nil
Telex: (via FAO FOODAG
BDI) 5092

Cameroon

CIP-Cameroon Liaison Office
P.O. Box 279
Bamenda, Cameroon
Phone: (237) 36-3285
Fax : (237) 36-3921
Telex: 5892 KN & 842 KN
E-mail: C.MARTIN or
CGI238

Middle East & North Africa

Tunisia

CIP Regional Office
11 rue des Orangers
2080 Ariana, Tunis, Tunisia
Phone: (216-1) 71-6047
(216-1) 53-9092
Fax: (216-1) 71-8431
Telex: 14965 CIP TN
E-Mail: CGI019

Egypt

CIP-Egypt Liaison Office
P.O. Box 17
Kafr El Zayat, Egypt
Phone: (20-40) 58-6720
Telex: 23605 PBTNA UN

South & West Asia

India

CIP Regional Office
IARI Campus
New Delhi 110012, India
Phone: (91-11) 573-1481
(91-11) 574-8055
Telex: 3173140 FI IN
3173168 EIC IN
Cable: CIPAPA, New Delhi
E-mail: CGI046

East and Southeast Asia & the Pacific

Indonesia

CIP Regional Office
c/o CRIFC
Jalan Merdeka 147
Bogor, Indonesia
Phone/Fax: (62-251) 31-3687 & 31-7951
Home: (62-251) 32-3801
E-Mail: CGI193

China

CIP-China Liaison Office
c/o The Chinese Academy of Agricultural Sciences
Bai Shi Qiao Rd. No. 30
West Suburbs of Beijing
Beijing, People's Republic of China
Phone: (86-1) 831-6536
Fax: (86-1) 831-6545
Telex: 222720 CAAS CN or 22233
E-Mail: CGI030
Cable: AGRIACA

Philippines

CIP-Philippines Liaison Office
c/o IRRI
P.O. Box 933
Manila, Philippines
Phone: (63-94) 50-015/19 Ext. 248
Fax: (63-2) 817-8470
(63-2) 818-2087
Telex: 40890 RICE PM, 40860 PARRS PM, 63786 RICE PN
E-mail: CGI401 or IRRI

Network Coordination Offices

PRACIPA

(same address as PROINPA, Bolivia)

PRAPACE

B.P. 1218
Kigali, Rwanda
Phone: (250) 84761
Telex: 22510 TRAKIG Rwanda
Cable: (use above address)

PRECODEPA

c/o Programa Nacional de Papa
IDIAP
Cerro Punta, Chiriqui
Panama
Phone: (507) 71-2036
Fax: (507) 71-2084 (PRECODEPA)
Telex: 3679 IDIAP PG

PROCIPA

(same address as CIP)

SAPPRAD

(same address as CIP-Philippines Liaison Office)

UPWARD

(same address as CIP-Philippines Liaison Office)

The CGIAR: A Global Agricultural Research System

The Consultative Group on International Agricultural Research (CGIAR), established in 1971, is an informal association of more than 40 public and private sector donors that today supports a network of 16 international agricultural research centers around the world. More than 1,800 scientists representing 60 nationalities conduct research at the CGIAR center headquarters and in close to 40 client countries.

The majority of the centers study specific food commodities and/or ecoregions. Other centers have mandates focused directly on germplasm conservation, economics and food policy, or national agricultural research system support. As a whole, center program objectives include increased productivity; better management of natural resources; improvement of the policy environment; strengthening of national agricultural research capabilities, germplasm conservation, enhancement, and dissemination; and fortification of linkages for cooperation.

The CGIAR centers maintain close collaborative relationships with the national research systems of their client countries. They and their partners conduct research on most of the principal food commodities consumed in developing countries, commodities that provide about 75% of food energy and protein to the local populations. The centers share the goal of contributing to sustainable improvements in agriculture and forestry in ways that will enhance nutrition and well-being, especially for people with low incomes.

CIP's membership in the CGIAR provides opportunities for close collaboration and sharing of resources with sister centers. These opportunities are increasing with the addition of new centers and expanded mandates in the CGIAR system, and with a strengthened system-wide focus on resource management and ecoregional considerations.

CIAT	*International Center for Tropical Agriculture* Cali, Colombia
CIMMYT	*International Maize and Wheat Improvement Center* Mexico City, Mexico
CIP	*International Potato Center* Lima, Peru
IBPGR	*International Board for Plant Genetic Resources* Rome, Italy
ICARDA	*International Center for Agricultural Research in Dry Areas* Aleppo, Syria
ICRAF	*International Center for Research in Agroforestry* Nairobi, Kenya
ICRISAT	*International Crops Research Institute for the Semi-Arid Tropics* Hyderabad, India
IFPRI	*International Food Policy Research Institute* Washington, DC, USA
IIMI	*International Irrigation Management Institute* Colombo, Sri Lanka
IITA	*International Institute of Tropical Agriculture* Ibadan, Nigeria
ILCA	*International Livestock Center for Africa* Addis Ababa, Ethiopia
ILRAD	*International Laboratory for Research on Animal Diseases* Nairobi, Kenya
INIBAP	*International Network for the Improvement of Banana and Plantain* Montferrier-sur-Lez, France
IRRI	*International Rice Research Institute* Manila, Philippines
ISNAR	*International Service for National Agricultural Research* The Hague, the Netherlands
WARDA	*West Africa Rice Development Association* Bouake, Ivory Coast

CIP in the News

Los A nes

Copyright, 1991,
Los Angeles Times
Reprinted by permission

COLUMN ONE

Debut for the Hairy Potato

■ With its unmatched potential for feeding the world's hungry, scientists are laboring mightily to make a better spud. That requires outwitting some ever-resourceful in

Gorbachev

POTATO: Spud That Fights Aphids

POTATO: Scientists Seek Improved Varieties to Help Combat Hunger

Vend
Life to

Fearing Collisions in Space, U.S. Tracks Orbiting Debris

■ Science: With 7,000 pieces of junk circling Earth, some say a disaster for manned craft is virtual certainty

Beyond the domains of scientific research and agriculture, CIP's activities become known to the general public through media coverage. Every year, journalists from many countries visit CIP locations and report on our work. The following article appeared in the USA, on page one of the Los Angeles Times, December 25, 1991. It is reprinted here (in a slightly abridged version) with the publisher's permission.

Debut for the Hairy Potato

■ With its unmatched potential for feeding the world's hungry, scientists are laboring mightily to make a better spud. That requires outwitting some ever-resourceful insects.

By WILLIAM R. LONG
TIMES STAFF WRITER

LIMA, Peru—K.V. Raman placed a "hairy potato" leaf under a microscope rigged with a television camera, then sprinkled a few tiny aphids on the leaf's dark surface. Suddenly, on a nearby video monitor, it was the giant aphids vs. the hairy potato.

Live and in color. Hungry aliens advancing over the magnified leafscape. Getting gummed up and bogged down in a forest of sticky stalks. Struggling mightily. Then weakly.

Finally, the aphids were still. Raman, an entomologist from India, smiled triumphantly. The hairy potato had prevailed.

"It's something like flypaper, yeah," Raman said. But it's much more than that.

The hairy potato is a new, hybrid potato plant with tiny, goo-tipped "hairs" on its leaves and stems that keep aphids, beetles, and other bugs from eating at humanity's expense. The hybrid helps increase crop yields and reduces the need for costly and toxic insecticides.

It is one of many innovations the Peru-based International Potato Center is harvesting in a major effort to stem the advances of world hunger and environmental contamination.

Potatoes, first domesticated many centuries ago here in the Andean region, offer unmatched potential for feeding the Earth's increasingly crowded population, expected to reach 6 billion by the end of the century. As the International Potato Center likes to point out, the potato can produce "more nutritious food faster and on less land than any other food crop."

It's also extraordinarily adaptable, according to Gregory J. Scott, an economist at the center. Potatoes are grown in 140 countries, surviving at altitudes ranging from below sea level to more than 14,000 feet, in deserts and in the humid tropics, and as far north as the Arctic Circle.

While the Soviet Union is by far the world's biggest producer, potatoes are

also the main staple in such countries as Peru, Bolivia, and Colombia. Potato production is on the rise throughout much of the Third World, doubling, for example, in billion-strong China since 1960.

Also, developing countries have enormous potential for increasing production further, Scott noted. Average Third World yields range from 12 to 30 metric tons per acre, compared with 75 to 85 tons in the United States and a potential 170 tons an acre for some of today's improved varieties.

In terms of value, potatoes already are the world's No. 4 food crop, after rice, wheat, and corn. But the few potato varieties grown commercially in most countries are vulnerable to devastating plagues and blights. As a result, farmers use more chemical pesticides on potatoes than any other crop except cotton.

One of the main priorities of the International Potato Center—known by its Spanish initials as CIP—is to reduce the need for those chemicals, which increase farmers' costs, contaminate rural environments, and sometimes endanger the health of consumers.

Developed in a joint project by the CIP and Cornell University, hairy potatoes currently are being tested by commercial farmers in the United States. They have been successfully grown on an experimental basis without insecticides in Peru and the Philippines, said Raman.

"We are not saying we are going to zero application of these insecticides," he said. "But we can cut them back 80% or so."

While the hybrid's resistance to insects has been proven, Raman said, the CIP is still working on "improving the quality of the tuber and maybe pushing the yields more."

The tuber is the potato plant's edible end—technically an underground stem rather than a root. The "eyes" of a potato tuber are really buds, and when they are planted, they sprout and produce new potato plants.

Tubers come in myriad sizes and shapes. Breeders hope that the hairy potato tuber eventually will be as big as your basic Idaho potato. Hairy potatoes now being tested yield up to 1.8 pounds of tubers per plant, while hairless commercial varieties, with heavy use of insecticide, can yield more than 2.2 pounds per plant.

The hairy potato has been proven resistant to the Colorado potato beetle, a feared pest in the United States, the Soviet Union, and Eastern Europe. Most insecticides used against the Colorado beetle have been withdrawn from the U.S. market because they contaminate ground water.

Other insects stymied by the hairy potato include the potato tuber moth, the leaf miner fly, thrips, mites, and aphids—all major threats to potato crops in developing countries.

Hubert Zandstra, director general of the CIP, predicted that hairy potatoes will be in widespread commercial use "three to five years from now—with a lot of luck, two years."

Obviously, the hairy potato did not materialize overnight. Nor did any potato, for that matter.

As long as 2,000 years ago, Andean farmers began cultivating domesticated varieties derived from wild potato species. After the Spanish conquest in the 16th Century, the potato

reached Spain and began to spread through Europe.

It was the main staple in some European countries by 1845, when a fungus called late blight wiped out the tuber in Ireland and caused the infamous Potato Famine. Nearly 1 million people died, and up to 2 million emigrated, many to the United States.

Ireland's potatoes died out because all of them were the genetic descendants of only a few varieties brought from the new world, and all were vulnerable to late blight. Scientists say more diverse genetic material might have provided resistant varieties.

Today, four varieties account for three-fourths of all potatoes grown in the United States—but it needn't be that way. More than 5,000 domesticated and wild potato varieties are alive and well at the CIP headquarters in the Lima suburb of La Molina.

The core of the [CIP] is a "genetic bank" that preserves living samples of all known potato varieties.

One section of the genetic bank is a white, vault-like chamber where the temperature is kept at 42 degrees [Farenheit] and pinkish fluorescent light washes over high rows of metal shelves neatly packed with test tubes. The sterile tubes contain small potato plants that will stay alive up to four years, their development arrested by the low temperature.

All of the known varieties of the potato are packed into a space the size of a living room, safer and far more compact than open fields for keeping the genetic material of one of the world's most important foods. "You have exactly the same material here as you have in five hectares," said John Dodds, a British biochemist, as he peered into the chill brightness. A hectare equals about 2 1/2 acres.

Every two to four years, plants are rotated out of the cold room to a warmer "multiplication room." There they are given hormone treatments and light variations that make them produce tiny potato tubers whose eyes can be used for planting and normal propagation.

"We take some of the material back to the field and plant it to take another look at it," Dodds said.

Zósimo Huaman, a Peruvian with a British Ph.D., is in charge of maintaining the CIP genetic bank. He said it contains about 1,500 wild potato varieties and 3,500 native American domesticated ones.

Through centuries of painstaking breeding and selection, Andean Indians developed potatoes with a multitude of virtues. Huamán said some grow at extremely high altitudes and are frost resistant; others grow in coastal desert areas, drawing their moisture from the sea mist.

"Some have flesh that is completely red or purple," he said. "They used these to dye cloth. Other potatoes, for example, are very tasty and are selected to be eaten only roasted."

Of hundreds of varieties still eaten in Peru's highlands, Huaman said his favorite is a potato with deep yellow flesh. "This in my opinion is the tastiest potato. In the Lima market it reaches the highest prices."

The CIP's treasury of genetic material is being used to breed potatoes suitable for widely varying growing conditions and tastes around the globe. And just as the center has sent samples of desert potato plants to Israel and frost-resistant plants to the Soviet

Union, Huamán said, it could send different potatoes to the United States to give consumers there a wider variety of tastes and textures.

One of the CIP's main projects has been to collect wild and domesticated varieties from throughout Latin America so that diversity useful for breeding new varieties will not be lost. But some wild varieties, previously classified by botanists, already have become extinct.

"We went to look for these potatoes, and unfortunately many of these can no longer be found because they were lost forever," Huamán said. Such "genetic erosion," in potatoes as well as other species, irreversibly limits man's possibilities for making the best use of the planet's natural life forms.

Huamán observed that without wild varieties with sticky little "hairs," called glandular trichomes, the hairy potato would not have been possible.

"We are just beginning to see what is the potential of these wild potato species," he said.

Technicians at the CIP and Cornell developed the hairy potato through a long process of plant cross-breeding, mixing the hereditary material, or germ plasma, of selected wild potatoes and commercial varieties from the United States and Europe. "Back-crosses" and "recurrent selection" through successive generations of plants finally produced the one with the desired characteristics.

The CIP has used the same conventional techniques to breed new potato varieties that look and taste better, grow faster under different conditions, and contain more nutrients. Now the center also is using high-tech genetic engineering to improve potatoes by implanting synthetic or "designer" genes, bypassing the long breeding process.

Dodds, the biochemist who heads the CIP Genetic Resources Department, and Jesse Jaynes of Louisiana State University are using a bacterium as a vector for transferring synthetic protein genes into potato cells to enrich the nutritional value of tubers. Dodds also hopes to endow potatoes with designer genes that will prevent the multiplication of viruses and provide resistance to bacteria.

In one project, Dodds and Jaynes have put anti-bacterial genes from a giant silk moth into potato cells. A CIP spokesman said the moth genes have proven effective in giving potatoes greater resistance to disease.

But such genetically engineered material is confined to the laboratory because of "bio-safety" concerns such as unpredictable propagation and a lack of legal framework for using it in the field, a CIP spokesman said.

"It's tested under very controlled conditions, and absolutely none goes into the field because we simply don't have guidelines," the spokesman said. "Science is ahead of regulations."

Fortunately, that is no problem for varieties improved by conventional breeding methods, including the hairy potato.

A Research Overview

A social scientist seeks farmers' opinions on a new late-blight-resistant variety, as part of the cultivar selection process in Huanuco, Peru.

CIP has become an internationally acknowledged center of excellence through more than 20 years of work to improve the production and utilization of potato and sweetpotato as basic foods in the developing world. This year's programmatic overview concentrates on the recent structural reorganization that has been carried out to enhance the Center's effectiveness. CIP will build on its experience and expertise to catalyze the translation of research results into products and services that will have practical impact in farmers' fields.

For administrative and programmatic effectiveness, CIP's ten Thrusts have been regrouped into six Programs and our eight regions consolidated into five, by major continental area. We are also strengthening collaboration with development-oriented institutions, and assisting them in the use of CIP's products. Our present strong collaboration with national programs will be complemented by closer ties to non-governmental organizations (NGO's) and private industries that have comparative advantage in specific aspects of the development process.

In formulating our research agenda, we recognize that it is impossible to meet all the needs that may arise in CIP's client countries with relation to the diverse aspects of potato and sweetpotato production and utilization. We are using a simple philosophical framework to help us in making pragmatic choices that will maximize our practical output. The guidelines are focus, integration, balance, and impact. The following are some examples of how CIP's revised framework for the research program is operating.

Focus

To facilitate the revision of CIP's research agenda, a formal priority setting exercise was conducted last year in collaboration with the International Service for National Agricultural Research (ISNAR). The process involved the evaluation of all research projects based on factors such as the importance of the constraint being studied, the likelihood of research success, and the probability of adoption of the technological product as compared with the research costs involved. The whole of CIP's scientific community participated in the process, and in most cases decisions reflected a consensus.

This exercise translated CIP's collective institutional knowledge into quantitative data, which is being used as a valuable tool in resource allocation. Our new project-based budgeting system strengthens the

correlation between priority setting and resource allocation. This system replaces the previous mode of budgeting by Department and/or by Regional Office. With resources allocated on the basis of programmatic priorities, Program Leaders now play the central role.

This year's Production Systems Program report includes a simulation study done in collaboration with CABO-DLO in Wageningen. This study has enabled us to sharpen the agroecological characterization of the world's potato growing zones. It will ultimately help us to quantify the potential impact of our work, as well as to improve technology design, thus contributing to the focusing of resources.

Integration

The six new Programs address global concerns as well as specific regional and national needs in a holistic way. Research, training, and information activities at headquarters and in the regions have been integrated within the Programs, facilitating better management both at the technical and the administrative levels. This increased integration will help us maximize the practical effect of our research results.

For example, the Insect and Nematode Management Program report shows significant progress in control of potato tuber moth and Andean potato weevil. Non-chemical methods identified for the management of these pests have the potential to reduce the financial and environmental costs of potato production by counteracting dependence on harmful and costly chemicals. Training and information activities will help translate these research results into practical alternatives for farmers.

Another aspect of integration that will receive careful attention is the area of inter-Program management. For example, since potato and sweetpotato breeding are important components of several Programs, strategy papers on these subjects are being conceptualized on a cross-Program basis. A strategy paper is also being developed on the propagation dissemination, evaluation, and release of the breeding products emerging from the Programs.

Balance

The balance between short-term and long-term goals is one of our primary concerns. We are committing resources now to strategic work that may not fully pay off in practical terms for many years. Thus, this research investment is balanced by allocating resources for translating existing

knowledge and technology into immediate practical impact. The following examples illustrate how we are approaching this question.

The Propagation and Crop Management Program report shows that true potato seed (TPS) technology is already being adopted on a large scale throughout the world, particularly in India, Bangladesh, Indonesia, Egypt, Nicaragua, and Paraguay. Vital elements in this success story include breeding for improved germplasm, and research on TPS production methods. An additional factor is the development of more efficient dormancy management to provide faster and more uniform seedling emergence and growth. In the short term, emphasis must be placed on widespread use of the existing genetic materials and technology. In the longer term, however, we will emphasize the development of improved progenitors for the production of hybrid TPS. Feedback from farmers in Indonesia, for example, indicates the need to improve earliness, as well as resistance to bacterial wilt.

Rapid advances in sweetpotato virus detection are shown in the Disease Management Program report. Much of this success is based on the application of NCM-ELISA procedures to sweetpotato. In the short term, the emphasis is on distribution of NCM-ELISA kits and antisera to our regional personnel and to national program scientists. In the longer term, we will complement this with the development of improved virus resistance.

The Postharvest Management and Marketing Program report contains substantial new information on analyses of sweetpotato market opportunities and requirements, processing techniques for human and animal consumption, and germplasm characteristics for specific processed products. Initial emphasis will be on applying the available information to catalyze horizontal transfer of existing techniques, especially for greater use of sweetpotatoes for animal feed. In the longer term, we will concentrate more on the development of new processing technologies, as well as on germplasm improvement.

Impact

This year's Germplasm Management and Enhancement report shows that we have continued to progress in the identification of valuable genes from the potato and sweetpotato germplasm collections. We have also advanced significantly in our ability to utilize these genes in our breeding programs. For example, new diploid potato families were generated by using 2n gametes, producing 2x potatoes with improved agronomic characteristics

and resistance to bacterial wilt, potato tuber moth, potato leafroll virus, potato virus Y, and root-knot nematode. The genetic constitution of these families facilitates more efficient transmission of quantitatively segregating resistance to several of the pests from the diploid to the tetraploid level. This provides us with a valuable tool for accelerating the development of improved resistance in advanced potato materials.

The report also shows that we are complementing conventional enhancement approaches with biotechnological techniques. Through genetic engineering at CIP we can now transform potato clones by inserting antibacterial genes, as well as the coat-protein gene against potato leafroll virus. We have also made progress in restriction fragment length polymorphism (RFLP) mapping for potato trichome characteristics, and in the use of polymerase chain reactions to amplify RFLP markers. All of this will facilitate germplasm enhancement.

There is little doubt that such advances can ultimately translate into improved potato varieties. As we have mentioned, CIP is fine-tuning its potato breeding strategy to attain maximum impact in farmers' fields. Perhaps an even greater challenge, however, than increasing our impact is that of documenting it. In this and other areas the emphasis will be on illustrative case studies. Better documentation of the value of CIP's products will encourage their expanded use by our clients and beneficiaries and foster the continued support of donors.

In Conclusion

All of our activities will continue to be based on strong, extensive collaboration with colleagues in our partner countries. Other concerns that will be given special attention are environmental protection, gender and equity issues, the role of biotechnology, and the sustainability of agriculture. More specifically, CIP will augment its activities in the Andes to contribute more broadly to equity, environmental protection, and sustainable agriculture in this fragile agroecosystem. The focus will be on biodiversity of Andean root and tuber crops and the management of natural resources. In this work, coordination with national organizations, other international centers, and NGO's will be especially important.

CIP is well poised to move ever more strongly into a focused, integrated, balanced mode to produce practical impact. The result will be improved welfare for the people we serve. The progress achieved during 1991 is documented in the following pages.

A farmer evaluating potato clones at flowering in Cochabamba, Bolivia. Of the 20 farmers participating in this PROINPA trial, seven were women. Scientist-farmer collaboration from planning through evaluation encouraged community advancement.

Program 1

Production Systems

1991 In Review

The Production Systems program is a consolidation and refocusing of activities reported in previous CIP Annual Reports in the Thrusts on production and distribution of advanced breeding material, warm climate potato and sweetpotato production, cool climate potato and sweetpotato production, and potato and sweetpotato in the food systems of developing countries.

An important aspect of the refocusing was the addition of a more transparent and specific agroecological perspective to CIP's research. The principal agroecologies for potato and sweetpotato in CIP's client countries are based on climatic and geographic criteria. Potatoes are important in the Temperate, Highlands, Arid-Mediterranean, and Subtropical Lowlands agroecologies; sweetpotatoes are important in Temperate, Highlands, Subtropical Lowlands, Semiarid Tropics, and Humid Tropics agroecologies.

In November 1990, a definitive synthesis of research on potato intercropping was published in *Field Crops Research*. The potential for potato to follow rice in the swamps in the East African highlands was again confirmed by yields reaching 30 t per hectare in farmers' fields in Burundi.

Preliminary results on farmer participation in clonal selection in the Bolivian Andes show that women farmers, men farmers, and scientists shared the same notions of plant health and vigor for most characteristics. Differences in varietal preferences among production zones or between men and women farmers were not marked.

Several methods were developed and intensively tested in the Dominican Republic to assess the economic and agronomic importance of the sweetpotato weevil, *Cylas formicarius elegantulus*. Weevil damage was estimated at US$88 per hectare. Extrapolating these results to the greater Caribbean Region, effective weevil control would generate about US$15 million in benefits.

A group of 40 highly selected potato clones and progenitors for yield, tuber quality, and resistances were cleaned-up from diseases for use in CIP and national program breeding activities. Of these clones, two are immune to potato virus Y (PVY), two to potato virus X (PVX), 18 to both PVY and PVX, three are resistant to leaf roll and six have high dry matter and low reducing sugar contents and are good for processing as chips and french fries.

In the Philippines, 22 clones selected for long storability in diffuse light in the lowland tropics and high yield were evaluated in farmers fields at three sites. Farmers selected several of these clones, and we are multiplying them for further on-farm trials.

In Taiwan, after six years of testing, two PVY immune clones are being multiplied for dissemination to farmers.

To date, sweetpotato seed families comprising a total of about 2,500 individuals from a wide variety of sources and different agroecologies have been evaluated at Yurimaguas in Peru. High yields and general adaptation of members of these seed populations to the lowland humid tropical conditions of Yurimaguas suggest that very specific physiological adaptations to agroecological conditions (such as photoperiod sensitivity) either do not exist in sweetpotato, or may be easily overcome through selection among segregating progenies.

A new sweetpotato variety named Alto Urubamba (CIP clone ME12) was released in Peru. Clones NCSU 925 and NCSU 1135—introduced from North Carolina State University—continue to find good acceptance among farmers and consumers in Egypt.

In 1990, we began an in-depth interdisciplinary study to assess the impact of pesticides in an intensive, year-round, commercial potato-producing area in northern Ecuador. Preliminary results of modelling the potential for such intensive pesticide use to result in groundwater contamination show that only very low levels of pesticides accumulate at the bottom of the root zone and could possibly be delivered to groundwater. High organic matter content of the soil, which increases its sorption capacity, and the short persistence of the chemicals appear to be responsible for these findings. Occupational safety in the application of pesticides appears to be a more important environmental problem than groundwater leaching.

In November, CIP conducted a priority setting exercise of its restructured research portfolio. The presumed importance of controlling late blight and finding low-cost propagation methods for clonal planting materials in potatoes was confirmed. The importance of the Subtropical Lowlands for both potato and sweetpotato was also highlighted.

Research, training, and information activities in Production Systems are organized around the following areas of emphasis:

- characterization of potato production constraints and opportunities
- characterization of sweetpotato production constraints and opportunities
- adaptation and integration of potato production technologies
- adaptation and integration of sweetpotato production technologies
- evaluation of the impact and sustainability of potato production technologies

Characterization of Potato Production Constraints and Opportunities

Specific objectives of this project are to:

- establish informational benchmarks for impact evaluation,
- quantify the potential for potato expansion in developing countries by agroecology,
- measure yield gaps in representative benchmark locations, as well as the scope for economically bridging such gaps,
- assess the scope for cost savings and the effects of input policies in different production systems, and
- develop and update varietal trait and technology profiles consistent with producer circumstances.
- The major output is better quantitative and qualitative information to guide decision-making on technology design and resource allocation within and across potato production systems in developing-country agriculture.

Agroecological Characterization for Potato Production

The Centre for Agrobiological Research (CABO-DLO) at Wageningen in the Netherlands conducted a simulation study for CIP on the crop potential of potato under irrigated and rain-fed conditions in different agroecological zones. Agroecological characterization was explored with a crop model with local data on the production environment.

The weather data were obtained from the Müller database, which contains a global set of long-term monthly average values of weather variables for 978 meteorological stations. Information on soils came from a world soil data file from NASA. This data base consists of 15,413 records with information extracted from the FAO/UNESCO soil map.

Identification of potential growing seasons, assuming that water was non-limiting, was the first step in the characterization process. The length of potential growing season was determined from daily temperature data. Temperature constraints for growing the crop were assumed to be: daily minimum temperature above 5°C, daily maximum temperature below 28°C, a minimum temperature requirement of 1,250°Cd (Cd = duration of season expressed as temperature sum), and a maximum temperature requirement of 2,000°Cd. The minimum crop requirement of 1,250°Cd matches the requirement of a short growing season crop for production of seed-potatoes in temperate regions or that of an early maturing crop in tropical regions.

Based on these assumptions, it was possible to find a growing season for potatoes in the many temperate and subtropical regions of the world. In particular, there is productivity potential in terms of temperature in the northern subtropical zone stretching from Mexico to North Africa and on into the Indo-Gangetic Plain of South Asia and South China. In contrast, temperature constraints to potato production are binding in much of the lowland tropics.

The simulation of potential yield (maximum tuber dry matter production that can be achieved given planting and harvesting dates) from a simple crop growth model

gave a sharper agroecological characterization. For a specific variety, potential yields are dependent only on solar radiation and temperature. All other conditions such as water and nutrient supply and pest and disease control are assumed to be optimal. Assuming temperature limits of 5 and 28°C and a light use efficiency of 2.9 g Mj^{-1}, potential yields (in tons of dry matter) for climatic by soils zones are shown in Map 1-1 for the highest yielding season. The highest potential yields are found in the temperate zones at latitudes between 40° and 50° latitude in the northern as well as in the southern hemisphere.

At higher latitudes, yields are lower because low spring and autumn temperatures reduce the length of the growing season. Closer to the equator, high summer temperatures reduce the growing season and lead to low harvest indices. Areas with high potential yields are the tropical highlands with suitable temperatures year-round. On an annual basis, potential yields in a Mediterranean climate are higher because at least two (spring and autumn) crops can be grown.

This modelling effort could be extended in several directions to improve technology design and to quantify potential impact. Such extensions range from a global assessment of enhanced frost, heat, or drought tolerance to a scenario analysis of the effects of climatic change. The calculation of potential yields not only outlines the boundaries of technically feasible potato cultivation but also provides the basis for estimating and subsequently explaining productivity gaps in well-defined potato growing regions.

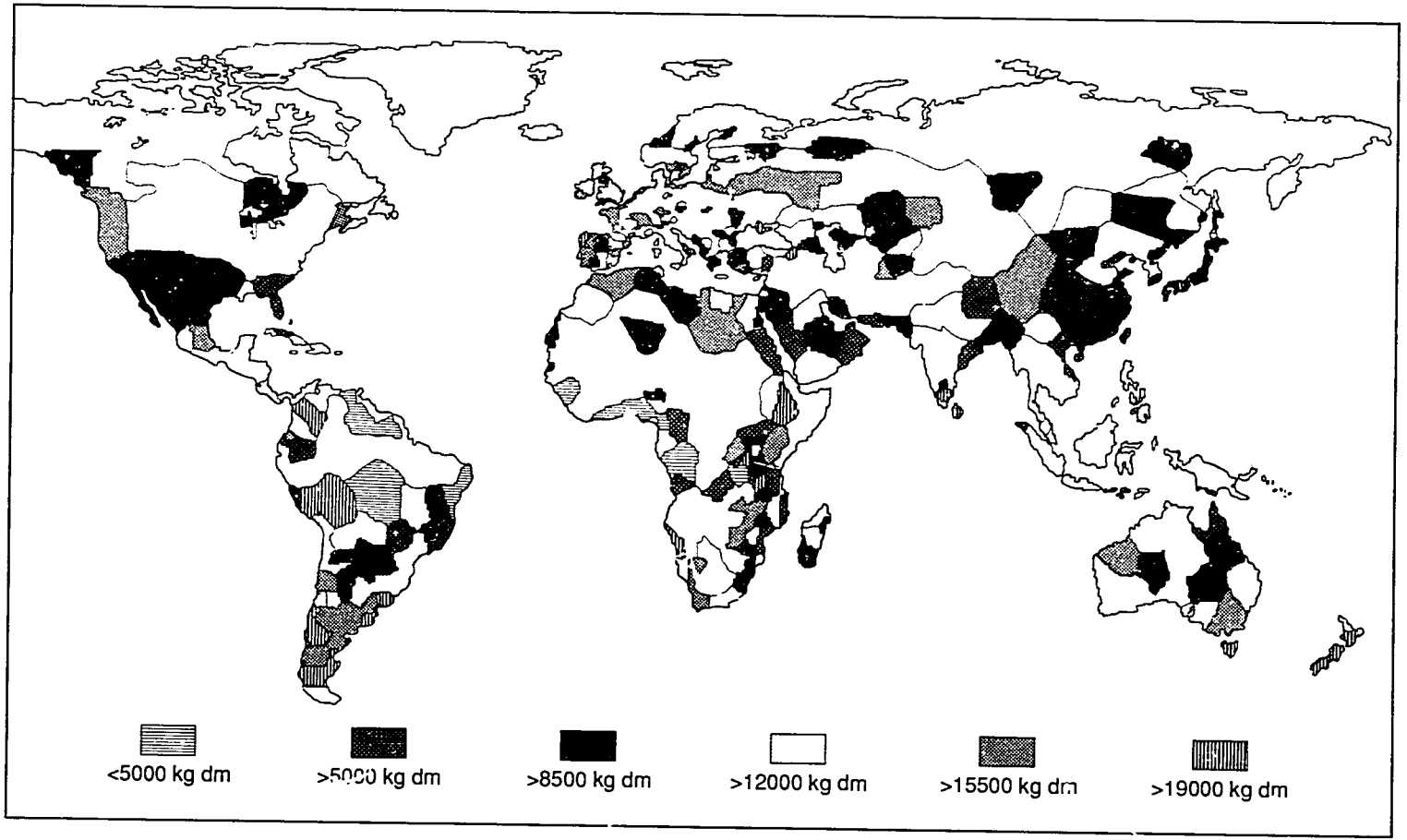
Potato Intercropping Systems

Intercropping potato with other crop species is a prevalent practice in the tropics, but it is largely based upon non-documented farmer experience. Improvement of indigenous systems and the creation of systems appropriate to future potato-production zones in hot areas require a clear understanding of their physical and biological interactions.

In November 1990, a definitive synthesis of research on potato intercropping was published in *Field Crops Research* (Vol. 25 (1,2), 1990). The papers in that issue were the result of a symposium on intercropping with potatoes in the tropics, held in Kunming, China, and cosponsored by the Asian Potato Association, CIP, FAO, the Chinese Academy of Agricultural Sciences, and other institutions in China. The authors provided basic information on the present status of intercropping with potato, giving specific examples from contrasting agroecological zones. Their results help to unravel, in part, the complexities of intercropping systems involving the potato, and assist in progress towards increased food production from land already under cultivation.

Four intercropping systems suitable for the potato that minimize the influence of interspecific competition, while maximizing the use of wasted resources by one or other component crops, were identified: I relay-cropping potato into an existing annual shade crop; II intercropping with perennials; III intercropping with annuals; and IV relay-cropping an annual shade crop into an existing potato crop.

The specific cooling effect of shaded soil on crop emergence under conditions of high soil temperature in system I, and on the detrimental effect of high temperature late in the potato cycle in system IV, were noted. In addition, utilization of available solar energy is enhanced. Intercropping with perennials (system II) and



Map 1-1. Agroecological zoning for potential yields (dry matter is about 20%) of *Solanum* spp. for climate-by-soils zones based on highest yielding season.

annuals (system III) represent systems with possibilities for manipulation of crop cultural practices in the dominant crop. These range from limited (e.g., in plantation tree crops) to almost limitless possibilities (e.g., in pruned alley crops) with a concomitant range of management decisions.

A potato crop in the tropics may withstand reductions in the receipt of irradiance of up to 25% for extended periods with negligible yield decline. Selection of clones adapted to this level of reduction may be made under sole-crop conditions. With further reduction in irradiance, differences in genotypic ability to tolerate shade are expressed. Therefore, it was suggested that, to increase total productivity beyond that attributable to temporal complementarity and efficient use of photosynthetically active radiation, incorporation of shade tolerance will be necessary.

Farmer Preferences for Clonal Traits in the Bolivian Andes

Farmers in the Bolivian Altiplano (generally 3,000 m) tend to own less than 5 ha of land (cultivated on a rotational basis), have an integrated crop-animal ecosystem, seasonal migration, low incomes, and little or no access to inputs or credit. Quechua—and Aymara—speaking communities in most of the highlands organize the use of grazing, farm and irrigated lands, social policy, and political participation through group meetings and consensus. Men predominate at these meetings.

Under such conditions, special efforts have to be made to incorporate farmers' preferences, particularly those of women, in technology design. This study focused on farmer participation in clonal selection of potatoes, primarily with resistance to late blight. Farmers evaluated this advanced clonal material in a locational (field) trial carried out by the Breeding and Phytopathology Departments of PROINPA in 1990-1991.

Participating farmers came from two potato-producing zones in Cochabamba province with high incidence of late blight. The participants (13 men and 7 women) were selected by consensus during meetings among members of seven communities. Scientists requested that at least one participant from each community be a woman farmer. The communities were also requested to select farmers known for their agricultural ability in potato production, their demonstrated willingness to share their knowledge with other farmers, and the ability to participate for three days in the field investigation.

Farmers evaluated tubers from different clones before and during flowering as well as at harvest. Prior to and in full flowering, thick stems, lack of leaf disease, plant height, growth habit, color of leaves (darker preferred) color of existing flowers (associated with known varieties), high stem count, and leaf width were the most cited characteristics in descending order. Farmers' and scientists' notions of plant health and vigor converged for most characteristics.

At harvest, the 20 farmers selected a total of 39 clones of the 138 originally planted, while scientists' final selection totaled 43. Of these, 23 clones were the same for both groups (X mean yield ($\bar{x}$) = 937 g/plant), including the 10 clones most frequently chosen by farmers at harvest ($\bar{x}$ = 993 g/plant). Overlapping selections were generally higher yielding and free of evident disease or insect problems. Where farmer and scientist selections diverged,

farmer selection ($\bar{x}$ = 706 g/plant) most often relied on skin color, form, size and number of eyes in relation to market characteristics, while scientist selections ($\bar{x}$ = 664 g/plant) were more dependent on resistance to *Phytophthora infestans* or other desirable morphological qualities for future breeding.

Postharvest evaluations of culinary quality, cooking time, dry matter and other sugar content were carried out on the 10 clones most often selected by farmers at harvest. Frequency of farmer choice of these clones before and during flowering was tallied with that at harvest. Preliminary results are presented in Table 1-1. Of the 10 clones, perhaps 5 have good potential for multiplication in farmers fields. Clones 382146.15 and 386105.8 require too much cooking time (56 and 57 min), particularly in the fuel-scarce highlands. Clone 381403.30 has an unacceptably bitter flavor. Ratona's yield is too low. The two clones selected most for their plant characteristics, 79-918-1x282-11-1 and 84-75-16 are watery, good flavored with moderate cooking time. These two show most promise for initial on-farm, farmer-led trials.

Table 1-1. Characteristics of the ten clones most frequently selected by farmers at harvest in a clonal trial for resistance to *Phytophthora infestans*, Cochabamba, Bolivia, 1990-91.

Clone No.	Kg/plant (No. plants of 10)	Culinary characteristics	Color		Cooking time (3500 m) minutes	Dry matter %
			Skin	Flesh		
375333.1	1.06 (7)	Watery Flavorless Regular	Purple	White	39	19.2
79-918-1x 282-11-1	0.97 (10)	Watery Good	White	White	39	20.2
381382.34	0.78 (8)	Floury Good flavor Very good	White	White	36	18.1
382146.15	0.99 (9)	Watery Good	White	White	56	20.2
84-75-16	1.06 (10)	Watery Good	Purple/ white	Cream	43	23.4
386105.8	1.28 (8)	Watery Regular	White	Cream	57	19.2
676008	1.10 (9)	Excellent Floury The best of 10	Rose	Yellow/ purple	25	25.4
371379.121	0.83 (9)	Floury Very good	Rose	Cream	44	22.2
Ratona	0.25 (10)	Floury Very good	Purple	Cream	35	20.2
381403.30	0.87 (8)	Watery Flavorless Bitter	White	White	35	19.2

The attendance rate of participants during the investigation was over 95%. There appeared to be no significant difference between production zones, or men and women in terms of characterization of plants or potato tubers, either in relation to characteristics cited or to overall number of observations. However, women's attendance at meetings to discuss research procedures and results was much higher than at initial meetings, indicating that the diffusion of information to women and their interest in participation increased. Hundreds of farmers attended a slide presentation about this study.

In 1992, research will continue with farmers in the two zones being provided with 10 or more tubers of the promising or moderately acceptable clones, as well as a few new frost-resistant clones. Concurrent trials are being carried out by the Breeding Department of PROINPA in conjunction with experimental stations and other institutions in various areas of Bolivia.

Characterization of Sweetpotato Production Constraints and Opportunities

The primary objective of this project is to review, generate, and synthesize information on important sweetpotato production systems in Asia, Africa, and Latin America. Such information aids in deciding in which disciplines to invest, on which problems to work, to which regions to allocate resources, where more in-depth information on problem identification is needed, and how sweetpotato research should be structured.

A second objective is to enhance national program capacity for diagnostic research on production constraints and farmer preferences. Training workshops and methods development are fundamental to this objective.

Asia. Based on the results of UPWARD (User's Perspective with Agricultural Research and Development) network research projects in several Asian countries, three general sweetpotato production systems have been identified: intensive, commercial production; extensive, largely subsistence production; and household gardening.

Intensive Commercial Production

The Philippines. Approximately 10-15% of farms cultivating sweetpotato sell more than 90% of their production and can be termed commercial sweetpotato producers. The majority of sweetpotato growers consume the bulk of their production, but they also sell about 35%, on average. Only home garden owners can be considered truly subsistence-oriented in their production strategy.

Commercialization is accompanied by a decline in varietal diversification. Typically, Filipino commercial farmers plant from one to three varieties, while more subsistence-oriented farmers sow from three to seven. Commercial farmers often use introduced varieties; such usage is rare among more extensive, subsistence-oriented farming households.

Commercial farmers are interested exclusively in sweetpotato roots, while both

types of subsistence farming families use the roots and the tips (as a green vegetable).

Nepal. Sweetpotato is of minor importance, and marketing of the crop is common. It is estimated that more than 90% of production in the plains is sold at market. Harvests occur between October and February, covering the period of two major festivals when grains are rarely eaten. Sweetpotato is bought, sold, and bartered for home consumption and as an offering to the gods.

Extensive, Largely Subsistence, Production

This production system is often located on hillsides. It is a generally established practice among ethnic minorities living in various upland areas of the Philippines, Indonesia, Papua New Guinea, and probably other areas. These groups represent the true "sweetpotato cultures" of Asia. Several studies in the Philippines have focused on such groups and especially on the changing role of sweetpotato brought about by new socioeconomic and policy factors. As population increases and fallow periods are reduced, sweetpotato yields decline. At the same time, growing need for money has lead to the introduction of cash crops, such as vegetables, where climate and topography permit, or to agricultural or non-agricultural out-migration.

The Philippines. A new project explores to what extent user-focused research and development can rapidly respond to emergency needs in a typical hillside, extensive production system. The work concerns the reestablishment of farming practices by ethnic minority groups whose cultivable lands were destroyed by the Mount Pinatubo eruption in June 1991 and who depended on sweetpotato as a co-staple with rice. The project is making available new varieties of sweetpotato which farmers choose from the local agricultural station. These varieties are planted out in home gardens for multiplication. The research team works with the farmers in evaluating the material to identify suitable varieties for transfer to the new swidden farms.

In the Cordillera region of the Philippines, the emphasis of government agricultural development policy on corn and rice is partially responsible for the stagnation of sweetpotato production in the area. Resource management policies and programs designed to stimulate reforestation also have an adverse impact on sweetpotato in upland swiddens.

Home Gardens

The Philippines. Home gardeners rarely sell more than 10% of their crop. Home garden sweetpotato growers rely heavily on non-farm income, suggesting that sweetpotato is an important contribution to food needs for families otherwise depending on purchased food.

Research among urban slum dwellers in the central Philippines investigated sweetpotato grown in pots as a source of green vegetables for households with very low incomes, no space for a home garden, and often limited direct sunlight. Different types of cultivars were tested for leaf quality and resistance to leaf-eating pests, different receptacles assessed, and a range of freely available household "fertilizers" were tried. Early technology acceptance studies of the families who had participated in the experiments indicated continuing and expanded use of pot gardens.

Across Systems Research

The Philippines. Investigations on the development of "memory banking" as a complement to genebanking continued. Memory banking involves the systematic documentation of indigenous knowledge and technologies associated with local varieties in order to produce an archive of local knowledge resources which will be available for future generations.

The first phase of the project drew to a close having established herbarium specimens of local varieties, in vivo germplasm collections at three ex situ sites, local drawings of varieties, technical drawings of varieties, a file of local (farmer) evaluation criteria and technical characterization, a file of indigenous beliefs and practices associated with sweetpotato production and utilization, taped life histories of senior farmers, and agricultural calendars.

UPWARD countries. Several other projects in the Philippines and in Sri Lanka have also studied management of and knowledge about varieties as a part of their activities. While results clearly show sophisticated knowledge about varieties, they also reveal problems in maintaining seed of the range of varieties and in obtaining new varieties.

Marketing is one of the major farming-system roles played by women.

Marketing overviews were included in most of the general food system studies carried out in five regions of the Philippines, in the main sweetpotato-producing area of Sri Lanka, in several locations in the hills and plains of Nepal, and in most regions of Thailand. The most surprising finding is the extent to which the crop is marketed and its consequent importance as a small scale income earner.

Marketing channels are complex, with up to four tiers or levels. Many actors in the system perform on more than one level: farmers may also be assemblers, assemblers are frequently also wholesalers, and retailers sometimes obtain supplies directly from producers.

The Philippines. Research into the contribution of sweetpotato to vitamin A needs of pre-school children showed how variable its role is depending on the season and the location. In central Philippines, neither roots nor leaves make a contribution to the vitamin A supply for pre-school children during July. The crop's relative contribution to Vitamin A needs is of much greater importance in the northern highlands where the sweetpotato root is one of the major foodstuffs. Though sweetpotato leaves were not consumed in any quantity, probably because of the large choice of other green vegetables, the roots contributed more than 10% of total retinol equivalent score for some children.

Studies of small scale processing suggest that for some families this is an important source of income, as high as US$280 per week in the case of small enterprises making candies, and around US$20 for a single woman making sweetpotato patties. But, overall, the volume of sweetpotato involved in this processing is very small, and it does not represent a major opportunity for producers.

Knowledge of gender patterns in work activities is important to assess the prospects for adoption of different types of technologies and their consequences on households and individuals in society. Gender is an integral component in several of the research projects supported by UPWARD. In particular, activity profiles and time allocation were studied in two contrasting sweetpotato-growing cultural regions of the Philippines. One site was a Tagalog-speaking village in Quezon; the other was located in a Maranao-speaking area in Northern Mindanao.

In spite of differences in religion and culture, the gender division of labor in sweetpotato production, processing, and marketing was quite similar across the two study sites (Figure 1-1). Men specialize in production activities, and women figure prominently in marketing, processing, and storage.

Africa. In characterizing sweetpotato production systems, 1991 was a year of sowing the seeds for a crop of surveys to be harvested in 1992. In Tanzania, meetings were held with researchers from the national program and from universities to organize a national survey project. Surveys of farmers will be combined with the collection and the preliminary evaluation of sweetpotato varieties. In Uganda, field work on a national survey of 10 districts will be completed by the national sweetpotato research program in March 1992. Similar work on a national survey of 1,250 households in Rwanda will be finished by the Ministry of Agriculture's survey team in 1992 as well.

In Burundi, a sweetpotato survey in 40 villages using group interviews was carried out in collaboration with COSCA—the IITA/CIAT/Rockefeller Foundation research project on cassava which is being

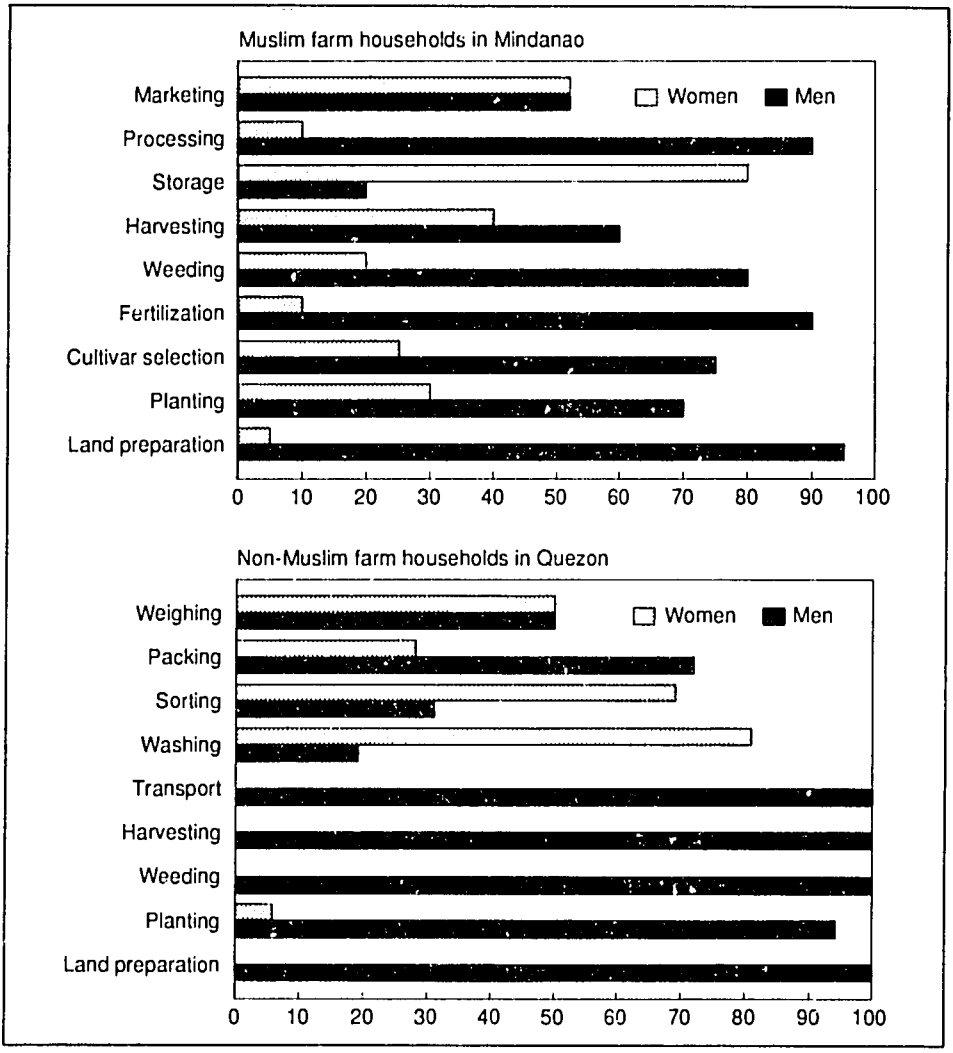


Figure 1-1. Gender division of labor (%) for sweetpotato activities in two sites in the Philippines.

financed in Burundi by the East and Southern African Root Crops Regional Network (ESARRN). CIP has been assisting with the design and analysis of the sweetpotato questionnaire. A similar survey in Kenya, based on group interviews in 30 villages, was carried out in collaboration with COSCA. It will complement data collected by CIP and KARI in 1989 (see CIP Annual Report 1990). Field work was completed in 1991.

Economic Loss Assessment of Sweetpotato Weevil

Globally, the sweetpotato weevil (SPW) is the most important pest of the crop. Weevil infestation results in quality and weight losses to damaged roots. In spite of the widely recognized importance of the pest, reliable estimates of the size of quality and weight losses are not readily available.

The Dominican Republic. From March through December 1991, several methods were developed and intensively tested to assess the economic and agronomic importance of the SPW, *Cylas formicarius elegantulus*. Sweetpotato farmers in two major producing regions were visited twice, immediately before harvest and several weeks later after the production was sold. The first visit permitted damage measurement in a randomly selected sample of plots; and information was elicited on the production system and its cost. During the return visit, information on sales was gathered.

Two innovative features of this economic loss assessment were the detailed treatment of partial damage and the explicit consideration of the weight loss in damaged roots. The results showed that assessment of the size of economic loss was sensitive to information on these two aspects.

In the Dominican Republic, sweetpotato is marketed as Grade A export, Grade A domestic, Grade B domestic, and animal feed. This market classification is affected by weevil damage, as well as by damage from other pests and disease. The size, shape, and appearance of the root also affect quality.

As a result of information gathered during the pretests, 21 different categories were defined to capture different levels of partial and total economic loss (Table 1-2). It was also assumed that roots with severe weevil damage could not be sold as animal feed, due to their bitterness.

The need to adjust the estimates for weight loss reflecting larva tunneling

Table 1-2. Economic categories used to assess sweetpotato weevil damage in the Dominican Republic.

Grade A export marketable
Grade A export sold as Grade A domestic, due to superficial SWP damage
Grade A export sold as Grade A domestic, due to superficial damage from other pests or disease
Grade A export sold as Grade B, due to mild to moderate SPW damage
Grade A export sold as Grade B, due to mild to moderate damage from other pests or disease
Grade A export sold as Grade B, due to severe damage from other pests or disease
Grade A export not marketable due to severe to total SPW damage
Grade A export not marketable due to severe or total damage from other pests or disease
Grade A domestic marketable
Grade A domestic sold as Grade B, due to mild to moderate SPW damage
Grade A domestic sold as Grade B, due to mild to moderate damage from other pests or disease
Grade A domestic sold as animal feed, due to severe damage from other pests or disease
Grade A domestic not marketable due to severe or total SPW damage
Grade A domestic not marketable due to severe or total damage form other pests or disease
Grade B marketable
Grade B as animal feed, due to severe damage from other pests or disease
Grade B not marketable due to severe or total SPW damage
Grade B not marketable due to severe or total damage from other pests or disease
Animal feed marketable
Animal feed not marketable due to severe or total SPW damage
Animal feed not marketable due to severe or total damage from other pests or disease

through damaged roots also became apparent during data collection. Damaged roots weighed significantly less than undamaged roots of the same size and shape.

Estimates from the San Juan Valley, the second largest sweetpotato producing region in the Dominican Republic, are suggestive of the size of economic losses and of the importance of including information on partial quality losses and on weight reduction of damaged roots. Incorporating both corrections gave an estimate of weevil damage of US$88 per hectare. Production destined for animal feed sold at only 14% of the Grade A-export price. Production Grade B-domestic market fetched 27% and production Grade A-domestic market was 82% of the Grade A-export price.

The use of a more aggregate quality classification (marketable, not marketable due to weevil damage, and not marketable due to other damage) led to overestimates approaching 65%. In contrast, failure to include weight loss reductions from damaged roots resulted in a 29% underestimate of weevil damage.

Economic losses were highest in months when prices were higher and growing conditions drier. Economic losses were highly and positively correlated with yields. On average, 39% of production was damaged by the weevil. This level of damage translated into a 40% decrease in producers' income.

Extrapolating these average losses suffered by the 31 farmers in the sample from the San Juan Valley to the country as a whole, the weevil annually costs the Dominican Republic about US$600,000. The weevil is widespread in the Caribbean and Central America. If the results from this case study are representative for the region, the total economic benefits from effective weevil control would amount to about US$15 million.

Adaptation and Integration of Potato Production Technologies

Four agroecologies (Subtropical Lowlands, Temperate, Highlands, and Arid-Mediterranean) account for 98% of potato production in the developing world. By breeding for multiple traits in its advanced populations, CIP provides a broad range of durable protection against biotic and abiotic stresses that often interact to reduce the impact of single-factor resistance and desirable agronomic traits. To date, potato breeding populations combine: resistance to potato leafroll virus (PLRV), PVX, and PVY with heat tolerance, for the warm Subtropical Lowlands and the Arid-Mediterranean region; resistance to late blight, PVX, and PVY, for use across all potato growing agroecologies; resistance to late blight and cyst nematode, for the Temperate and Highland areas; and resistance to *Alternaria*, PVX, and PVY with heat tolerance, for the Subtropical Lowlands.

The integration of these multiple resistances with IPM and agronomic practices will also receive attention. Over the medium term, attention will shift from potato intercropping to novel multiple and relay-cropping systems, which often stretch the limits of crop adaptation.

The overall objectives are to generate and monitor advanced potato materials adapted to specific agroecologies, and to integrate component research into improved cropping systems for verification in well-defined production environments.

Advanced Potato Materials Adapted to Specific Agroecologies

Peru. During 1991, two potato populations were evaluated at La Molina and San Ramon to identify: superior progenitors with high general combining ability (GCA) for yield, earliness, tuber quality, and adaptation to warm and hot environments combined with resistance to the most important diseases (i.e., PVX, PVY, PLRV, bacterial wilt, late blight, and early blight); and, to identify superior progenies to be used by NARS for variety selection. The first population was assembled as 17x4 line by tester mating design, where the lines were duplex PVY-immune and the testers carried other resistances. The best line for heat tolerance, yield and earliness at both locations was YY-13. YY-3 and YY-11 were excellent at San Ramon and YY-16 at La Molina. The second population was assembled in a 12x3 line by tester mating design where the lines were PLRV-resistant and the testers PVY- and PVX-immune. The best lines for GCA at both locations were 88018 and 88146. The tester XY.9 proved to be excellent. The highest-yielding, earliest-maturing and most heat tolerant progenies also combining resistance to two or three diseases were, at San Ramon, YY-3 x XY-9, 88052 x XY-9, and 87031 x XY.4. At La Molina, the best was YY.13 x AVRDC-1287.19.

As a result of this project, a group of 40 clones and progenitors selected for yield, tuber quality, and resistances have been cleaned-up from diseases for use in CIP breeding activities and NARS. Of these clones, two are immune to PVY, two to PVX, 18 to both PVY and PVX, three are resistant to PLRV, and six have high dry matter and low reducing sugar contents and are good for processing as chips and french fries.

A set of 46 tuber families from the CIP-INRA (Institute National de la Recherche Agronomique) cooperation project were field-evaluated during the hot summer of 1991 under arid conditions at La Molina and compared to five European cultivars used as controls. At 90 days after planting, the 12 top tuber families yielded from 15 to 20 t/ha, while controls Desiree, Claustar, Spunta, Ackersegen, and Fanette, yielded from 6.6 to 12 t/ha.

An important activity within this project is the breeding for tolerance to frost, early maturity, wide adaptability and other major constraints of the highlands as late blight, cyst nematodes and viruses. Testing and selection of clones with frost tolerance and good agronomic characters is conducted year-round at high altitude locations in Peru. Crosses of frost tolerant clones and sources of resistance to the potato cyst nematode are also routinely made. Of the 135 frost-tolerant clones passed to the Peruvian potato program, seven were selected with yields over 2 kg/plant and are now undergoing multiplication for use in regional trials.

The Philippines. Yields of CIP clones LT-7 and 378597.1 have been consistently as high as those of Sequoia, Cosima, Katahdin, and Red Pontiac cultivars, as is attested to by evaluations made at Canlunbang (150 m). Diffuse light storage (DLS) of 229 tuber families for nine months, resulted in yields of over 30 t/ha in 28 cases, while yields of over 40 t/ha

were obtained from 4 families: 385145.1 × 385152.32 (48.2 t/ha), 385110.59 × 384071.17 (48 t/ha), 385080.3 × TPS 13 (44.5 t/ha), and 385110.59 × LT-7 (43.6 t/ha). The cultivar Cosima (from cold storage) used as control yielded only 18.2 t/ha.

A total of 39 advanced clones selected at Canlunbang and Cagayan were tested for yield and long storability in DLS, using rooted cuttings and 16 of them yielded over 20 t/ha. The highest yielders were the CIP clones 385130.11 (29.4 t/ha), 385132.10 (25.4 t/ha) and 385114.31 (25 t/ha) while Cosima (from cold storage) yielded 20.7 t/ha.

Twenty-two clones selected for long storability in DLS and high yield in Canlunbang and Cagayan were evaluated in farmers' fields in three sites at the Cagayan Valley. The top yielders were 385144.31 (B-71-240.2 × Y84.005) with 30.6 t/ha and 385130.11A (Y84.025 × 378015.16) with 29.3 t/ha. Farmers selected several of these clones and we are multiplying them for further on-farm trials. Also several clones were provided to SAPPRAD.

Fiji. In trials conducted with the collaboration of the Sigatoka Research Station, the potato clones 384071.3 (Atzimba × NDD-277.2), originally selected in Vietnam; 377850.1 (BR-63.74 × DTO-28), local selection; and 384558.10 (A4.17 × LT-7), selected in Philippines, were found to be the best yielders. The clone 377850.1 may be released as a new cultivar and seed production is underway.

New Caledonia. Clones 24.16 (B-71-240.2 × DTO-bulk), 379667.421 (377831.5 × M.Tropical), and 378597.1 (TD 38.8 OP) had consistently high yields at two locations.

Taiwan. There are two very good PVY-immune clones selected from CIP materials. After six years of testing these two clones are now in multiplication.

Bolivia. The Bolivian national program is benefitting from enhanced frost-tolerant cultivars. This year the Bolivian program received 50 progenies with 10,000 seeds for evaluation and selection of frost-tolerant clones.

Potato in Rice-based Cropping Systems in East Africa

The traditional center for potato production in East Africa is the higher altitude zone of the Zaire/Nile divide. Agroecological conditions such as cooler temperatures and abundant rainfall are especially favorable for potato cultivation.

In response to increasing population density, potato production has gradually gained importance in rice-based cropping systems in the swamps. Heavy land at the bottom of the toposequence is reclaimed in a very labor-intensive mode of production.

Farmers plant rice during the rainy season, and beans, corn, and sweetpotato in the dry season. Farmers want a more profitable dry-season crop, with a short cycle of 3-4 months.

Since 1987, the Burundi potato program has conducted trials in swamps with selected existing varieties. The results are very promising, indicating that about 40% of Burundi's potato production could be grown in the swamps during dry season.

In 1990 and 1991, more on-farm verification trials were carried out in rice fields in several swamps at three locations in Burundi. The varieties Muruta

(380506.10), Kinigi (378699.2), P.3 (374080.5), and the advanced clone BU 85058 were planted in each swamp after the June-July rice harvest. Potatoes were harvested in September-October. Chemical fertilizer (60-90-60 NPK) was applied at a rate of 350 kg/ha to a standard 100 m^2 plot. Phytosanitary control was used only for insects, such as leafhoppers and cutworms.

High yields in these trials confirmed earlier results. In the highest-yielding location at Ngozi, the average yield on the four farmers' fields included in the trials was 31 t/ha in 1990 and 30 t/ha in 1991 (for nine participating farmers). In the two other locations, average yields ranged from 12 to 17 t/ha per year.

More applied and adaptive research, particularly soil fertility research and agroclimatic base data analysis, is needed before these systems can be reliably transferred to other heavy wetlands of the East African highlands. Nonetheless, the 1990 and 1991 trials amply confirm the potential for potatoes to contribute to food production in response to population pressure.

Adaptation and Integration of Sweetpotato Production Technologies

This project has two main objectives. The first is to comprehensively analyze and report the results of international testing of elite germplasm so as to gain an understanding of the value of germplasm selected in certain environments (agroecologies) to varietal selection programs elsewhere. This information should make sweetpotato breeding more efficient at the regionally, nationally, and globally.

The second objective is to promote, assist in, and report on the selection and dissemination of new varieties by partners in the developing world. Activities include the identification of important selection criteria, and regional- and on-farm testing. To increase efficiencies, a participatory approach involving farmers is encouraged.

Overview and Analysis of International Germplasm Testing

During 1991, a significant amount of pathogen-tested, advanced germplasm from diverse sources, either as clones or as seed populations, was distributed for testing to national programs and CIP regional breeders from CIP headquarters, the CIP regional redistribution center in the Philippines, and North Carolina State University, under a CIP research contract. Additionally, the SAPPRAD cooperators are participating in an international germplasm exchange, using clones cleaned up by the Plant Research Institute, Australia.

Because germplasm is being transferred both as seed populations and as clones, a comparison can be made of the efficiency of the two methods for transfer of elite germplasm. Clean-up of clones is a lengthy and expensive process. Furthermore, shipment of clones in vitro is expensive, and losses may be high during shipping, or during transfer from in vitro to in vivo. In contrast, seed presents few quarantine problems, and large numbers of genotypes can be distributed at a low cost.

Information about the performance of internationally distributed elite germplasm is still very incomplete. Through systematic monitoring, we expect to make a much more comprehensive evaluation of the performance of internationally distributed germplasm in the coming years.

Peru. The performance of seed introductions from various sources at Yurimaguas (humid tropics, with low base status soils) has been reported in previous Annual Reports. Evaluations of seed introductions continued during 1991. To date, seed families comprising a total of about 2,500 individuals from AVRDC (Subtropical Lowlands), IITA (Semiarid Tropics), two Chinese programs (Subtropical Lowlands and Temperate), Vietnam (Humid Tropics), Japan (Temperate), USA (Temperate), Puerto Rico (Semiarid Tropics), Rwanda (Highlands), Tonga (Humid Tropics), and South Africa (Subtropical Lowlands) have been evaluated. Individuals with high, early yields of attractive roots were selected from each of these sources for varietal selection, and for contribution to broad-based breeding populations.

Evaluation of pathogen-tested elite clones and varieties has begun at sites in Peru, but results obtained so far do not permit a comprehensive analysis with respect to the adaptation of clones from different origins to different agroecologies, nor to the relative efficiency of seed versus clonal distribution of germplasm.

The adequate performance at Yurimaguas of seed populations from various agroecologies (including temperate regions where photoperiods vary markedly during the growing season), may indicate that very specific physiological adaptations to agroecological conditions (such as photoperiod sensitivity) either do not exist in sweetpotato, or may be easily overcome through selection among segregating progenies. More analysis will be necessary before conclusions can be reached.

The Philippines. Thirty-six elite introduced clones were evaluated at Canlunbang, a Humid Lowlands site. Nine of the clones came from Papua New Guinea, four from Taiwan, one from the USA, one from Korea, 10 from Vietnam, and 11 from the Philippines). The trial was harvested at 90 and 120 days after planting. Two Vietnamese clones (B007, B008), three clones from Papua New Guinea (PNG 6, PNG 135, and PNG 295), and one from the Philippines (L002) had early, high yields.

In SAPPRAD-sponsored multilocational trials, which compared introduced and indigenous cultivars at five lowland locations during the wet and dry seasons, clones from AVRDC, Papua New Guinea, and Puerto Rico were among the top performers at each location. Yields of clones L383 and L390 (CN 1038-16 and CN 1108-13) were outstanding. Clones selected for superior quality as food were from Puerto Rico (Papota) and Papua New Guinea (L318 from the lowlands, and Gonime from the highlands).

East Africa. Over the years, high yielding, elite clones from IITA have been evaluated by national programs in both highland (e.g., Rwanda and Uganda) and semiarid (e.g., Tanzania) agroecologies in this region. In general, initial evaluations identified introduced clones with high yields, but over subsequent years, these were progressively infected by viruses, and yields declined. Furthermore, lack of desirable taste characteristics has impeded the release and adoption of these clones as

varieties. The introduced germplasm has nevertheless been used to contribute sources of high yields and earliness to national breeding programs.

Under the auspices of ESARRN, true seed populations produced by the Rwandan (Highlands) national program were evaluated at Ukiriguru, Tanzania (Semi-arid Tropics), and several promising clones were selected for further evaluation.

The results in East Africa tend to support the conclusion that, especially in the case of germplasm transfer as seed populations, adaptations to climatic and edaphic (agroecological) conditions may not be as limiting to breeding success, as resistances to diseases and pests, and quality characteristics related to consumer acceptance.

Selection and Dissemination of New Sweetpotato Varieties

Peru. A new variety named Alto Urubamba (CIP clone ME12) was jointly released by the National University of San Antonio Abad of Cusco, and the Upper Urubamba Agricultural Production Cooperative. The variety is highly resistant to root-knot nematode, and matures in 3-4 months, in contrast to 7-8 months required by the local varieties. In addition to high yields, Alto Urubamba has taste quality characteristics preferred by the regions' farmers and consumers, and is thus in high demand.

The variety Jewel, introduced from the USA, will probably be released soon by INIAA. This variety produces high, early yields at important production locations on the Pacific coast, and in the Amazon basin.

Egypt. Clones NCSU 925 and NCSU 1135, introduced from North Carolina State University, USA, and which outyield local varieties, continue to find good acceptance among farmers and consumers. NCSU 925 has been released as a variety, and seed multiplication by the public and private sectors is underway. In 1991, about 40 ha were planted to these new materials; the area projected for 1992 is 200 ha.

Indonesia. A small set of advanced clones entered regional trials at five locations on the island of Java under varying climatic conditions. BIS 183, the most promising clone from previous years' trials, was evaluated in farmers' fields in two commercial production areas: Kuningan, west Java, and Magelang, central Java. The clone performed well in both locations. As well, a marketing and preference study assessed its market potential in Magelang. BIS 183 was judged by traders to have good skin, flesh, and shape characteristics similar to those of Magelangan, one of the most popular local varieties. Consumers were asked to rate both boiled and fried roots. The clone found higher acceptance among higher income urban consumers than among rural consumers.

India. Work is conducted in collaboration with the Central Tuber Crops Research Institute (CTCRI), and feeds into the All India Coordinated Root Crop Improvement Program. Adoption of two varieties selected by CTCRI, Sri Vardhini and Kalmegh, was accelerated this year at Sonepat near Delhi, and in Ganwa-Badaun in central India. Sri Vardhini outyielded local varieties by 100-150%, and was ready to harvest 20-25 days earlier. High farmer demand for planting material could not be satisfied, and multiplication efforts have been stepped up.

The Philippines. Researchers and farmers from six provinces of Luzon participated in a two-day workshop to study farmers' selection criteria. Farmers evaluated 37 cultivars based on root and foliage characteristics. Taste tests were also carried out. Preferred varieties had broad, purplish undamaged leaves, and high yields of smooth, uniform, red-skinned, yellow-fleshed, medium to large (250-500 g), ovate roots. Preferred cooked roots were sweet, with a dry, fine texture.

Sri Lanka. Under a SAPPRAD project, three improved Central Agricultural Research Institute (CARI) varieties (CARI-426, CARI-9, CARI-273) and a commonly grown local variety (Wariyapola) were evaluated in multilocational trials during the northeast and southwest monsoon seasons. The CARI varieties showed wide adaptability under a range of production systems, including rice-fallows stand with coconut, open-land upland, river valley basins, and home gardens.

CARI-426 outyielded all other varieties at all locations and seasons. It produces attractive pinkish-orange roots, with deep orange flesh color. However, because of its moist texture, the variety is unacceptable to some consumer groups.

Evaluation of the Impact and Sustainability of Potato Production Technologies

The objectives are: to quantify the agronomic, economic, social, and environmental effects of improved potato technologies; to document the rate of return to CIP's research; and, to determine the climatic, edaphic, economic, and social conditions leading to large off-site environmental effects threatening to the sustainability of improved potato technologies.

Environmental Effects of Intensive Pesticide Use

Among major field crops, potato cultivation uses the most pesticides. Interdisciplinary study was started in 1990 to assess the impact of the use of these pesticides in Carchi, an intensive, year-round, commercial potato-producing area in northern Ecuador. Three types of impact were defined: production, environmental, and health. The use of pesticides has an obvious positive effect on potato yields, but their use is also widely assumed to pollute the environment and cause health problems.

The project includes economic, physical and health-related aspects. The economic component features the monitoring of field-level production practices of a sample of farmers. Information is gathered on the types, rates, and timing of pesticide use.

In northern Ecuador, late blight (*Phytophthora infestans*) is the most important disease, and the study recorded the use of 34 different fungicides for its control. However, the farmers overwhelmingly select products with mancozeb as the control agent of choice (Figure 1-2).

The larvae of the Andean weevil (*Premnotrypes vorax*) and flea beetles (*Epitrix spp.*) are the major soil and foliage insect pests. The study documented the use of 25 insecticides for their control. Products with methamidophos are commonly

used for the leaf insects, and carbofuran for the Andean weevil (Figure 1-2).

The data from the 196 potato fields monitored in 1990 and 1991 reveal that farmers spent on average about US$120/ha on fungicides and about US$60/ha on insecticides at 1991 prices. These expenditures correspond to about 10% and 5% of the total costs of production, respectively.

The effectiveness and efficiency of pesticide use will be examined after data collection is completed. The data are used by as a starting point for physical and medical research. The former is well advanced while the latter is just starting. The medical research will focus on farm worker safety during pesticide handling and application, rather than on the long term effects of consuming contaminated food or water.

The pesticides that are applied to farm fields become an environmental problem once they leave the field. After consideration of all possible pathways for off-site effects of pesticides, work in the physical component has concentrated on leaching to groundwater as the most important.

A limited number of field samples was obtained and simulation modeling used to estimate the fate of pesticides in a variety of unstudied conditions. Preliminary results of the modeling exercise show that only very low levels of pesticides accumulate at the bottom of the root zone and could be possibly delivered to groundwater. Environmental contamination by leaching of pesticides to groundwater is

A view of the watersheds being studied for pesticide use, Carchi, Ecuador.

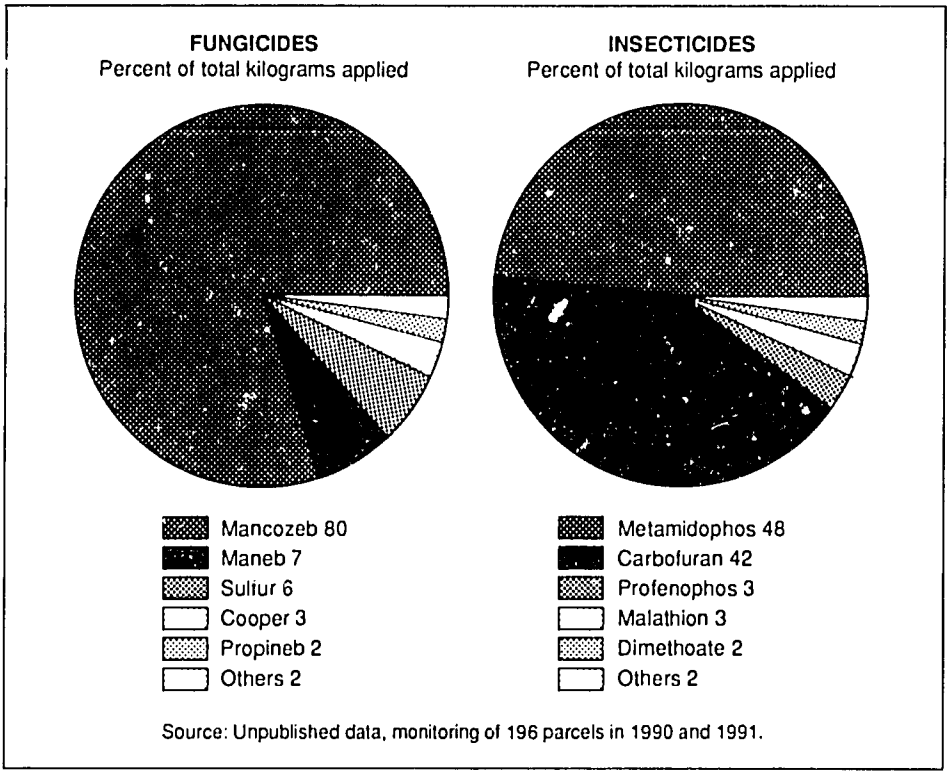


Figure 1-2. Active ingredients of chemicals applied in potato production in Carchi, Ecuador (monitoring of 196 parcels in 1990 and 1991).

apparently unimportant. Key factors for this result are the high organic matter content of the soil which increases its sorption capacity and the short persistence of the chemicals. In other intensive, commercial potato-producing regions with different pesticides and soils, leaching of pesticides to groundwater may be important.

Priority Setting

In November, CIP conducted a priority-setting exercise of its restructured portfolio of research projects, with the guidance of an economist from ISNAR.

The exercise confirmed the relative importance of some projects and the relative unimportance of others. For example, the presumed importance of controlling late blight and finding low-cost propagation methods for clonal planting materials in potato was confirmed (Table 1-3). Likewise, earlier thinking that a relatively low priority should be attached to work on field-storage diseases in potato and bacterial/fungal diseases in sweetpotato was supported.

However, some projects, such as integrated control of bacterial wilt in potato, received a lower than expected score because of a low probability of research success. Others, such as IPM for nematodes in sweetpotato, received a higher than

Table 1-3. Priority-setting exercise: project score by commodity.

Project	Score
POTATO	
Control of late blight	259,900
Low-cost propagation of clonal planting materials	242,500
Integration and adaptation of technology	174,100
Germplasm enhancement & molecular techniques	100,900
Combining resistances to viruses/fungi	99,200
Integrated control of bacterial wilt	95,100
Collection and characterization	92,100
Improvement of sexual propagation	76,300
Detection and control of viruses	75,800
Integrated management of potato tuber moth	64,900
Expanding utilization for developing countries	59,000
Characterization of production systems	51,200
Molecular approach to detect/control of pathogens	37,200
With resistance to insects/mites	36,500
Abiotic stresses and crop management	31,900
Integrated management of Andean weevil	14,200
Management of cyst nematode	5,200
Control of field-storage diseases	4,900
SWEETPOTATO	
Collection and characterization	154,700
Product development for developing countries	132,600
Characterization of production systems	85,800
Integration and adaptation of technology	80,300
Improved planting materials and management techniques	45,200
Integrated management of weevil	38,700
Germplasm enhancement & molecular techniques	30,400
Integrated management of nematodes	21,100
Identification control of viruses	20,700
Control of bacterial/fungal diseases	2,200

Note: The projects were ranked by the following scoring method: $(V_i \times P_{1i} \times P_{2i} \times P_{3i} \times P_{4i} \times P_{5i} \times E)$ where:

V = net value of potential increase in production available to consumers for agroecological zone i (AEZ_i) (in monetary units);

P_1 = importance of solving the constraint to achieve the potential in AEZ_i (in %);

P_2 = extent of technology adoption in AEZ_i (in %);

P_3 = probability of research success for AEZ_i (in %);

P_4 = importance of the project for the regions (between 0-1);

E = adjustment for environmental impact.

The project score is then obtained by summing across each agroecological zone.

expected priority because of extremely bright prospects of technical success.

For each research project listed in Table 1-3, scores were estimated by each of the important potato and sweetpotato agroecologies described earlier in this report. Combining these project scores within each agroecology gives a comparative picture of the expected economic importance of each agroecology to CIP's research. The importance of the subtropical lowlands for both potato and sweetpotato stands out in Table 1-4. About 97% of the subtropical lowlands for both potato and sweetpotato is in Asia.

Table 1-4. Comparison of expected benefits from research investments by commodity and agroecological zone.

POTATO	
Subtropical Lowlands	24.5
Temperate	12.5
Arid-Mediterranean	7.8
Highlands	5.3
SWEETPOTATO	
Subtropical Lowlands	29.0
Temperate	8.8
Humid Tropics	5.3
Highlands	2.8
Semiarid Tropics	4.0
Total	100.0

Training

At UPWARD's annual conference, held during Apr 2-5 at the University of the Philippines at Los Baños, experienced researchers on sweetpotato and young UPWARD researchers presented results of their investigation on sweetpotato farming households, merchants and consumers. Discussions at the working groups and the final business meeting permitted to identify the research areas and associated goals which UPWARD should pursue. The proceedings were recently published.

The Philippines. An Asia-wide training course on consumption and nutrition research was held November 1991. Rapid methods for evaluating nutritional status and studying the consumption habits of households were presented. Trainers came from UPWARD and from the Department of Nutrition of the University of the Philippines at Los Baños, where UPWARD is funding a number of research projects.

CIP economists participated in a training workshop hosted by CIAT for strengthening the disciplinary skills of social scientists working in NARS.

Brazil. In Recife, CIP social scientists co-hosted with CIAT staff a workshop on farmer participation in problem diagnosis and constraint identification. Researchers from several NARS in Latin America attended the workshop.

The germplasm collection is maintained in in vitro tissue culture, carefully stored under controlled light and temperature conditions. CIP's extensive germplasm collection has grown in 1991 with the addition of a substantial number of Andean root and tuber cultivars.

Program 2

Germplasm Management and Enhancement

1991 In Review

This Program constitutes the activities formerly included in Thrust II, Production and Distribution of Advanced Breeding Material. Work continued on collecting, managing, and improving the germplasm collection.

The collection of Andean potatoes was reduced by eliminating 607 accessions that were duplicates. There are 639 pathogen-tested potato accessions in the in vitro collection available for worldwide distribution. Highly efficient pathogen elimination in several advanced and native Andean cultivars was accomplished by the Austrian Research Center Seibersdorf in collaborative research. A core collection within group *S. tuberosum* ssp. *andigena*, the largest and genetically most variable group within the World Collection at CIP, is being established.

During 1990 and 1991 closer collaboration among potato genebanks around the world was achieved, and top priority was assigned to publishing a catalogue of wild potato species maintained in many countries.

More wild species were investigated for their reproductive characteristics with respect to pollen-stylar interactions and their breeding potential. Other wild species accessions have been evaluated for resistance to bacterial wilt (BW), and the identified resistance will be transferred to cultivated potatoes. New diploid potato families with resistance to BW, root-knot nematode (RKN), potato tuber moth (PTM), potato leafroll virus (PLRV), and potato virus Y (PVY) were generated. The effect of glandular trichomes on *Phytophthora infestans* infection was examined in 15 hybrids derived from haploid *S. tuberosum* × *S. berthaultii* crosses. Some potato genotypes were irradiated with gamma-rays to induce somatic mutations for improving agronomic characters of successful BW-resistant material. Genetic transformation through the insertion into potato clones of antibacterial protein genes, coat-protein genes, lytic peptide genes, and *bacillus thuringiensis* (Bt) genes for PLRV can now be done at CIP.

A new Restriction Fragment Length Polymorphism (RFLP) map for potato has been generated, mapping a total of 220 markers. Randomly Amplified Polymorphic DNA (RAPD) markers, generated by the polymerase chain reaction (PCR), have been adapted to analyze DNA variation in tuber-bearing *Solanum*, demonstrating that RAPD markers are suitable for large-scale assessment of genetic diversity of potato populations.

CIP's in vitro sweetpotato collection has been increased by 1072 accessions with materials received from the Asian Vegetable Research and Development Center (AVRDC). Experiments to assay long-term storage conditions for sweetpotato are

Previous Page Blank

underway. International distribution of in vitro sweetpotato accessions can now draw on a stock of 90 pathogen-tested accessions.

Seven collecting expeditions for sweetpotato genetic resources were undertaken in six Latin American countries, yielding 870 accessions of cultivated and wild material from 513 locations. Peruvian cultivated germplasm has been evaluated for its ability to perform at high altitudes and under mid-elevation jungle conditions. Sweetpotato germplasm collected in Cuba was duplicated at CIP, and 97 in vitro accessions were received. A revised version of sweetpotato descriptors has been submitted to IBPGR for publication, and guidelines for duplicate identification in sweetpotato collections have been produced.

The identification of sources of resistance to race 3 of *Meloidogyne incognita* has continued, evaluating accessions from Bolivia, Brazil, China, Colombia, The Dominican Republic, and Ecuador. Twelve accessions were found to be resistant, and 13 moderately resistant. Screening was also carried out for resistance to *Fusarium oxysporum* and the fungus *Diplodia gossypina*. Resistance to both pathogens was found.

In Peru, local and imported sweetpotato germplasm is being used to develop advanced populations with adaptation to various agroecologies. Priority traits are high yield, earliness, and high root dry matter content, to be combined with resistances and tolerances to principal abiotic and biotic constraints.

Work on selection of clones with high yield, scab resistance, and good plant survival rate is being conducted in cooperation with the Central Research Institute for Food Crops (CRIFC) and other Indonesian institutions.

Research on germplasm enhancement has focused on developing tetraploid (4×) storage-root producing interspecific hybrids between cultivated 6× *I. batatas* and wild 2× *I. trifida*. These hybrids are to be used as testers for the evaluation of wild species germplasm and as bridges for the transfer of selected wild species germplasm to the cultivated genepool.

Optimum conditions for plant regeneration via organogenesis from internodes, roots, and leaves of sweetpotato clones were established, and the research results are now being tested using *Agrobacterium*-transformed plants (varieties Jewel and Huachano). These plants are to be transformed with the cowpea trypsin inhibitor to engineer resistance to the weevil.

In crossability studies, it has been established that *I. trifida* and *I.* × *leucantha* acts as a bridge species. Additionally, it has been put forward that self-incompatibility in species of sweetpotato section *Batatas* is explained in the light of the stigmatic papillas.

Priorities for research on Andean root and tuber crops (ARTC) will be defined in 1992. However, a preliminary strategy for the systematic collection of these crops and their wild relatives has been formulated and several collecting missions undertaken with the participation of national partners. Collected material was deposited at national herbaria in La Paz, Quito, and Lima. As well, donations of oca germplasm from Peru and ulluco germplasm of Bolivian origin were received from the non-governmental organization SAPHA (Servicios Agrarios, Puno) and the University of Turku in Finland.

The identification of duplicates by means of morphological and biochemical characterization is a major objective for ARTC.

With the exception of maca, ARTC's are propagated by vegetative means. However, CIP research has demonstrated that all can produce botanical seed at different rates. Four viruses were identified in ulluco, and antisera for the detection of these viruses are now available. Attempts to eliminate virus from ulluco started in 1991 on 15 Peruvian commercial clones.

Work in this Program was divided into five primary projects. These were:

- Potato germplasm collection and characterization
- Potato germplasm enhancement and molecular techniques
- Sweetpotato germplasm collection and characterization
- Sweetpotato germplasm enhancement and molecular techniques
- Collection and characterization of Andean root and tuber crops

Potato Germplasm Collection and Characterization

In order to identify new sources of resistance, characterization of wild species is an important objective. Special emphasis is being placed on the overall improvement of screening methods. As well, collaboration with national programs for germplasm maintenance and characterization is a continuing priority.

The CIP World Potato Germplasm Collection

A total of 607 Andean potato accessions were found to be duplicates of other cultivars already maintained in the World Potato Collection at CIP. Of these, 455 accessions were duplicates from national or institutional collections donated to CIP in recent years. As well, 152 new duplicates were identified within the main collection that is conserved in the field as well as in vitro.

The in vitro collection now comprises 639 pathogen-tested accessions available for worldwide distribution. For a long-term storage assay, in vitro microtubers have been produced from 350 potato genotypes.

Pathogen elimination in several advanced and native Andean cultivars was accomplished by the Austrian Research Center Seibersdorf in a collaborative research project. In vitro cultures obtained from these cultivars were returned to CIP after virus indexing (comparative ELISA + test plants). Virus eradication was very efficient resulting in surplus mericlones for most accessions. For in vitro accessions received in 1991, the process has been adapted and mericlone production was started.

With the goal to select a Core Collection within *S. tuberosum* ssp. *andigena*, which represents the largest portion of accessions in the collection, isoenzyme analyses were undertaken. So far, about 1,000 accessions have been analyzed for six isoenzymes, utilizing tips from young leaflets of 3-4 week-old plants. Although the data obtained are being computerized

for further analyses, the following potentially new allozymes not previously reported in tuber-bearing *Solanum* species have been identified: in the isoenzyme IDH, allozyme 4; in locus PGMI, allozyme 3; and, in locus PGM2, allozyme 4.

Sources of resistance to the Andean potato weevil (*Premnotrypes vorax* Hustache) present in the fields at Porcon in the Cajamarca region of Peru have been identified in the potato collection. A total of 18 potato cultivars from several Andean countries, mainly from the taxonomic group of *S. tuberosum* ssp. *andigena*, showed no weevil damage in their tubers for three consecutive years. However, four susceptible check cultivars grown in the same fields had 45-75% of their tubers damaged by the weevil.

A donation of about 800 Peruvian potato cultivars was made to the National University of Cajamarca in Peru. Providing duplicate sets of material to interested NARS in the countries where these genetic resources were collected is an important way of insuring the maintenance of the World Potato Collection.

Inter-genebank Collaboration

A closer collaboration among potato genebanks around the world is becoming a reality. At an October 1990 meeting in Washington, DC, USA, representatives of the Braunschweig Genetic Resources Center, Germany; the Inter-Regional Potato Introduction Project, USA; and CIP, agreed that a joint data base of accessions maintained in these genebanks should be produced. A second meeting, held in Sturgeon Bay, Wisconsin, USA, in August, also included representatives from genebanks in Scotland, the former USSR, Germany, Argentina, Ecuador, and Peru. A data base structure and some standards to develop a joint data base were proposed by CIP on the basis of input received from other genebanks. This structure was accepted and the group agreed to formally create the Intergenebank Potato Database (IPD). Publishing a detailed catalog of the wild potato species has top priority.

Bolivia. The health status of the Bolivian Potato Collection maintained at Toralapa by IBTA-PROINPA has been substantially improved. The morphological characterization of this collection is in progress for the identification of duplicates. A systematic evaluation has been started to select the best accessions for tolerance to nematodes (Nacobbus spp. and Globodera spp.), frost damages, wart disease (Synchytrium endobioticum), and drought.

Argentina. A collection of *S. tuberosum* ssp. *andigena* maintained by INTA at Balcarce, Argentina, is being studied to determine its degree of genetic variation. Some cultivars of the triploid Andean potato species S. × *chaucha* have also been identified in this collection. Wild as well as primitive cultivated germplasm has been utilized in the Argentinean potato breeding program. Clones with high yields and excellent quality characteristics have been identified among *S. tuberosum* ssp. *tuberosum*, ssp. *andigena*, and S. × *chaucha*. The wild potato species, *S. gourlayi*, *S. acaule* ssp. *acaule*, *S. acaule* ssp. *aemulans*, *S. commersonii* ssp. *commersonii*, *S. commersonii* ssp. *malmeanum*, and *S. chacoense*, were found to be alternative sources of resistance to Fusarium spp., *Meloidogyne* spp., and PLRV. Subspecies *acaule*, *aemulans*, *commersonii*, and malmeanum have also been used for a successful, extensive genetic analysis at the level of individual loci by means of isoenzyme electrophoresis.

Potato Germplasm Enhancement and Molecular Techniques

Germplasm enhancement is achieved through the introduction into breeding material of traits from wild species; through the use of innovative tissue culture methods; through the production of true seed; and through the use of molecular techniques such as genetic engineering, gene mapping, and the development of PCR markers.

Germplasm Enhancement

Using various wild species as new sources of germplasm enhancement. Several wild species previously not utilized in programs of germplasm enhancement were investigated to study their breeding potential. Accessions unique to CIP's wild potato collection from the taxonomic series *Conicibaccata* and *Piurana* were intensively evaluated. Their reproductive characteristics, particularly with respect to pollen-stylar interactions, were studied in order to investigate interspecific crossability of these species with cultivated potatoes.

Hybrid seeds were generated in crosses with haploids of tetraploid breeding lines, and the characterization of their reproductive traits are underway. Simultaneously, screening for resistance to late blight and PTM was conducted.

Other wild species accessions, whose taxonomic identity is to be confirmed, have been evaluated for resistances to BW. Some genotypes were selected for crosses with diploid breeding lines to transfer the identified BW resistance to the genepool of the cultivated potato, following a successful breeding scheme established at CIP several years ago for this resistance at the diploid level. Hybrids were probably obtained in crosses of 2x potato breeding lines with the 2x non-tuber-bearing *Solanum* species *S. brevidens*, *S. etuberosum*, and *S. fernandezianum* which have a high potential of resistance to PLRV and bacterial diseases, such as *Erwinia*. The verification of the true hybrid nature of this material is underway by means of isozyme and RFLP markers.

Generating new breeding materials by enhancement with traits obtained from wild species. New diploid potato families were generated by using 2n gamete producing 2x potatoes with some resistance to RKN, BW, PTM, PLRV, and PVY. Preliminary evaluation indicated that some clones could have a combination of virus resistance with any of the other three pests or diseases as well as 2n pollen and improved agronomic characters. Among these families are some that will be selected for adaptation to long day conditions for the southern cone of South America, China, and the southern part of Africa.

Quantitatively segregating resistance to the PTM can be transmitted more efficiently in 4x x 2x crosses by 2n pollen produced through first division restitution (FDR) than in 4x x 4x crosses (Table 2-1). It appears that levels of transmission of these quantitatively inherited resistances depend on female (4x) - male (2x) interactions, as observed previously in transmission of RKN and BW resistances from the diploid to the tetraploid level.

Introgression of virus resistance genes derived from *S. acaule* was attempted by crossing tetraploid F1 hybrids of *S. acaule*

Table 2-1. Transmission of resistance to PTM from 2x (MR) and 4x (S) potatoes via FDR 2n pollen.

Females (4x)	Males (2x)	Number of progenies	
		Total	Resistance (%)[a]
Atzimba	84.38.12	28	1(R) + 2(MR) (10.7)
Atzimba	87HW13.7	34	3(R) + 3(MR) (17.6)
P-3	87HW13.7	34	2(R) + 4(MR) (17.6)
V-2	MI49.10	13	1(MR) (17.7)

[a] Laboratory and storage tests. MR = moderate resistance; R = resistant.

and tetraploid cultivated potatoes with 2x potato breeding lines. Different levels of ploidy, aneuploidy, and significant improvement of agronomic characters were observed in the resulting introgression lines (Figure 2-1). Virus resistance was found to segregate in this material, and resistance to potato virus Y (PVY), Potato Virus X (PVX), and Potato Leaf Roll Virus (PLRV) was identified. RFLP characterization has been initiated to understand the mechanism of introgression and thus to identify the transfer of the chromosome segments which carry the genes that confer virus resistance.

Figure 2-1. Tuber yield from an *S. acaule* introgression line (left) and a diploid progenitor of the introgression line (right).

The effect of glandular trichomes on *Phytophthora infestans* infection was examined in 15 hybrids derived from haploid *S. tuberosum* x *S. berthaultii* crosses. The race of the fungus used in this experiment was 1-3-4-5-7-8-10-11. A wide range of variability in the reactions of potato genotypes to the late blight pathogen was observed. It appears that the trichome properties confer some resistance to late blight and insects.

S. acaule, S. commersonii, and S. gourlayi are being characterized for their reproductive biology and ploidy manipulation as part of research designed to widen the base for genetic variability in tetraploid potato populations, and to incorporate resistance to viruses, *Fusarium* wilt, and aphids from these species into CIP's tetraploid breeding material. In order to achieve this goal, several hundred new dihaploids were generated from long day-adapted 4x *tuberosum* cultivars with virus resistance and processing quality, or both. These dihaploids are to serve as crossing partners with mainly diploid wild species representing a new source of a diverse pool of genes for further germplasm enhancement. The methods used to accomplish such germplasm transfer from the wild to the cultivated genepool of potatoes represent a varying combination of generation and use of haploids, utilization of 2n gametes, ploidy manipulation, recurrent selection,

in vitro and in vivo screening, and electrophoretic characterization.

Innovative tissue culture methods for germplasm enhancement. The concept that tissue culture may, through the generation of somaclonal variants, aid in the development of useful agronomic traits or resistances, such as insect resistance in potato, was supported by positive results obtained with glandular trichome material. Cultures of second and third generation backcrosses of this material yielded plants with greatly improved glandular trichome characteristics. A total of 134 plants regenerated from 5 diploid F1 hybrids of 2x cultivated potato and 2x *S. berthaultii* were evaluated for their trichome traits as well as agronomic and reproductive characters. Thirty-seven clones were selected for further use in breeding. Somaclonal variants with improved tuber resistance to PTM were also obtained from other sources of material. Evaluation of the improved tuber resistance as well as of the agronomic characters of this material is underway.

Some potato genotypes with good resistance to BW but relatively inferior agronomic characteristics, such as the Burundi clone Cr[illegible]148, were also irradiated with gamma-rays to investigate the possibility of inducing somatic mutations that would improve some agronomic characters. For this purpose, either protoplasts or in vitro plantlets were irradiated, and plantlets were regenerated after irradiation for evaluation of their insect resistance and agronomic characters.

True seed production and virus cleanup of 2x progenitors for international distribution to NARS. Botanical seeds on 4x × 2x and 2x × 2x crosses were produced and exported to CIP scientists in the regions and to NARS scientists worldwide to aid national efforts to increase genetic variability in breeding stocks. Some of the progenies derived from 4x × 2x crosses can be directly selected and evaluated in variety testing programs.

Twenty diploid potato genotypes that confer resistances to RKN, PVY, PLRV, BW, and PTM or a combination of these and which produce 2n pollen are being cleaned up from virus and soon will become available for international distribution.

Applying Molecular Technology

Genetic engineering. The identification and analysis of large samples of transgenic plants through dot blotting requires techniques of rapid DNA extraction and preparation of probes. CIP now has in-house facilities and capabilities to do this type of analysis.

Transformation through the insertion of antibacterial protein genes and the coat-protein gene for PLRV into potato clones can now be carried out at CIP. Two genotypes, Desiree and 86007, were used for transformation with *A. tumefaciens* and *A. rhizogenes* as vectors for gene coding for antibacterial proteins. Nearly 400 GUS (B-glucuronidase gene)-positive lines were obtained with the *A. rhizogenes* vector and 50 were obtained using *A. tumefaciens*. Preliminary dot hybridization indicated the presence of the antibacterial genes in these transgenic plants, but confirmation of the first set of results is underway using Southern Blot in an attempt to identify position effects and to determine whether the number of inserts corresponds to levels of observed resistance. For this purpose, GUS-positive plants were inoculated with *Pseudomonas solanacearum*, and these plants showed a wide range of responses to the pathogen.

Some transgenic plants appeared to be resistant to it while others were as susceptible as the original non-transformed genotypes.

Studies were carried out to demonstrate the effects of ploidy and inbreeding on the efficiency of regeneration after genetic transformation employing *A. tumefaciens* as vector. These effects were studied using a set of haploids and their original tetraploid progenitors as well as clone 7XY.1, and a set of diploid *S. phureja* and their somatically-doubled tetraploid derivatives. It appears that there are clear effects of inbreeding and ploidy on this trait, and that increased levels of inbreeding significantly reduce the efficiency of transformation.

Genotypic differences in the response of wild, cultivated and advanced hybrid breeding material to the efficiency of regeneration, following transformation with *Agrobacterium* sp., were also observed and determined by the GUS reporter gene.

The antibacterial protein gene constructs are at present inserted into the genomes of popular Peruvian potato varieties such as Yungay to improve their resistance to BW caused by *Pseudomonas solanacearum*.

A. tumefaciens, containing the sequence coding for the coat protein of PLRV, was used to insert this gene into cultivars Desiree and 7XY.1. Reporter genes and Elisa testing permitted identification of 54 plants as transformed. Further testing, both by Southern Blot and infection with PLRV is underway.

Several collaborative projects on genetic transformation in the area of basic and applied research are being carried out. Lytic peptide genes, using *A. tumefaciens* as vector, are also employed to transform potato genotypes for resistance to *Phytophthora infestans*. DNA hybridization analysis has demonstrated the presence of the cecropin gene which confers late blight resistance in transgenic plants. The transformed material was selected using the GUS reporter gene.

Bacillus thuringiensis (Bt) genes, which confer resistance to insects, have also been employed to transform some common European cultivars such as Desiree. Preliminary results have permitted identification of the presence of the gene in transformed genotypes as well as some actual insect resistance. This work is being carried out at the laboratories of ENEA in Italy.

Potato Gene mapping. In collaborative research with the Department of Plant Breeding and Biometry at Cornell University, USA, one progeny of a dihaploid of *S. tuberosum* (tbr) × *S. berthaultii* (ber) cross (N263) was used to generate a new RFLP map. The population used for this purpose consisted of 150 clones derived from a backcross between an F1 of a tbr × ber cross and ber, and about 220 markers were mapped. The mapping population is kept virus free. Along with some well-known genes, the new markers denominated as CD, CT, and TG from Cornell University and CP and GP from the Max Planck Institute in Germany were used to construct a new map, which is more complete than the original one constructed at Cornell University, this map seeks to tag properties related to both types of trichomes, A and B. They have already been tentatively mapped on specific chromosomes, and further efforts to obtain more conclusive results are underway.

Several other resistance genes have been targeted for mapping at CIP and in collaborative research with Cornell University. Resistance to RKN, race 3 of

Pseudomonas solanacearum, and the PTM is segregating in one and the same diploid population in Peru, simultaneous mapping for these characteristics is underway at CIP. Mapping of a resistance gene to the nematode *Globodera rostochiensis* is being carried out in a haploid population derived from the USA cultivar Atlantic at Cornell University.

Development of PCR markers. RAPD markers generated by PCR have been adapted to disclose DNA variation in tuber-bearing *Solanum*. Some factors affecting the reproducibility of the obtained results were investigated in collaborative research with Cornell University, Kobe University in Japan, and the University of Washington, USA. Factors such as quality and quantity of DNA samples were found to influence the reproducibility of results, and reliable and repeatable results were obtained through proper control of these factors and thus of PCR (Figure 2-2).

It was demonstrated that RAPD markers are suitable for large scale assessment of genetic diversity in potato populations due to the simplicity of this method. PCR is also used to amplify RFLP markers to avoid the use of plasmids which might still raise questions of biosafety. PCR amplified RFLP markers are also more easily labelled and provide clearer signals in Southern Blot hybridization compared to those amplified by using plasmid.

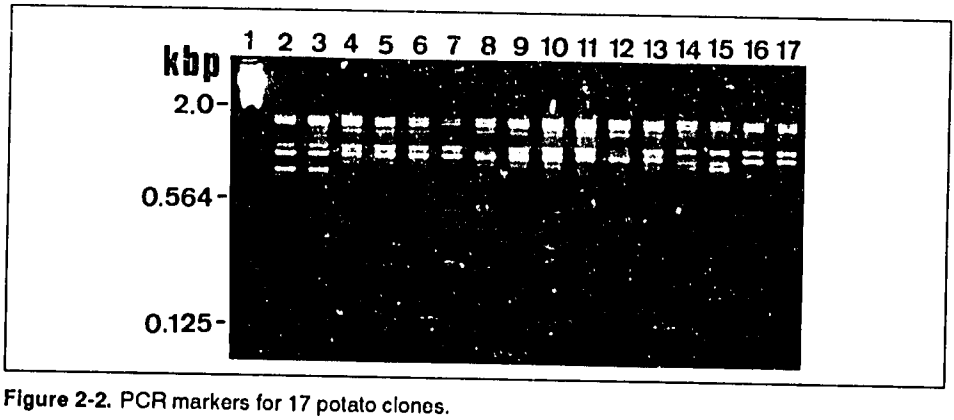


Figure 2-2. PCR markers for 17 potato clones.

Sweetpotato Germplasm Collection and Characterization

CIP's germplasm collection for sweetpotato is the world's largest. Objectives of this project include making the collection more comprehensive and eliminating duplicates. Future collecting work will focus on Central America, an underexplored area within the primary center of diversity. Characterization of accessions are being done in situ in collaboration with the national programs of the countries of origin, to avoid quarantine restrictions.

Maintenance of the germplasm collection. For 141 accessions from 11 species, seed stocks were increased to a total of 11,514. In intraspecific crosses involving four species, 441 seeds were generated; and from

interspecific hybrid populations, involving 7 species, 1,299 seeds were harvested (Table 2-2). In a set of four poly-crosses for four traits of interest to breeders, 17,528 seeds were obtained (Table 2-3).

In vitro collection and international distribution. The sweetpotato in vitro collection has been increased by 1072 accessions with materials received from AVRDC. Experiments to assay the possibility for long term storage so far have revealed differing growth patterns within the clones tested, and these experiments need to be continued.

International distribution of in vitro sweetpotato plantlets has been increased

Table 2-2. Intra- and interspecific hybrid populations generated in this work.

Female	Number of accessions	Number of genotypes	Male	Number of accessions	Number of genotypse	Total Number of seed produced
Intraspecific						
lca*	3	4	lca	2	3	33
tlc	5	12	tlc	6	13	362
trf	1	1	trf	3	3	20
trl	4	6	trl	3	6	26
Interspecific						
cdt	3	3	lca	2	2	100
cdt	2	2	trf	2	3	19
cdt	4	6	trl	5	11	251
cyf	1	1	cdt	4	5	19
gdf	1	1	cdt	4	5	84
lca	2	5	cdt	4	6	203
lca	2	2	trl	4	7	31
rms	1	1	cdt	1	1	25
trf	1	1	cdt	2	2	3
trl	5	11	cdt	4	6	559
trl	1	2	lca	2	2	5
Total	36	56		48	75	1740

* lca = *I. xleucantha*, tlc = *I. tiliacea*, trf = I. *trifida*, trl = *I. triloba*, cdt = *I. cordato-triloba*, cyf = *I. cynanchifolia*, gdf = *I, grandifolia*, rms = *I. ramosissima*.

Table 2-3. Generation of seed-pools using material of *I. batatas* (L) Lam.

	Number of parents	Number of seeds obtained
High starch and dry matter content	15	4,864
Heavy pubescence and abundant latex in vine	19	11,967
White flesh color	12	116
Mostly pigmented with anthocyanine in flesh	11	581
Total	57	17,528

since there are now 90 pathogen-tested accessions available.

Collecting sweetpotato genetic resources. Seven collecting expeditions were undertaken during 1991, and the following countries were visited: Mexico, Honduras (visited twice), Nicaragua, Argentina, Bolivia, and Peru. On these trips, 870 accessions of cultivated and wild material were collected in 513 locations. Cultivated material (I. batatas (L.) Lam.) is represented by 622 accessions (71.5%) and 248 accesions (28.5%) are wild material. Of the wild accessions, 163 (65.7%) have already been identified taxonomically, and of these, 119 (73%) are six *Ipomoea* species of section *Batatas* (Table 2-4).

Evaluating sweetpotato genetic resources. A part of the Peruvian cultivated germplasm has been evaluated for its yielding potential and for its ability to perform at high altitude (2,500 m). Germplasm with low sugar content, or so-called "camote papa", was evaluated for mid-elevation jungle conditions, and the effect of flowering on tuber root production was also determined.

Screening accessions from the germplasm bank for adaptation to cool environments. More material from CIP's sweetpotato collection was screened this year for adaptation to cool conditions. From 379 clones, 51 were selected for their relatively good performance under cool conditions at approximately 2,000 m in the highlands of Cajamarca, Peru. The selected material has already been planted in the field for further testing in replicated trials.

In previous tests, 16 clones were identified that had shown some degree of adaptation to cool environments after several replicated trials. Although these clones were the most adapted, they did not exhibit their full yield potential and were rather late maturing (Figures 2-3, 2-4). They are currently being used in poly-crosses with other improved breeding material to combine additional desirable traits such as earliness, high yield, and better root appearance.

Table 2-4. The taxonomic identification's given to newly collected wild species.

Specie(s)	Number of accessions collected	Countries explored
I. trifida	73	Honduras (5), Nicaragua (56), Mexico (12)
I. tiliacea	21	Honduras (8), Nicaragua (10), Mexico (3)
I. triloba	8	Mexico (8)
I. ramosissima	4	Nicaragua (4)
I. umbraticola	11	Honduras (3), Nicaragua (4), Mexico (4)
I. tabascana	1	Mexico (1)
I. peruviana	2	Peru (2)
Other *Ipomoeas*	28	Nicaragua (6), Mexico (22)
Ipomoea spp.	16	Nicaragua (1), Honduras (11) Mexico (4)
TOTAL	164	

Maintenance, Evaluation, Documentation, and Distribution of Sweetpotato Genetic Resources

A revised list of sweetpotato descriptors has been submitted to IBPGR for publication. Guidelines for duplicate identification in sweetpotato collections comprising a few key morphological descriptors have also been produced. A color chart for the characterization of storage root skin and flesh color is also included.

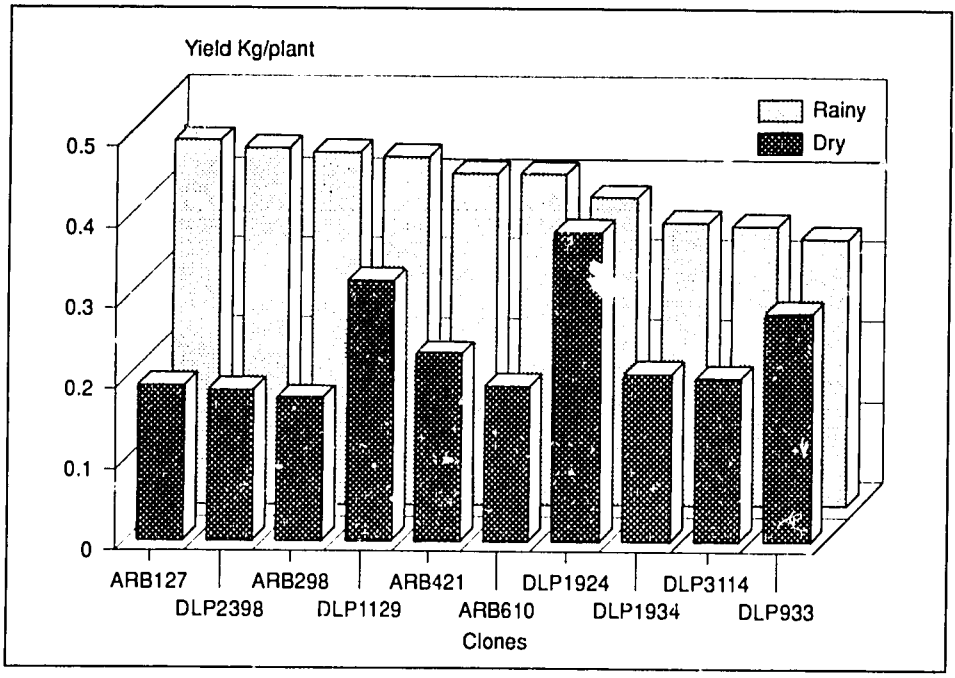


Figure 2-3. Yield performance by season of a sample of sweetpotato clones evaluated in Jesus, Cajamarca, Peru, 1991.

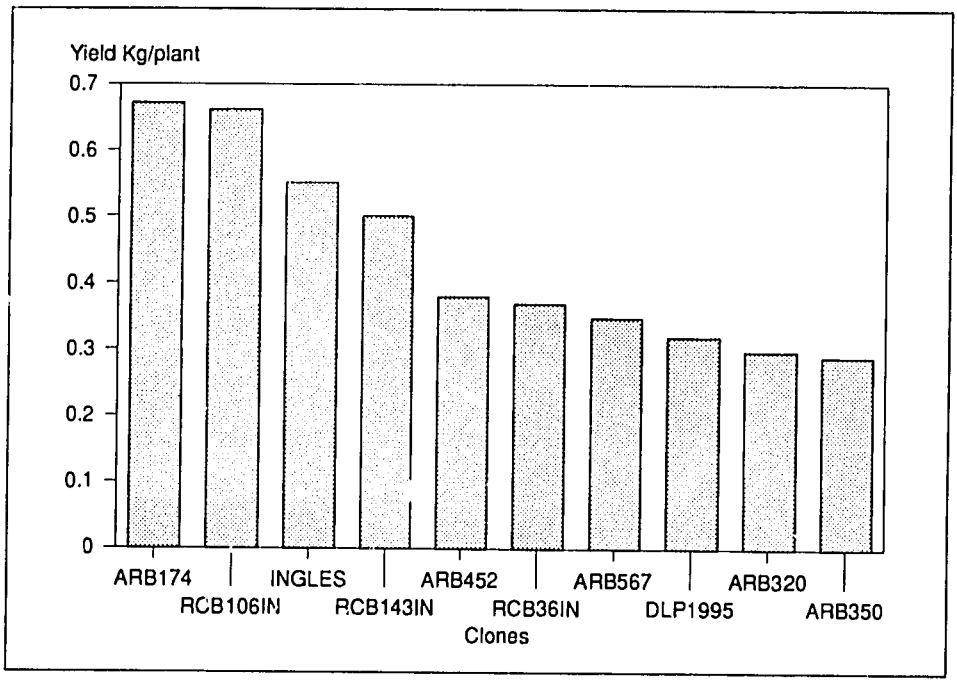


Figure 2-4. Yield performance of a sample of sweetpotato clones evaluated in Llacanora, Cajamarca, Peru, 1991.

Morphological data of key sweetpotato descriptors from 1,929 Peruvian accessions in CIP's collection have been validated in the field according to the new descriptor list. Cluster analyses of the data obtained sorted out 1,027 accessions within 212 morphologically identical groups. A total of 518 of these accessions comprising 168 groups was verified, and about 400 Peruvian cultivated accessions with identical morphology and electrophoretic patterns will be eliminated from clonal maintenance after obtaining seeds.

Yield trials with 340 accessions of Peruvian breeding lines were conducted by breeders at four sites in Peru. A total of 228 of the lines tested were not selected at any of the testing sites. A follow-up on sweetpotato characterization of national collections in collaboration with NARS was made in Jamaica (75 accessions) and in the Dominican Republic (215 accessions). Based on recorded data, new groups will be planted on the basis of morphological similarities. A similar approach has also been implemented in Mexico (260 accessions) and Argentina. However, in the latter two countries, national collaborators had already recorded morphological data and sent them to CIP for processing and to receive suggestions for a new planting order aimed at duplicate identification.

Cuba. Sweetpotato germplasm collected in Cuba with IBPGR funding during the past year by the national Cuban institution INIVIT was duplicated at CIP, and 97 cultivated in vitro culture accessions were received.

Bangladesh. Starting in January 1991, 46 accessions of native sweetpotato germplasm have been collected. Nine of these yielded 21-33 t/ha, considerably higher than the Bangladeshi national average of 11 t/ha. Genotypes SP-078 and SP-088 yielded 33.33 t/ha of tubers, SP-093 yielded 25 t/ha, SP-069, SP-080, SP-085, SP-089, SP-137 all yielded 22.22 t/ha, and SP-360 yielded 21.11 t/ha.

Seed treatment for storage. A simple method to dry sweetpotato seeds to about 5% moisture content for long term storage has been developed. It consists of placing the seeds in open Petri dishes, in trays together with a container filled with silica gel to 2-3 times the total weight of all seeds in the tray. After sealing the trays with transparent plastic, they are stored in an incubator at 15-17°C for about 14 days. During this time, the silica gel is replaced when its blue color changes (about three to four times). Viability and seedling vigor were not affected by this treatment, in contrast to viability and vigor lost in seeds stored with a 10% moisture content.

Evaluation of various resistances to biotic stresses. The identification of sources of resistance to race 3 of *Meloidogyne incognita* has continued as 273 accessions from Bolivia, Brazil, Colombia, the Dominican Republic, Ecuador, and China have been evaluated. Of these, 12 were found to be resistant and 13 moderately resistant. Screening for resistance to *Fusarium oxysporum*, carried out on 29 native Peruvian cultivars with high yield, showed that three of them might have some resistance; these will be reevaluated. Of 196 Peruvian accessions screened for resistance to *Diplodia gossypina*, 84 showed resistant reactions which need to be confirmed in future tests.

Sweetpotato Germplasm Enhancement and Molecular Techniques

The major objective of enhancement research is to combat the sweetpotato weevil (SPW), the crop's mejor pest. One approach is to cross *Ipomoea Batatas* with other *Ipomoea* species to allow access to a new genepool. Molecular techniques include developing innovative methods for germplasm multiplication.

Research on germplasm enhancement and population improvement is focusing on developing and improving breeding populations for priority characteristics at key regional locations, selected with a focus on agroecologies and biotic constraints. This project is a principal source of new materials for international testing, both as seed and as clones. These activities also serve as a training ground for sweetpotato breeders from national programs, and as a laboratory for the development of sweetpotato breeding methodology. Performance of materials developed under this project in each location, will be important in determining the future level and locations of work. During the last year, work has been ongoing at headquarters, and at regional locations in the Philippines, Indonesia, and China.

Peru. Local and imported germplasm is being used to develop advanced populations with adaptation to the agroecologies available at experiment sites in CIP's host country. Work is conducted at locations in the Amazon basin (humid tropics), in the highlands, and on the Pacific coast (arid and mediterranean). Materials are evaluated at different sites within and across agroecologies to select for yield stability. Priority traits are high yields, earliness, and high root dry matter content, combined with resistances and tolerances to the principal abiotic and biotic constraints. These constraints at the humid tropical sites (Yurimaguas and San Ramón) include excess moisture, low soil fertility, high temperatures, and the fungus *Diplodia*. In the highlands of Cajamarca at about 2,500 m, the principal constraint is low temperatures. At the Pacific coast locations of Vitarte, Cañete, and Tacna, constraints include RKN, cool winters, soil salinity, and drought.

In collaboration with the Universidad Nacional Jorge Basadre Grobmann-Tacna, selection has been conducted under saline soils since 1985. This program, which includes hybridization and seedling selection, has developed a number of advanced clones with tolerance to salinity (5 to 10 mmho/cm), high boron concentrations (more than 4 ppm), and some tolerance to drought. These clones produce yields of over 20 t/ha (root dry matter content ranges from 20 to 40%) in 100 to 120 days, and have a range of root skin and flesh colors.

During the last year, selection of high yielding early maturing clones, some of them also combining high dry matter content and resistance to RKN, was made in the Amazon Basin and at coastal locations. These clones are being cleaned up from pathogens for international distribution, and are also being used as parents in a new cycle of selection.

Root yields and dry matter contents of some selected clones evaluated at San Ramón are presented in Table 2-5. These and other results indicate the tendency in sweetpotato for dry matter content to

Table 2-5. Evaluation of advanced sweetpotato clones planted (density 37,037 plants/ha) at San Ramon, Peru, rainy season and dry season, 1991.

Clone	Rainy season Yield/plant(g) 120 days	Dry season Yield/plant(g) 90d	105d	120d	Dry matter (%) 90d	105d	120d
SR 88.050	613	650	867	1054	25	26	35
SR 88.075	-	763	803	1002	23	26	27
LM 88.113	-	513	610	938	31	32	36
LM 88.082	-	432	658	760	28	33	35
LM 88.014	1106	468	511	733	34	35	35
LM 88.040	545	372	496	490	35	35	34

increase during the growing season, but some clones produce and maintain a high root dry matter content from a relatively early harvest date.

Crossability studies have enhanced knowledge about sweetpotato section *Batatas*. In interspecific crosses, it was shown that *I. trifida* and *I.* x *leucantha* act as "bridge species" during geneflow from wild to cultivated species (Figure 2-5). In the first research stage, self-compatability was determined in *I. tribola* (2x), x *Leucantha* (2x), *I. lacunosa* (2x), *I. tenuissima* (2x), *I. cynanchifolia* (2x), *I. grandifolia* (2x), *I. ramosissima* (2x), and *I. cordato-triloba* (2x), as well as self-incompatibility in *I. trifida* (2x), *I. tiliacea* (4x), and *I. batatas* (4x, 6x). Sexual compatibility is related to a multiallelic sporophytic incompatibility system which is expressed in the stigmatic papillas. In the second stage, 4162 cross pollinations were performed between 11 species at two locations. Seventy-six interspecific combinations from 110 theoretically possible combinations in a diallelic 11 x 11 design were obtained. Of the 76, 37 succeeded with a crossability rate ranging from 0.01 to 1.00 in one location. In the other, 11 of 17 combinations were successful when estimating crossability by seed production.

Considering the factors affecting crossability, it was found that latitude is one of the factors explaining flowering synchrony in progenitors; whereas seed germination of the progeny and the early death of seedlings is explained in the light of the unbalanced genome (embryo/endosperm) relationship. The evaluation of crossability of interploidy crosses of diploid with tetraploid progenitors and the corresponding reciprocals-generated diploid and triploid progenies and maternal effects were observed. In crosses between hexaploid and diploid progenitors, hexaploid progenies were generated, a maternal effect prevailing. When *I. trifida* is hybridized reciprocally with *I. batatas*, *I.* x *leucantha*, *I. tenuissima*, and *I. ramosissima*, the crossability range is from 0.01 to 1.00. In crosses between *I. trifida*, as male progenitor, with *I. cordata-triloba*, *I. cynanchifolia*, *I. grandifolia*, *I. lacunosa*, and *I. triloba*, crossability varies from 0.06 to 0.23. Reciprocal crosses of *I.* x *leucantha* with *I. grandifolia*, *I. trifida*, and *I. triloba*, had a crossability range from 0.01 to 0.95. In crosses between *I.* x *leucantha*, as female progenitor, with *I. cordato-triloba*, *I. cynanchifolia*, *I. lacunosa*, and *I. tenuissima*, crossability ranged from 0.27 to 1.00. The cross of *I.* x *leucantha*, as male

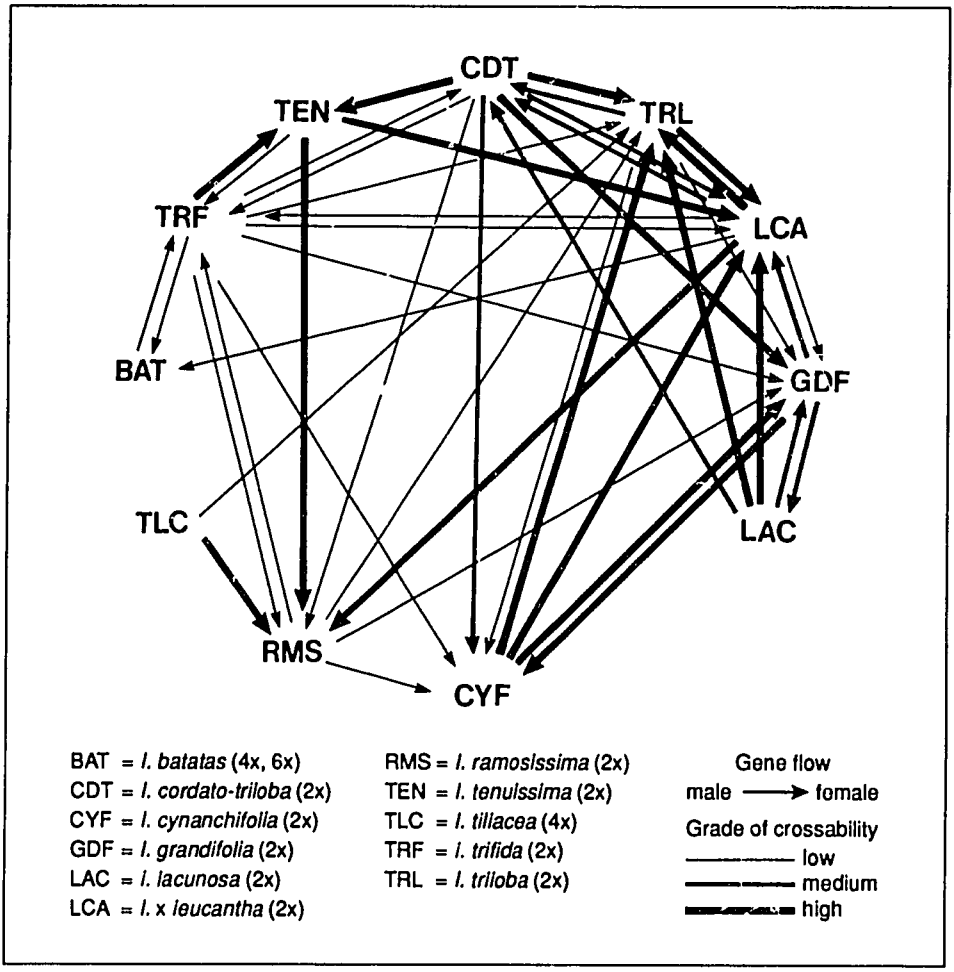


Figure 2-5. Polygon of crossability between eleven *Ipomoea* species, section *batatas (convolvulaceae)*.

progenitor, with *I. batatas* and *I. ramosisisima* gave a crossability range of 0.03 to 0.52. The morphological characterization of some progenies and progenitors shows that the nectary color is the main distinctive trait.

Indonesia (Humid Tropics). Work is conducted in cooperation with the Central Research Institute for Food Crops (CRIFC) at Bogor, and other national institutions in Indonesia. Germplasm has been collected from various parts of the country. About 540 clones are now under preliminary characterization, and some have been screened for weevil and scab resistance. Evaluation of storability of harvested roots was measured by observing root quality and weight loss for 40 days after harvest. A few accessions showed good storability.

Clones with high yield potential, scab resistance, and good plant survival rate were selected for use as parents in a recurrent selection program. Materials from

this project will feed into Indonesian variety selection programs, and be made available for international distribution and testing.

The Philippines (Highlands and Humid Tropics). Research continued with national program cooperators on the evaluation of local and introduced sweetpotato germplasm for yield, earliness, root dry matter, shade tolerance, and for SPW and RKN resistance. Superior clones were identified for each trait and will be used in advanced breeding programs.

Heritabilities for root yield, root size, number of roots per plant, and dry matter content were estimated by parent-offspring regression during dry and rainy season trials (Table 2-6). Sixty open-pollinated seedlings per parent were evaluated using an RCBD with three replications. Root dry matter heritabilities in two rainy season trials were moderate, indicating that progress can be expected in selection for this trait.

China (Subtropical Lowlands). The principal aim of the project, carried out under contract with the Guandong Academy of Agricultural Sciences (GAAS), is to assist in the evaluation of the Chinese germplasm collection for a number of traits such as resistances to BW, *Fusarium* wilt, and weevil infestation. Tolerance to drought and humidity and storability of roots are also evaluated, as are quality components such as dry matter content and culinary quality. Promising clones from these evaluations have been included in a crossing nursery, and seed has been used in the selection of improved clones.

Germplasm Enhancement Using Wild Sweetpotato Species

The objectives in this area of research are to develop methods for the evaluation and utilization in breeding of the closer relatives of the cultivated sweetpotato for traits of high interest, including weevil resistance, high root dry matter content, and hybrid vigor.

Utilization of the Wild Species Ipomoea trifida. So far, research on germplasm enhancement has focused on developing tetraploid (4x) storage-root producing interspecific hybrids between cultivated 6x *I. batatas* and wild 2x *I. trifida*. These hybrids, which induce storage root formation in interspecific progenies, are to be used as testers for the evaluation of wild species germplasm. They may also serve as bridges for the transfer of selected wild species germplasm to the cultivated genepool if their ploidy can be manipulated through the use of 2n pollen or colchicine doubling.

Table 2-6. Heritability estimates in sweetpotato, Canlubang, the Philippines, 1989-1991.

	1989		1991	
	Rainy season	Dry season	Rainy season	Dry season
Yield	0.11 ± 0.24	0.38 ± 0.12	0.17 ± 0.18	0.34 ± 0.42
Root per plant	0.42 ± 0.19	0.02 ± 0.14	0.25 ± 0.26	0.40 ± 0.37
Root size (length)	0.07 ± 0.19	0.81 ± 0.32	0.15 ± 0.20	0.44 ± 0.35
Dry matter(kg)	0.47 ± 0.17	–	0.38 ± 0.12	–
Number of parents	24	18	22	38

Collecting sweetpotato, *I. trifida*, in the wild.

During the past year, research was conducted to improve the storage root characteristics of the 4× tester population. This was done through intermating the best yielding 4× interspecific hybrids from work of previous years. New testers will be selected from among seedlings for high root production, reduced dry matter content, earliness, and attractive appearance. Progenies from the interspecific tester population were sent to cooperators in the Jiangsu Academy of Agricultural Science in China, and to Indonesia.

Work was also conducted on the evaluation of germplasm accessions of *I. leucantha*, *I. triloba*, *I. ramosissima*, *I. tenuissima*, 2× and 4× *I. trifida*, by crossing them reciprocally with the 4× testers. Except for *I. trifida*, the wild species used produced seed only when used as females. The nature of this unilateral interspecific incompatibility, which has important implications for wild species utilization, is under investigation. Progeny evaluations of the interspecific crosses will permit the evaluation of the wild species accessions.

Applying Molecular Techniques to Sweetpotato Breeding

Transformation and regeneration of sweetpotato cultivars. The objectives in this area are to develop and use molecular techniques for the transformation and regeneration of selected varieties to improve some high priority traits. Although work in this area is just beginning, strong collaboration with institutions having a comparative advantage in the area of DNA technology is anticipated.

During the past year, optimum conditions for plant regeneration using organogenesis from internodes, roots, and leaves of nine sweetpotato cultivars were established through the testing of different growth regulators and culture conditions. The cultivars Jewel and Huachano were found to have high organogenic potential.

The results of last year's research are now being tested using *Agrobacterium*-transformed plants of Jewel and Huachano as model cultivars, with the intention of using cowpea trypsin inhibitor constructs to engineer resistance to weevil. This work is being conducted in collaboration with Agriculture Genetic Center, a private UK company.

Collection and Characterization of Andean Root and Tuber Crops

Although priorities for research on Andean root and tuber crops (ARTC) will be defined in a planning conference in early 1992, a preliminary strategy for the systematic collection of these crops and their wild relatives has been formulated and collections are underway.

Collecting missions and germplasm donations. Several collecting missions were undertaken with INIAP, the national agricultural research institute of Ecuador, IBTA, the national agricultural research institute of Bolivia, and CICA, the center for the study of Andean crops in Cusco, Peru. National scientists nominated by their respective national program accompanied CIP researchers on their collecting missions.

Duplicates of collected accessions were left with collaborating institutions. A considerable amount of herbarium material was deposited at the national herbaria in La Paz and Quito, as well as at UNALM in Peru. A collecting mission in Bolivia, jointly undertaken with IBTA, resulted in the collection of 93 accessions. Another small expedition carried out in Peru yielded 40 samples.

A donation of about 80 accessions of oca germplasm from the Department of Puno in Peru was received from the nongovernmental organization SAPHA

Showing a sample of one of the ARTC, mashua.

(Servicios Agrarios, Puno). Another important donation of about 120 accessions of ulluco, mainly of Bolivian origin, came from the University of Turku in Finland. This material had been collected by Finnish researchers studying the reproductive biology and variability of ulluco. A duplicate set of this material had been left in Bolivia, but could not be maintained there. CIP will therefore now return an identical set to Bolivia for utilization in breeding programs.

By November, collections carried out by CIP and donations received from NARS accounted for CIP's ARTC germplasm holdings (Table 2-7).

Experience with potato and sweetpotato collections would indicate that ARTC collections are highly duplicated and not representative in terms of geographic coverage. Therefore, 1992 collection activities will concentrate on northern Argentina, northern Chile, and possibly Colombia, in order to fill identified geographic gaps. Efforts will also concentrate on identifying duplicates by means of morphological and biochemical characterization.

Conservation of ARTC germplasm. Some duplicates of the accessions listed above are maintained either as field collections or in vitro by the NARS of the material's country of origin, such as INIAP (Quito, Ecuador, field collection and in vitro), CICA (Cusco, Peru, field collection) and IBTA (Cochabamba, Bolivia, field collection). A complete set of ulluco, oca, mashua, and yacon accessions is being duplicated in vitro at CIP Quito and CIP La Molina, and arracacha and achira are maintained as potted plants in an insect-proof greenhouse at CIP La Molina. Maca, which displays orthodox seed storage behavior, is maintained as botanical seeds at -18°C.

With the exception of maca, ARTCs are exclusively propagated by vegetative means. However, practically all have retained their ability to set botanical seed at different rates as is the case with mashua, arracacha, yacon, mauka and achira. It had appeared that sexual seeds of yacon were unknown and probably not produced at all. However, CIP's collecting activities, yielded the discovery and collection yacon seeds. Furthermore, seed production was achieved in La Molina (on the dry Pacific coast of Peru), under very different

Table 2-7. ARTC germplasm held in CIP's collection.

Species	Common name	Number of accessions	Origin
Oxalis tuberosa	oca	212	Peru, Bolivia, Ecuador
Ullucus tuberosus	ulluco	134	Peru, Bolivia, Ecuador
Tropaeolum tuberosum	mashua	15	Peru, Bolivia
Polymnia sonchifolia	yacon	12	Peru, Bolivia
Arracacia xanthorrhiza	arracacha	11	Peru, Bolivia
Canna edulis	achira	9	Peru, Bolivia
Mirabilis expansa	mauka	1	Peru
Lepidium meyenii	maca	33	Peru

conditions from those of the warm Andean valleys, where the ARTCs originate. Thus, the possibility of maintaining germplasm of these crops through sexual seed is under investigation.

Characterization and documentation. In collaborative research between CICA and CIP, a collection of 480 oca accessions from the southern Andes was morphologically characterized.

Procedures for a computerized compilation of passport and morphological data have been developed. The documentation of ARTC germplasm includes photographing the underground parts of each plant accession, the preparation of herbarium specimens collected during the various collectingmissions, and the field planting of material at Quito, Ecuador. All of these data and materials are organized for easy cross-reference.

A research contract with INIAP's plant nutrition department determined the raw protein (using the Kjeldahl methods) and dry matter content of around 400 accessions of oca, ulluco, and mashua from the Ecuadorian INIAP collection. Preliminary analysis of the data obtained suggests that the nutritional variation of these species in Ecuador is very limited.

Virological studies. Serological virus determination and partial characterization of four viruses previously found in ulluco at CIP and in research collaboration with San Marcos University of Lima, Peru, confirmed previous results by Brunt et al. in 1982 which identified ullucus mosaic virus, ullucus virus C, papaya mosaic virus strain ullucus, and ullucus mild mosaic virus. Antisera for the detection of these viruses were produced and are now available. Attempts to reduce the cost of the DAS-ELISA test have demonstrated that penicillinase enzyme was as sensitive as alkaline phosphatase in the detection of ulluco viruses. This is a much cheaper test than DAS-ELISA, and is now routinely used in the detection of ulluco viruses. Kits for the PCN-ELISA test are available and have been sent to CIP's Highland station at Quito, and to the biotechnology laboratory of San Marcos University.

Virus elimination. Attempts to eliminate ulluco virus began in 1991. Plants of 15 Peruvian commercial ulluco clones, maintained at CIP's germplasm bank in Peru, were selected for virus elimination by heat treatment. The stem tips of 20 cm high plants were clipped off and placed in a rustic thermotherapy chamber under continuous light and temperatures from 29-33°C. These conditions induced rapid growth of new shoots from the axillary buds. Meristemes were cultured after two weeks of heat treatment. This work is still in progress.

Training

Training on Germplasm Management

Zaire. A germplasm management course, held in Bukavu, June 9-13, was organized by PRAPAC with participation of 16 trainees from Burundi, Rwanda, Uganda, and Zaire.

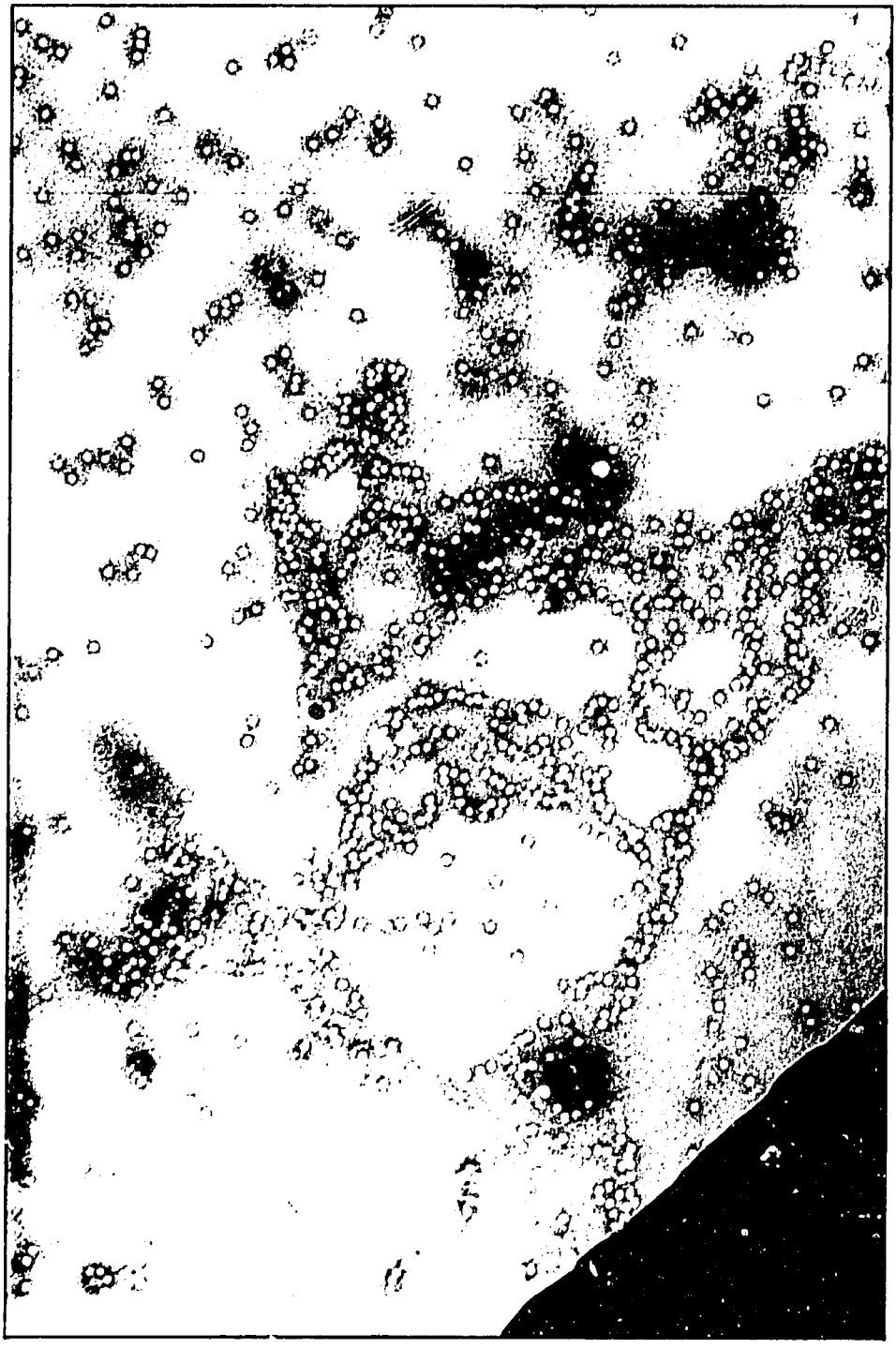
Mexico. An international course on the evaluation and selection of potato germplasm was held at the National Potato

Program in Toluca, August 9-11. It was organized by PRECODEPA and funded by CIP Region II. Participants were from Guatemala (1), El Salvador (1), Honduras (1), Nicaragua (1), Panama (1), the Dominican Republic (1), Haiti (1), Cuba (1), and Mexico (2).

Training in Potato Breeding

Peru. A workshop on advances in potato breeding in Andean countries, was held in Lima, February 4-7. It was jointly organized by CIP Region I and PRACIPA, with funding from IDRC. Participants from Bolivia (4), Colombia (4), Ecuador (3), Venezuela (3), and Peru (13) attended the workshop. Breeding topics discussed included fungal and viral diseases, insect and nematode resistance, earliness, frost resistance, genetic engineering, quarantine regulations and exchange of genetic materials.

Colombia. The PRACIPA network organized a breeding projects coordination meeting in Rio Negro and Bogota, June 24-28. The meeting was hosted by ICA and the CIP Region I office in Bogota. Nine participants from Bolivia (2), Ecuador (1), Peru (1), Venezuela (1), and Colombia (3) attended the meeting.



Electron microscope view of sweetpotato virus C-4. Many destructive sweetpotato viruses remain unknown. The challenging task of identifying them and determining their relative importance remains to be done.

Program 3

Disease Management

1991 In Review

Through the process of restructuring CIP's research efforts, Program 3 incorporates the activities of former Thrusts III (Control of Bacterial and Fungal Diseases) and IV (Control of Virus and Virus-Like Diseases). Disease management continues to be an important and necessary part of CIP's research agenda.

Diseases of potato and sweetpotato caused by fungi, viruses, bacteria, and viroids can drastically reduce the production of these crops in developing countries unless methods of integrated control are utilized. CIP collaborates with other institutions worldwide to develop the components for disease control, especially screening for resistance in germplasm and its utilization by NARS and in breeding programs.

Field resistance to potato late blight has been further improved using both a major-gene containing and a major-gene free population, combined with resistance to potato viruses X and Y.

In Peru, the recently released Canchan-INIAA variety is gaining popularity and two more cultivars are being considered for varietal release. Three varieties were released in Uganda and many promising selections are soon to be named in several other countries.

The potato bacterial wilt (BW) resistance program has undergone significant changes. Screening in Peru has been expanded from San Ramón (race 1) into Cajamarca (race 3) and Piura (races 1 and 3). Fundamental heritability studies were begun with numerous sources of resistance and a new breeding scheme was initiated emphasizing race 3, which was found to be more homogeneous than race 1 and the principal cause of the disease. Further, because potato plants become more susceptible to wilt in the presence of the root-knot nematode (RKN), renewed emphasis has been placed in combining these resistances. A monoclonal antibody developed in China was effective in detecting most strains of *Pseudomonas solanacearum*. At Wisconsin, USA, RFLP taxonomic studies of the bacterium using over 200 strains and several probes has permitted a tentative new classification scheme based on natural groupings.

The *Erwinia* resistance program was expanded to include screening for resistance to blackleg after the initial selection for soft rot resistance. In Tunisia differences in resistance to soft rot were found among varieties, and interaction to cause greater disease incidence of *Erwinia* with *Verticillium* wilt fungus was shown.

Screening for virus resistance in wild potato species has yielded new accessions for resistance to PLRV, PVX^c, PVX-HB, PVX-GUA, PVY, PVS, PVT, and PSTVd. Breeding for resistance to PLRV has produced eight highly resistant clones. Four

Previous Page Blank

varieties from Poland were reconfirmed as highly resistant to PLRV and to the aphid *Myzus persicae*. It was shown that immunity to PVX and PVY can be transferred by protoplast fusion. Combination of resistances to PVX, PVY, and early blight (*Alternaria solani*) has been achieved.

The virus detection program continues to provide antisera to the major potato viruses and a new PLRV antiserum is being prepared. Nitrocellulose membrane ELISA and nucleic acid spot hybridization procedures have begun to be employed to monitor the stability of immunity to PVX and PVY worldwide. Two probes were selected and compared for their ability to detect different PVX strains, both being highly specific for the strain used for its preparation, but a recombined probe detects all strains and isolates so far tested. A unique recombinant probe, for both true seed transmitted pathogens PVT and PSTVd, was prepared and proved to be effective.

Sweetpotato chlorotic leaf distortion disease, originally described in the USA, was found in Peru and Kenya. True seed from Brazil, Ghana, Kenya, Nigeria, Papua New Guinea, the Philippines, Peru, and the USA also was found to carry this disease.

Laboratory methods to test for resistance to fungi that cause rots of sweetpotato storage roots were developed and screening conducted on about 300 accessions of CIP's germplasm for *Rhizopus, Diplodia* and *Fusarium* rots. In three accessions resistance to *Fusarium oxysporum* only was found. Screening for resistance to scab in the field in Indonesia resulted in 20% of 130 clones reacting as highly resistant. Surveys in sub-Saharan Africa revealed an incidence of previously described diseases, as well as two unknown diseases whose etiology is being investigated.

The unidentified sweetpotato virus C-4 was characterized as to symptomatology under greenhouse conditions. It was shown to be transmitted by an aphid to *Ipomoea nil*, and the virus particles shown to be isometric of about 30 nm diameter. The C-2 virus was named sweetpotato chlorotic flecks virus (SPCFV). It was found to be widespread in China, Japan, and Peru and was isolated from plants from Bolivia, Brazil, Colombia, Cuba, and Panama. It infected several cultivars, but not Imby 3102. Work is progressing on C-3 and C-6.

Virus detection kits for potato viruses are a well used CIP product. Antisera, Das-ELISA, and NCM-ELISA kits were distributed to evaluate more than 750,000 virus samples.

Disease management activities are divided into projects centered around particular diseases or general categories. Project objectives are the control of potato late blight, soft rot and blackleg, and powdery scab; detection of viruses and of plant resistance to viruses combined with resistance to fungi; and integrated control of bacterial wilt in potato. .. eetpotato, the objectives are to control fungal and bacterial diseases; identify viruses and resistances to viruses, and to develop detection methods.

Control of Late Blight

The control of potato late blight *(Phytophthora infestans)* focuses mainly on developing host resistance as the major component of integrated control. Horizontal resistance is less vulnerable and thus preferred in breeding. To this end, two sources of resistance are being used, one that contains major genes (R-genes) in addition to horizontal resistance (Population A) and the second containing only horizontal resistance genes (Population B). Until now, following a multilocation testing scheme that includes key locations where late blight is endemic and severe (Rionegro, Colombia; Ruhengeri, Rwanda; and Toluca, Mexico), many late blight resistant clones have been developed for distribution to NARS for utilization as potential varieties. Emphasis is now being placed on the use of Population B as the major future source of resistant cultivars.

Breeding activities with Population A this year concentrated on field testing of clones from the ninth and tenth generation or group (G-9 and G-10) for horizontal resistance to late blight, in Rionegro, Ruhengeri and Toluca. Selected clones showed late blight resistance, wide adaptability, and good agronomic attributes.

The test at Toluca, that includes clones of G-9 previously selected in both Rionegro and Ruhengeri, led to the selection of an additional 42 resistant clones to be distributed to NARS. Six of these yielded around 2.5 kg per plant (Figure 3-1).

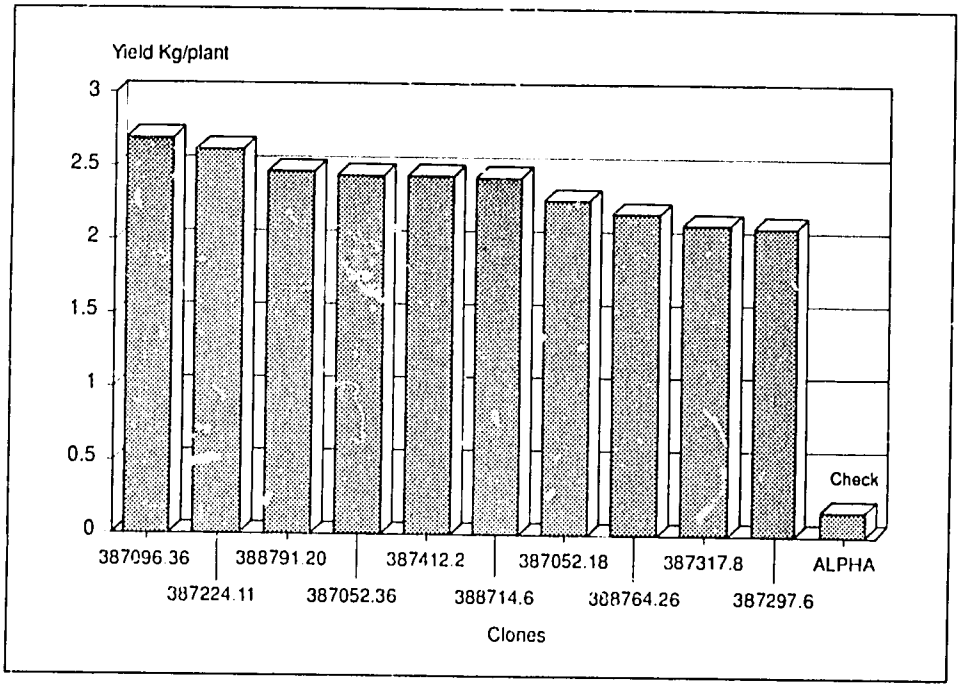


Figure 3-1. Potato yield response under late blight conditions in a sample of clones selected from G-9, tested at Toluca, Mexico, 1991.

Field testing of about 3,000 G-10 clones for the first time at both Rionegro and Ruhengeri, resulted in the selection of 544 and 203 late blight resistant clones, respectively. Of these clones, 92 were confirmed to combine resistance to late blight and immunities to PVY and/or PVX. Immunities to PVY and PVX are being gradually introduced into Population A.

A frequency-distribution histogram of the apparent infection rates *r* calculated for all G-10 clones at Rionegro and Ruhengeri confirmed that the different degrees of infection expressed by a population of clones in the field follow a normal distribution curve. This demonstrates that resistance to late blight is of a quantitative nature and subject to improvement by increasing its frequency (Figure 3-2). It is also evident that the screening locations are suitable, although some unknown R-genes for vertical resistance exist that could interfere with the selection process.

Breeding with Population B for horizontal resistance to late blight in the absence of R-genes included:

- Successful crossing of the 31 most advanced putative R-gene free clones, with varying degrees of horizontal resistance, that were selected by screening Population A. Progenies obtained through appropriate mating designs will permit researchers to estimate clone heritability of late blight resistance, verify the absence of R-genes, and determine the stability of resistance and their parental value for breeding.
- Identification of a new set of 25 clones derived from Population A, quite probably

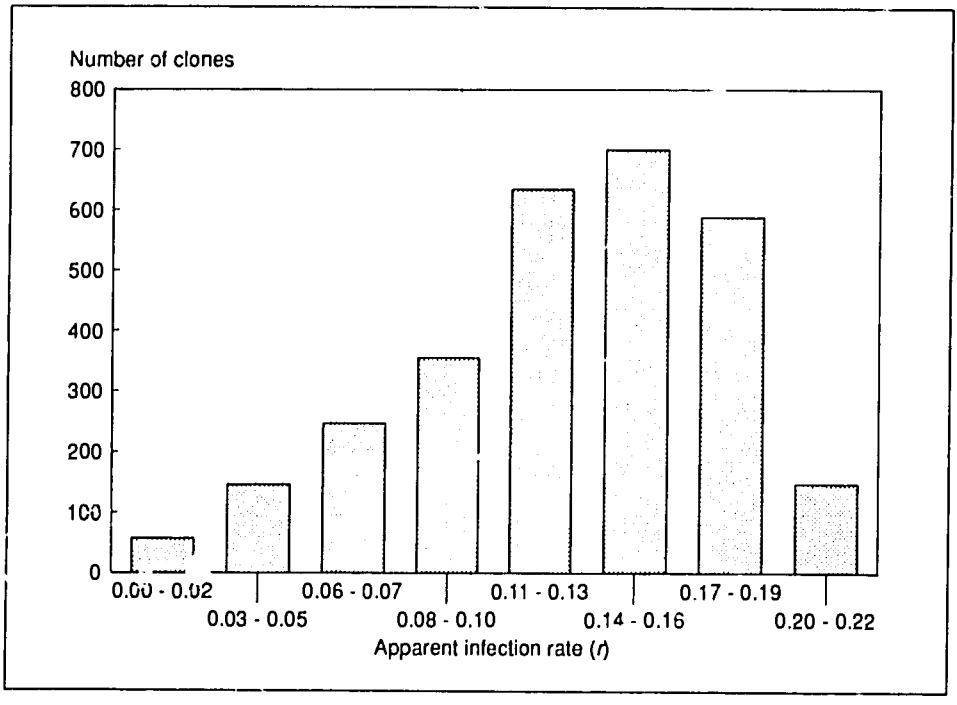


Figure 3-2. The number of G-10 clones infected at varying rates indicated that LB infection follows a normal distribution curve (Rwanda, 1991).

free of R-genes and having different degrees of horizontal resistance. Simultaneous inoculation of detached single leaves of a large sample of clones was done with a race zero strain and a complex race that included virulence to the weak genes R2, R4, R10, and R11. These tests were carried out under controlled environmental conditions in Lima. Positive leaf infection with both races followed by lesion growth and a high sporulation rate (Figure 3-3) indicated the absence of R-genes. Subsequent progeny tests of selected clones will be conducted to confirm their freedom from R-genes and to use them in breeding.

- Initial selection of 2,730 single-hill clones that are potentially resistant, from among a population of 60,000 seedlings transplanted and exposed to natural infection in the field at Quito, Ecuador. This mid-term breeding population for horizontal resistance to late blight originated from native R-gene free *Andigena* and *Tuberosum* germplasm. Trials in larger plots are scheduled for the following season to reconfirm resistance and to select for agronomic attributes.

Results of these efforts should speed up progress to achieve high levels of horizontal resistance to late blight in cultivars free of R-genes.

Peru. The Peruvian national program receives most of the advanced late blight resistant germplasm developed at CIP as direct support. During the last five years, 14 clones in regional trials have shown high yields and stable resistance to late

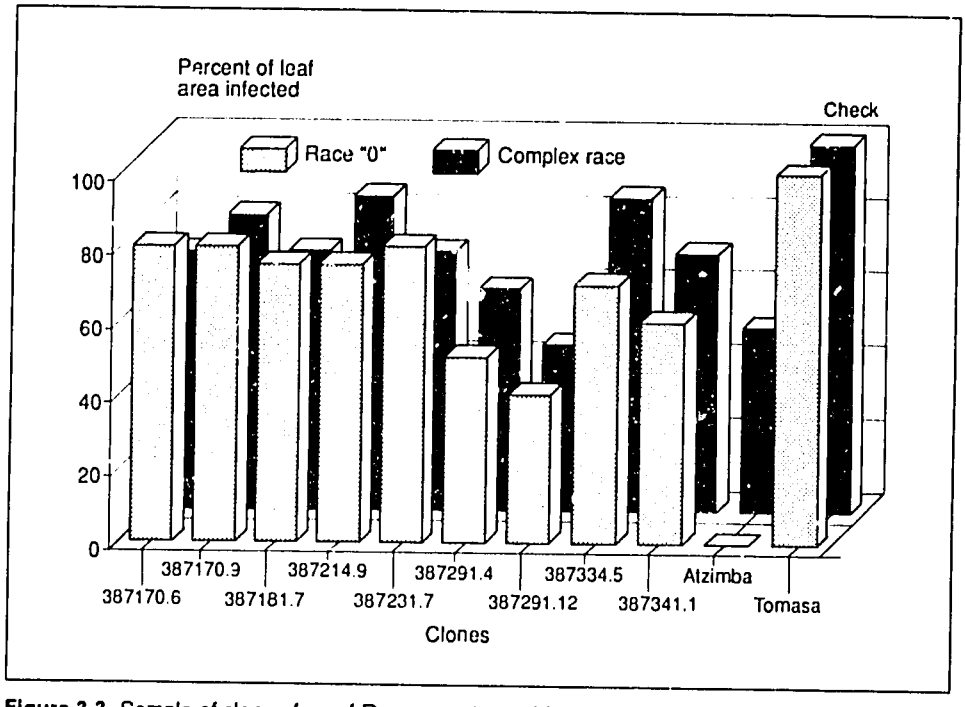


Figure 3-3. Sample of clones free of R genes extracted from Population A by inoculating detached single leaves with either race "0" or a complex race.

blight. Clones 377744.1 and 380474.6 are soon to be released as varieties. Likewise, the recently released late blight resistant variety CANCHAN-INIAA developed by INIAA and CIP with farmers participation is rapidly gaining popularity as a result of efforts by individual farmers and some nongovernmental organizations.

Burundi. Regional trials in Burundi were carried out during the two potato growing seasons in 1991. Four CIP clones showed high resistance to late blight, good adaptability, and outstanding yields, 382147.18, 382195.21, 381381.26, and 381381.9. CIP clone 382147.18 had the highest tuber yield with and without fungicide treatment for late blight control. Clone 381381.26 had a short period of tuber dormancy, a highly desirable character because it permits two consecutive planting seasons. Check varieties Muruta and Kinigi produced poorly when not sprayed. Other clones and varieties were slightly affected by late blight, indicating their high levels of horizontal resistance.

Cameroon. Five promising advanced late blight resistant clones have been selected over a four-year period at four experimental stations in Cameroon. Clone 720055 (of Mexican origin) and CIP clone 382121.27 were selected for variety release, and are in the seed production stage. CIP clone 382381.20 is on standby to replace 720055 if the latter fails to show stable horizontal resistance to late blight. So far, this last clone has only shown hypersensitive reaction to late blight infection. This result shows that local races in Cameroon were not able to overcome unknown R-genes present in this clone. It was therefore impossible to assess the clone's true level of horizontal resistance.

Ecuador. For about eight years the Ecuadorian potato program (INIAP) has

A late blight test in Santa Catalina, Ecuador.

received CIP materials bred with emphasis on resistance to late blight and cyst nematode. One late blight resistant variety, Santa Rita, has already been released. Other promising clones are undergoing advanced trials for final selection as resistant varieties. Some of these clones show tuber yields comparable to or greater than those of local cultivars (Table 3-1).

Mexico. Five CIP-selected clones (382143.17, 380026.12, 382245.20, 381381.9, and 380018.21) from the international testing scheme for late blight resistance carried out at Toluca Valley, were in regional trials throughout the country and had good adaptation, high yields, and good late blight resistance. After regional trials, advanced clone 380024.6 was rated as excellent by the INIFAP Potato Program.

The Philippines. After several years of in-country regional trials of the most advanced clones selected for resistance to late blight and adaptability, four of seven clones showed excellent yield performance and outyielded the local susceptible checks Granola and I-1035 (Table 3-2). P-6 (CIP 380496.2) was the highest yielder, at 22.2 t/ha, double the yield of check I-1035 (11.4 t/ha). However, it was not selected because of its purple splashed skin color. Further studies on farmers' acceptance of new varieties with obvious advantages are needed to help capitalize on available technology and satisfy farmers' requirements.

Uganda. After three years of testing and selection of late blight resistant clones introduced from CIP, three new varieties were released in 1991 with their original CIP numbers. Results of 13 on-station and 16 on-farm trials conducted at five locations from 1989 to 1991 indicate that varieties 381381.20, 381379.9, and 374080.5 had good adaptation, resistance to late blight, and high tuber yields. After approval by the Uganda Variety Release Committee, these clones are undergoing multiplication as basic seed stocks for dissemination throughout potato growing areas.

Venezuela. The Venezuelan potato program reported that most advanced clones

Table 3-1. Yield performance of advanced late blight resistant potato clones tested over several locations in Ecuador, 1991 (reported by INIAP, Ecuador).

CIP Number	Pichincha t/ha	Carchi t/ha	Quito kg/plant	Chimborazo kg/plant
384163.	80.0	47.9	2.8	1.6
382119.17	73.2	54.7	2.6	1.8
382172.3	72.9	-	-	-
384375.3	65.2	51.9	2.2	1.8
384292.	61.0	30.7	2.3	2.1
384343.	56.6	-	-	-
384304.	52.2	37.5	1.9	1.8
Local checks				
Cecilia	72.3	6.3	-	0.5
Esperanza	65.0	30.6	1.7	1.1
Catalina	50.2	-	1.2	-
Gabriela	39.9	19.4	1.1	1.1

Table 3-2. Tuber yields of seven late blight resistant potato clones grown in farmers' fields in three locations in the Philippines, 1991.

Clone	Sayangan (2,300 m) t/ha	Sayangan (2,300 m) marketable (%)	Sinipsip (2,700 m) t/ha	Sinipsip (2,700 m) marketable (%)	Sinto (2,500 m) t/ha	Sinto (2,500 m) marketable (%)	Mean t/ha
P-6	23.0	95	22.0	93	20.8	87	22.2
LBR-5	17.8	95	15.0	88	19.3	90	17.4
I-1085	14.8	90	15.0	90	16.8	88	15.5
LBR-13	13.6	90	13.0	70	9.5	78	12.0
LBR-9	9.7	92	10.0	77	15.0	88	9.7
LBR-3	7.6	70	13.7	70	10.8	92	10.7
I-1039	6.4	90	9.0	83	8.8	95	8.1
Checks							
I-1035	11.0	90	10.0	90	12.3	85	11.4
Granola	10.2	82	4.3	20	6.5	82	8.9
Mean	12.8	88	12.6	81	13.3	87	12.9
CV (%)	21.8	8	25.0	12	23.0	8	
LSD (0.05)	4.1	10	5.4	16	4.5	11	

previously introduced from CIP were undergoing regional trials for variety release. Tuber yields of the most promising late blight resistant clones (382147.18, 382147.7, 382157.22, 382121.25, and 382140.14) were two to five times higher than those of popular susceptible cultivar Granola.

International distribution. During 1991, 21 countries received late blight resistant materials as clones and/or segregating progenies for resistance to late blight (Table 3-3).

Integrated control of bacterial wilt (BW)

Peru. An in vitro technique was investigated as a possible alternative to the mass screening technique currently used for screening of genetically transformed plants. Sap from transformed plants was extracted, filtered, and spotted at the center of petri plates uniformly inoculated with *Pseudomonas solanacearum*. A zone free of bacterial growth occurred where spotted with the sap of transformed plants, but not when the sap was from control plants, suggesting that only transformed plants produce a bactericide.

The three polyclonal antisera produced in 1990 were compared using DAS-ELISA and NCM-ELISA techniques. The one prepared against strain CIP-204 was best. It was tested for detection of latent infection in tubers, compared with plating on Kelman's agar medium. Samples consisted of 2-5 tubers sliced 2 mm thick from the stolon end and macerated in 15 ml of PBS. The three techniques detected the presence of *P. solanacearum* in most samples (Table 3-4). Therefore, because it is easier to use and interpret, NCM-ELISA should be recommended for use by NARS to detect latent infection in seed programs (membranes can be spotted and mailed to CIP for completion of the tests). NCM-ELISA kits were prepared and sent to NARS of Chile, Egypt, Indonesia, Kenya,

Table 3-3. Distribution of late blight resistant material from the International Late Blight Project during 1991.

Country	Number of clones	Clones from tuber families	True seed/ families
Bolivia[a]	99	885	6,000/30
Burundi	122		
Colombia[a]	34		3,750/25
Ecuador			11,500/23
Ethiopia	104		
Ghana	110		
Guatemala	69		
India	49		
Kenya	41		
Madagascar	79		
Malaysia			3,000/15
Nepal	20	320	
Netherlands			4,600/23
Nigeria	75	426	
Panama	10		
Philippines	128		4,000/20
Rwanda[a]	113	614	
Sri Lanka	16		
Uganda[a]	102		
Venezuela			1000/10
Vietnam			4,000/20
Total	1,171	4,363	27,500/166

[a] These countries received 2 shipments.

Mauritius, Nepal, Nigeria, the Philippines, and Uruguay.

In an attempt to further minimize the variation that occurs in screening tests for resistance, cuttings from up to six different nodes of given plants were tested, using resistant variety Molinera and susceptible varieties Ticahuasi, Yungay, and Revolución. Inoculum consisted of 5×10^7 cfu/ml of isolate CIP 204. There were significant differences between different sets of cuttings for a given variety. The younger, more apical cuttings were more resistant than more basal ones. The nodes were numbered from 1 to 6 from the base to the apex. Significant differences per variety, starting with the most resistant, were: Ticahuasi 5-2, Yungay 6-4, Revolución 5-4, and Molinera 4-3. Therefore, using multiple cuttings from one plant causes greater variability than if only one apical cutting per seedling is used.

Close to 9000 plants of 363 genotypes were screened for resistance under greenhouse conditions for five different breeding programs (results reported elsewhere). Because the Huaraz field screening site cannot continue to be used, new sites are being explored. At San Juan, Cajamarca, the uniformity of soil infestation with the bacterium is being established. In Piura near the equator, two field sites (Huancabamba, 2,080 m, and Frias, 1,810 m) were utilized to screen 175 genotypes that

Table 3-4. Detection of latent infection of potato tubers harvested from field grown plants that showed bacterial wilt symptoms, by plating on Kelman's agar or by two serological tests.

Sample Number	Culture medium[a] Kelman + TZC	DAS-ELISA[b]	NCM-ELISA[c]
T#1	-	0.142	-
T#2	-	0.196	-
T#3	+++	0.392	++++
T#4	+++	0.605	++
T#5	+++	0.573	++++
T#6	++	0.458	-
T#7	+++	0.201	-
T#8	+	0.192	-
T#9	-	0.231	-
T#10	+++	0.625	++
T#11	+++	0.580	+++
T#12	-	0.299	-
T#13	+++	0.692	++
T#14	+++	0.665	++
T#15	-	0.222	-
T#16	-	0.173	-
T#17	-	0.201	-
T#18	++	0.215	±
T#19	-	0.114	-
T#20	+++	0.300	-
T#21	+++	0.266	-
T#22	++	0.443	+
T#23	-	0.335	+++
Buffer	-	0.146	-

[a](-) = No typical colony was observed (-), (+) = 2-5 colonies/plate, (++) = 5-10 colonies, (+++) = more than 10 colonies/plate.

[b]Mean of absorbance at (405 nm) of four wells per sample, read after 20 min.

[c](-) = No reaction, (+, ++, +++, ++++) = represent a low, medium, high, and very intense purple color 20 min after adding the conjugated enzyme.

include the best resistance available from numerous sources. The low latitude and relatively low altitude for potato growing, are very favorable conditions for BW development. Twelve clones yielded over 1 kg/plant and had no foliar wilt, but latent infection occurred in the symptomless tubers. This relative resistance should prove useful, provided the most tolerant clones are the most resistant ones under less adverse conditions.

A genetic study of the general and specific combining abilities for resistance to *R. solanacearum* was conducted in a population developed to include immunity to PVX and PVY. The 120 clones selected at San Ramón in a heavily infested field were evaluated under greenhouse conditions in La Molina and their *narrow-sense* heritability for resistance to BW was found to be low (0.18). Clones (382291.3 x XY-16).82 and (381050.1 x XY-13).23 were resistant

to strains of races 1 and 3 and showed good yield and medium earliness.

When 100 clones were arranged in a 10 × 10 lattice for evaluation for resistance at San Ramón, the most resistant, medium earliness clones were (381077.1 × XY-13).73, (382291.1 × XY-13).68, and (381077.1 × XY-16).28. Tubers of the 30 resistant clones from the previous evaluation were assayed for latent infection. Only clones (381077.1 × XY-16).28, (382302.2 × XY-9).55, and (382291.1 × XY-16).68 failed to show latent infection.

The search for new genetic resources and the use of RFLP to monitor the introgression of genes conferring resistance followed by the mapping of genes of a 2x population has begun by screening a group of 34 F1 plants with race 3 isolate 204. Results are pending, as are those of screening for resistance to RKN.

Attempts were made to transform potato genotoypes to combine natural resistance with synthetic resistant-gene constructs by inoculation with *Agrobacterium tumefaciens* containing antibacterial genes. It was initially shown that regeneration without infection was possible. However, when plants were infected with the gene construct, regeneration did not take place. Thus, different media were tried. Diploid *Solanum phureja* clones CCC1386.26 and PI123050.2, and the tetraploid obtained by endomitosis in callus culture of the first of these, CCC1386.26.82, were tested for their regeneration ability in three different media using leaves, leaves with petiole, and stem segments as explants. Desiree, a cultivar with well-known regeneration capacity was used as a control. Regeneration occurred in the three tested genotypes, with a higher rate of success with stem segments. The less inbred genotypes had greater regeneration ability.

Because potato plants become more susceptible to *P. solanacearum* when attacked by RKN, resistance to this parasite is of great interest for integrated control. An evaluation was made of the reaction to *Meloidogyne incognita* of 224 diploid potato clones developed by intermating 24 2x clones (having either single or combined resistance or tolerance to *Meloidogyne incognita, Globodera pallida, Phthorimaea operculella, Pseudomonas solanacearum*, early blight, and soft rot) with three 2x clones having resistance to PVY and PLRV. The genetic background of these clones includes various potato cultivars and breeding lines (*Solanum tuberosum* ssp. *tuberosum* and *S. tuberosum* spp. *andigena, S. bokasovii, S. gourlayi, S. chacoense, S. multidissectum, S. phureja, S. spursipilum, S. yungaenses*, and *S. stenotumum*). Approximately 60% of the clones were found to have varying degrees of resistance to *M. incognita*. Only one clone was found to be highly resistant while 78 were resistant and 54 moderately resistant. Some clones showed resistance to both *M. incognita* and *P. operculella*. Since over 50% of these clones produce functional 2n pollen and some produce 2n eggs, there appears to be a good possibility of transferring the resistance traits by 2x - 4x crosses. A total of 5 clones having resistance to either *M. incognita* and *P. solanacearum*, or *M. incognita* and PLRV are presently included in the pathogen tested list or are being cleaned up for distribution.

The possibility that *M. incognita* is implicated in the dissemination of potato spindle tuber viroid (PSTVd) was investigated. Data suggest that PSTVd may be carried on the surface of the female

M. incognita, on the cuticle of juveniles, inside the egg mass, and on the surface of eggs extracted from PSTVd-infected plants. This is of particular interest since the egg masses left in the soil from one season to the next can become a focal source of PSTVd infection. This is the first report of possible involvement of a tylenchoid nematode in the dissemination of a viroid.

The role of *M. incognita* on the incidence of some tuber diseases under storage conditions was investigated. Data indicate 59% of the tubers infected with *M. incognita* at the time of storage rotted after 60 days storage as compared to 13% of uninfected tubers. After 4 months of storage, the rate of rotting increased to 68% for infected and 16% for uninfected tubers. *Erwinia* spp., *P. solanacearum*, and *Fusarium* spp. were the organisms primarily isolated from the rotted tubers. The total weight losses due to rotting of tubers were 60% and 17% for infected, and 89% and 26% for uninfected tubers after 60 and 120 days of storage.

China. The effectiveness of four monoclonal antibodies (McAb) produced by established hybridoma cell lines was determined by testing them against 45 strains of *P. solanacearum* from potato of various geographical origins, including Beijing, Hebei, Hubei, Huang, and Hunan provinces. Determinations were made by indirect ELISA. Bacterial suspensions were sonicated and diluted to 50 mg/ml. Monoclonal antibodies were harvested from ascitic fluid and diluted to 1:100 in 0.01 M PBS (pH7.4). Reactions were generally considered positive when the absorbance value was two times greater than the negative control. Results indicated that the McAb3 reacted strongly with all 45 strains of *P. Solanacearum* tested, whereas McAb2 reacted moderately with all strains. McAb1 and McAb4 showed positive reaction with all strains except Po 2 and Po 10.

A modified immunofluorescent test with McAbs was used for detecting BW latent infection of potatoes. The tissue extract was prepared from samples of tuber seeds by homogenizing and centrifuging at 1500 rpm for 5 min. The supernatant was then centrifuged at 8000 rpm for 10 min. The pellet containing bacteria was resuspended, incubated with McAbs for 1 hr, then centrifuged and resuspended in FITC conjugated antimouse immunoglobulin for another hour. Bacteria were pelleted, then resuspended in 0.5 ml PBS and collected on the surface of a polycarbonate membrane filter (0.2 micrometer pore size, 13 mm diameter) by filtration. The stained polycarbonate membrane was mounted on microslides with glycerol PBS (9:1) and coverslips. All bacteria extracted from each sample were intercepted and captured on the surfaces of the membrane filters. This method could enhance the detection rate of BW latent infection. However, it requires more McAb and FITC conjugated antimouse immunoglobulin than the normal IFA method.

Indonesia. Potato germplasm was screened for resistance to *Pseudomonas solanacearum*. True potato seed from the CIP breeding population were germinated and multiplied at Tangkuban Prahu, West Java, in 1990-91. Clones were selected based on adaptability and tuber shape using cultivar Granola as a check. Screening was done at the Horticultural Research Institute Substation (at 1,100 m), Segunung, West Java. Before screening, the field was planted with seedlings of tomato cv. Gondola, a local variety. By 25 days after planting, 28% of plants were wilting. The distribution of wilted plants was uniform

throughout the field. One month after planting, the field was plowed to incorporate the plants into the soil. The clones were planted in a 5-hill plot with 35 cm between hills and 80 cm between rows. A completely randomized design was used with each hill representing a different clone.

Of the 151 clones tested, 9 were selected based on the percentage of infested tubers. Only 3 clones (S60, S89, and S102) did not show any symptoms on either stems or tubers, and S78 had no tuber symptoms, but stems wilted. A highly significant correlation coefficient was obtained (r = 0.627) between the percentage of stem wilting and the percentage of tuber infection. Although further studies are required, the degree of stem wilting could be used as a marker for the selection of resistant clones in this environment. Next year selected clones will be tested for resistance in two locations and during two seasons. Adaptability of the clones will be monitored and the level of latent infection will be evaluated after harvest.

Kenya. In collaboration with the National Agricultural Laboratories (NAL), 68 clones from CIP's BW resistance program were planted for evaluation during the rainy season (April), in a plot that has been continuously planted to potatoes and is heavily infested with the pathogen. The following 18 clones were rated as resistant: 900927, 376999.6, 800935, 387973.12, 800977, 387067.2, 800942, 800959, 387973.7, 386295.1, 720025, 386191.21, 678009, 387968.5, 378015.16, 800949, 386295.8, and 800937.

The Philippines. A search began for a biological control agent to be used in the integrated control of BW. Eighteen potato root samples were collected at Lantapan, Intavas, Dalwangan, and Canlubang. A total of 341 rhizobacteria were isolated and maintained for in vitro screening against *P. solanacearum.*

Three strains—A1, B1 and B2—of *P. solanacearum* were used in screening of the rhizobacteria isolates. A total of 144 isolates inhibited the growth of *P. solanacearum* in vitro, indicating their antagonistic capabilities. Among them, 75% were against strain A1, 55% against strain B1, and 60% against strain B2. Some antagonistic rhizobacteria were effective against all strains of *P. solanacearum*, whereas others were effective against only some.

Ten antagonistic rhizobacteria isolates were selected for a greenhouse test. Strains T2, N3, and C4 of *P. solanacearum* and two potato varieties 38.6 and Cosima were used in experiments at Los Baños. Disease control by rhizobacteria isolates was more effective using variety Cosima, than with 38.6. Some antagonistic rhizobacteria isolates controlled strain C4 when it was inoculated to the potato plant. However, no treatment proved effective against strains T2 and N3. No antagonistic rhizobacteria isolate could consistently control the disease, especially when the different strains of *P. solanacearum* were used as inoculum.

Uganda. In collaboration with the Ministry of Agriculture, field experimentation was initiated to determine the best rotation to manage BW by integrated control practices, including the use of resistant cultivars. Initial results were a low incidence of wilt with susceptible varieties but none with resistant Cruza 148 (720118).

United Kingdom. Research conducted for CIP at Rothamsted Agricultural Research Station was initiated this year. Studies began with tomato plants, which can be

more easily managed under controlled conditions. The pathogenicity of diverse strains of *Pseudomonas solanacearum* was investigated using in vitro cultured axenic tomato plants inoculated and incubated under strictly controlled environmental conditions. Strains representing a range of biovars, races, and RFLP groups differed in pathogenicity and aggressiveness. Host-pathogen interactions were significantly affected by temperature, nutrient medium, pathogen strain, and inoculation technique. However, the method was too severe to detect specific differences in resistance or tolerance of cultivars to different strains. Instead, both susceptible and resistant cultivars showed rapid and high mortality. In future, host-pathogen interactions will be studied by infectivity titration (using several levels of inoculum), at different temperatures, and will involve susceptible and resistant cultivars of potato, tomato, eggplant, pepper, and groundnut.

United States. A comprehensive study of the taxonomy and genetic diversity in *P. solanacearum* by means of RFLP analysis has been completed at the University of Wisconsin with more than 200 strains, based on the use of seven different probes. The data are being analyzed, including calculations of similarity coefficients to develop a new taxonomy of the species based on natural groupings that reflect its evolution.

Race 3-specific DNA sequences were isolated to develop a DNA probe for rapid identification of *P. solanacearum* by means of subtractive hybridization. During the past year, efforts continued to develop a diagnostic kit based on the use of nonradioactive probes for hybridization with sample DNA. Extensive studies with two different nonradioactive detection systems included FMC Chemiprobe, which sulfonates cytosine in the DNA probe and then detects the hybridized DNA with a mouse monoclonal antibody, and Boehringer's Genius system, which labels the probe by incorporating digoxigenin-labeled dUTP, which is recognized by an antibody-alkaline phosphatase conjugate. Both systems are effective in detecting race 3 bacteria from pure culture, but are subject to high background problems when used to detect bacteria squeezed from potato tubers, as would have to be done in the field.

The nature of the signalling system that results in induction of the hypersensitive reaction in plants to certain *P. solanacearum* strains, appears to involve cytoplasmic membranes that exhibit tyrosine kinase activity. Phosphorylation of this protein on tyrosine residues, which is unusual for prokaryotes, was demonstrated by phosphoaminoacid analysis of base hydrolysis products and by immunoanalysis. Membranes isolated from a polygalacturonase-defective regulatory mutant with reduced pathogenicity also exhibited reduced in vitro phosphorylation. Since PG is induced *in planta*, the results suggest that the tyrosine kinase plays a role in recognizing environmental signals that are important in pathogenesis.

Control of Soft Rot and Blackleg (*Erwinia*)

Peru. At CIP headquarters 318 clones, mostly *S. tuberosum* ssp. *andigena* (ADG), selected up to 1990 as resistant to soft rot with isolate CIP 004 of *Erwinia chrysanthemi* (Ech), were re-evaluated. Ten tubers per clone were injected with 0.01 ml of a suspension of about 5×10^4 bacteria/ml of isolate CIP 367 of Ech. Tubers were then maintained for 72 hours in an incubation misting chamber with

controlled temperature (27-30°C). From the 318, none had rot diameters less than 0.9 mm (HR), 12 had from 1.0 to 3.9 mm (R), 104 from 4.0 to 6.9 mm (MR), 137 from 7.0 to 9.9 mm (S), and 65 had rot diameters of more than 100 mm (HS).

Tubers of a new population of 2,750 potato clones from the first generation of crosses involving 56 ADG cultivars and 13 *tuberosum* × *andigena* hybrids were also evaluated with the injection method in the misting chamber, with 465 being HR, 132 R, 213 MR, 207 S, and 1,733 HS. Selections with HR soft rot reactions are being multiplied for re-evaluations using 10 tubers each. Furthermore, remaining tubers of those clones selected as HR, R, or MR to soft rot were evaluated for resistance to blackleg caused by Ech. Of 566 clones, 259 showed no blackleg when their stem cuttings were transplanted into a perlite substrate infested with a suspension of 1×10^5 bacteria/ml. Moreover, 73 of the 259 clones survived a re-evaluation with a suspension of 1×10^6 bacteria/ml. The 73 clones combining resistance to both soft rot and blackleg are being propagated for further tests.

Two line by tester (5 × 3 and 4 × 3) experiments were made including 14 clones selected from progenies of ADG cultivars with several degrees of resistance to soft rot. A total of 27 progenies was planted at La Molina in a completely randomized block design with 3 replicates of 30 genotypes each. From 2,430 genotypes planted, 930 were selected at harvest 110 days after transplanting. The ANOVA of these two experiments showed no significant differences between the lines in both experiments, which indicates a General Combining Ability (GCA) effect. However, the line by tester interactions of both experiments did not yield significant differences thus indicating the absence of Specific Combining Ability. Lines CIP 700031.3 and ERW 376.2 and tester CIP 700726.7 showed the highest GCA to transmit their soft rot resistance to their progenies. In general, these experiments showed the percentage of soft rot resistant (HR, R, and MR) genotypes in all progenies to be relatively high. In the 5 × 3 experiment, the percentage of resistant genotypes ranged from 37% (obtained in the cross CIP 700031.3 × CIP 702734.1) to 17% (cross CIP 703855.5 × ERW 88-056.02). In the 4 × 3 experiment the range varied from 44% resistant genotypes (cross ERW 376.2 × CIP 700726.07) to 4% (cross CIP 703660.2 × ERW 399).

Additional research established better methods to reduce variability in screening for resistance to soft rot and blackleg. Two storage conditions for tubers after a 20-day suberization or curing period were 5°C and 22°C, with evaluations by microinjection inoculation at 10-day intervals (up to 100 days) with *Erwinia chrysanthemi* at three concentrations. Incubation was partially anaerobic at 28°C. Susceptibility decreased rapidly with time in storage and was also lower with cold storage (Table 3-5).

The following inoculation methods to test for blackleg were evaluated:

- Plants obtained from tuber sprouts were transplanted to plastic containers containing perlite inoculated with bacterial suspension (1×10^5 cfu/ml). The containers were placed under greenhouse conditions at 26-29°C for 8 days.
- Potato tubers were inoculated with bacterial suspensions (1×10^7 cfu/ml) by vacuum infiltration prior to planting in pots containing sterile soil. The pots

Table 3-5. Effect of time and temperature on the susceptibility of stored potato tubers inoculated with *Erwinia chrysanthemi* using the microinjection method.

Storage	Diameter of rotted tissue in mm		
(days)	22°C	5°C	mean
10	17.10 a	13.70 bcd	15.40 a
20	15.77 ab	11.68 de	13.73 a
30	14.57 bc	7.90 ghi	11.07 b
40	12.62 cd	8.38 gh	15.50 bc
50	13.37 bcd	7.55 hij	10.46 bc
60	13.55 bcd	6.50 ijk	10.02 cd
70	11.45 def	6.05 jkl	8.75 d
80	9.10 gh	5.40 kl	7.25 e
90	10.07 efg	4.85 l	7.46 e
100	9.65 fgh	5.27 kl	7.46 e

Means followed by the same letter are not significantly different at P = 0.01 by Tukey's test.

were placed under greenhouse conditions at 26-29°C.

- Using vacuum infiltration, potato tubers were inoculated with bacterial suspensions (1×10^7 cfu/ml), prior to planting under field conditions at San Ramón Experiment Station.

When the tubers were inoculated by vacuum infiltration to produce blackleg, all clones showed a higher percentage of plants with blackleg symptoms under greenhouse conditions than under field conditions. The most significant differences in susceptibility to blackleg among clones occurred 45 days after planting, both in the field and the greenhouse. Santa Catalina, Yana Puna, and Juana Blanca clones showed more resistance under both conditions (Table 3-6). In another test, plants of all clones obtained from tuber sprouts and transplanted to infested perlite showed more susceptibility to blackleg than those obtained from tubers inoculated by vacuum infiltration. The differences in susceptibility among clones occurred 72 hours after transplanting to infested perlite. Santa Catalina was significantly more resistant than Revolución, Serrana, and Granola but did not differ significantly in susceptibility from the other 12 cultivars. In a comparison of the susceptibility of 16 clones to blackleg using the three inoculation methods, some clones such as Santa Catalina (resistant) showed consistent susceptibility across methods. Other clones showed varying degrees of susceptibility depending on the inoculation method. For example, Jatun Huanca was among the more resistant clones when inoculated by the first and third methods but it was one of the most susceptible with the second method.

Tunisia. Research was conducted at 5 locations by the Tunisian Potato Seed

Table 3-6. Incidence of blackleg in 16 potato cultivars under field and greenhouse conditions after inoculation with *Erwinia chrysanthemi* by vacuum infiltration.

	Blackleg (%)			
Clones	Field		Greenhouse	
Revolución	15.83	cde	80.00	a
UP to date	27.50	bc	77.50	ab
Granola	30.83	bc	75.00	abc
Desiree	49.17	a	75.00	abc
Rosita	13.33	cde	67.50	abc
Ms-1c-2	35.83	ab	67.50	abc
Achirana inta	23.33	bcd	62.50	abcd
Jatun huanca	5.832	de	62.50	abcd
Mariva	15.00	cde	60.00	bcde
Serrana inta	23.33	bcd	57.50	cdef
Yungay	8.33	de	57.50	cdef
Señorita	19.17	bcde	45.00	def
Pirola	19.16	bcde	45.00	def
Juana blanca	15.00	cde	42.00	ef
Yana puna	3.33	e	40.00	fg
Santa Catalina	1.66	e	25.00	g

Means followed by the same letter are not significantly different at P = 0.01 by Duncan's Multiple Range Test.

Program on the susceptibility of different varieties to Erwinia soft rot. Cultivar reaction varied with location, with symptoms or latent infection being more pronounced in the heavy soils at Saida and Ghar El Melh. The cultivar Atica was most susceptible, whereas Cardinal was the most tolerant. There was no direct relation between dry matter content or total sugars and disease incidence.

The interaction between *Erwinia carotovora* subsp. atroseptica and the fungi *Verticillium dahliae* and *Colletotrichum coccodes* was studied in the greenhouse. Each pathogen produced damage, but when combined the damage increased.

Control of Powdery Scab

The Philippines. At Benguet State University, screening of potato cultivars and clones for powdery scab (*Spongospora subterranea*) resistance and evaluation of different fungicides and three methods of fungicide application to control powdery scab were evaluated in the greenhouse and in the field. Of the 30 potato clones and cultivars evaluated, BW-5 was rated as highly resistant; Yungay, P-2, Huaycha Paceña, P-6, Cosima, Poos-590, and G-5 as resistant, while all others--including Baraka were very susceptible (Table 3-7).

Soil treatment with most fungicides used was found to be more effective in controlling the disease compared to dipping and dusting of seed tubers. Among the fungicides tested, Curzate (a.i. = 465 g/kg Mancozeb and 40 g/kg Cymoxanil) and Erosal (a.i. = 800 g/kg Elemental sulfur) were the most effective. Future activities include screening of additional cultivars and a breeding program for resistance and adaptation.

Resistance to Viruses

Peru. Wild *Solanum* species are the most valuable reservoir of genes resistant to pathogens. In 1991 further accessions with resistance to some potato viruses were identified in limited evaluation trials. Fifty-three accessions including eleven different species were evaluated for resistance to PVX, PLRV, PVY, APMV, APLV, and PSTVd. *Solanum sucrense*, previously reported as immune to PVX^c and hypersensitive to PVX-HB, demonstrated a differential hypersensitive reaction to these two viruses. Plants grafted with PVX-HB or PVX-GUA suffered severe apical necrosis while plants grafted with PVX^c reacted with only small necrotic lesions. Virus infection could not be detected in grafted plants. However, both viruses could be detected in mixed infections (PVX^c and PVY), suggesting that co-infection with PVY breaks the resistance of this accession to PVX^c. To date,

Table 3-7. Disease reaction[a] of 10 of 30 potato cultivars and clones field tested for resistance to powdery scab. Buguias, the Philippines, December 1990 to April 1991.

Cultivar/Clone	Infection rate (%)	Disease index
BW-5	0.00 a	0.00 a
Yungay	2.10 ab	0.70 ab
P-2	2.50 ab	1.00 b
Huaycha Paceña	4.80 ab	1.25 b
P-6	8.70 ab	1.33 b
Cosima	9.30 ab	1.38 b
Poos-590	9.60 ab	1.20 b
G-5	11.00 ab	0.95 b
P-3	11.80 ab	1.00 b
Baraka (check)	46.80 e	3.10 de

[a] Average of five replications.

Any two means having a common letter are not significantly different at the 5% level.

70% of the 17 accessions evaluated as resistant to PVX are from Bolivia.

Two *Solanum candolleanum* accessions have been found with resistance to PVX^c, PVX-HB, PVX-GUA, PVY and PSTVd. An accession of *Solanum raphanifolium* with a high level of resistance to PLRV was identified. No virus was detected in graft-inoculated plants. This accession is also resistant to mechanical inoculation with PVS and PVT.

Resistance to PLRV infection in clones G-1, G-5, ICA Guantiva, Chacay INTA, Berolina, Santanlalea, SC-2559, and Huaycha Paceña has been confirmed. Five new sources of resistance to this virus from the CIP pathogen-tested collection were identified. Crosses by CIP breeders created eight clones with high levels of resistance to PLRV. They did not show any infection after seven years of exposure to PLRV in trials conducted at two locations in Peru (Ica and Tacna) with high vector and inoculum pressure. From 60 families with combined resistance to PLRV, PVY, and PVX, 550 clones were selected for future evaluations and selection.

Polish cultivars Bogna, Irga, Orlik, Brda, Lotos, and Fregata, which were reported as highly resistant to PLRV, were tested under greenhouse conditions against ten PLRV isolates available at CIP. The results obtained confirmed that, except for Orlik and Fregata, these cultivars were resistant to PLRV. The resistant cultivars also showed resistance to the aphid *Myzus persicae.*

A diploid Polish accession DW84-1457 was graft-inoculated with various PLRV isolates. Results showed that this clone is highly resistant to both infection with and multiplication of PLRV. Analysis of F1 progenies of *S. acaule* (OCH-13824 and OCH-13823) showed that in these clones resistance to aphids (antixenosis), resistance to PLRV infection, and resistance to translocation to tubers are heritable characters.

Different aphid species *(Myzus persicae, Aphis gossypii, Macrosiphum euphorbiae,* and *Rhopalosiphum padi)* collected from different regions in Peru were evaluated for their efficiency to transmit PLRV isolates from Peru, South Korea, and China. Evaluations were made on acquisition and inoculation thresholds, transovarial transmission of the virus to their progenies, and the aphids' feeding behavior on host plants.

M. persicae was the most efficient vector for the acquisition and transmission of PLRV. *M. persicae* clones collected from warmer climatic regions were more efficient vectors than the clones collected from cooler areas of Peru. However, PLRV isolates from Peru were transmitted more efficiently than the foreign isolates by all *M. persicae* clones tested. The shortest acquisition period of Peruvian and Korean isolates of PLRV by *M. persicae* clone San Ramón was 2 minutes. For the Chinese PLRV isolate it was 3 minutes. Transovarial transmission of PLRV isolates to the progenies of aphids was negative.

These results suggest that PLRV and its vector have adapted to each other in their particular environment. Therefore, breeding and testing for resistance to PLRV should be site-specific.

Experimental results also indicate that immunity to PVX and PVY is transmitted through protoplast hybridization. The diploid parents immune to PVX and PVY were extracted from the tetraploid clone V3 (CIP 378650.1), a tuberosum hybrid with immunity to PVX derived from *S. acaule*, and to PVY from *S. stoloniferum.*

The V3 clone flowers scarcely and it is male sterile. However, the somatic hybrids flowered profusely and showed improved male fertility under CIP headquarters conditions. These results illustrate the good prospects of breeding at the diploid level and of somatic hybridization to accelerate the breeding for immunity to PVX and PVY.

Combining Resistances to Viruses and Fungi

Studies on the variability of PVX and PVY allowed the selection of tetraploid and diploid sources of heritable immunity to PVX and PVY, which are being used by several breeders at CIP. Efficient and reliable seedling screening for immunity to PVX and PVY has been established and is used to test 30,000-60,000 seedlings/year. The technique is being implemented in some regions. The stability of immunity to PVX and PVY has been confirmed under field conditions at headquarters and in Uruguay.

Advanced clones or cultivars from the CIP pathogen-tested seed program were evaluated for their reaction to PVXcp (55 entries) and PVY^{o} (20 entries). Nine clones reacted as immune to PVX. Of these, Huayro (CIP 703304, *S. chaucha*), Yurac Wana (CIP 703351, ssp. *andigena*) and Carnera (CIP 703482, ssp. *andigena*), are native cultivars; the *S. vernei* backcross hybrid (VTN) 62-33-3 is nematode resistant; TS-4 (CIP 383300.21) is a TPS progenitor and Yagana INIA (CIP 720139) is a Chilean cultivar recently released with high resistance to PLRV and *Globodera rostochiensis*. Three clones reported to be resistant to late blight reacted as immune to PVY: CIP 386011.5, CIP 387026.13, and CIP 383081.27.

During summer at San Ramón, 50 progenies were evaluated for resistance to *Alternaria*. The best progenies for yield and earliness and resistant to EB were: 380587.21 × XY-16, LT-7 × YY-9, CGN-69-1 × YY-9, Tollocan × YY-9 and C85.003 × YY-9. A flush-out system has been established to avoid latent infection of *P. solanacearum*. The 105 previously selected clones were reevaluated for agronomical characters at La Molina and for resistance to *Alternaria* at San Ramón. Seventy-six clones were tested at La Molina for earliness, yield and tuber quality, the best clones being (EB85.008 × XY-16).72, (EB87.007 × XY-9).11 and (EB87.001 × XY-20).72. In greenhouse trials, 60 progenies (EB × XY and EB × Y), were evaluated for resistance to PVY or both PVY and PVX. From these, 46 progenies were evaluated in the field at La Molina (July-October) for agronomical characters, selection, and introduction into the flush-out system.

At EMBRAPA (Brazil), CIP progenies segregating for PVY or PVY + PVY immunities have been screened at the seedling stage. This process has become a routine first step in the evaluation process. Since 1989, virus resistant materials were evaluated for early blight resistance and 22 resistant clones were selected. Their vegetative period fluctuated between 70 and 95 days. In another evaluation of 60 virus resistant clones, 36 showed a high level of resistance to early blight and yields of up to 49 t/ha with vegetative periods of from 72 to 95 days.

Colombia. A total of 112 progenies derived from crosses using PVX- and PVY-immune as female parent and *P. infestans*-resistant clones as male parent were screened for immunity to these viruses in Colombia at Tibaitata (greenhouse) or

La Selva (screenhouse). Procedures were tested to determine the possibility of selecting for combined immunity to PVX and PVY and resistance to late blight under these conditions. The surviving mother plants have provided the basic progenitors for the Colombian National Potato Program to breed for combined immunity to PVX and PVY and resistance to late blight.

Virus Detection

Peru. Serological detection of viruses continues with high efficiency, except for PLRV because of the recent depletion of CIP's antiserum stock.

A polyclonal antiserum for PLRV is being improved by the elimination of non-specific reactions. Production of a new PLRV antiserum has ben initiated. Changes in the virus purification method included the use of affinity chromatography, enzyme treatments using two different enzymes, and use of IgG against normal proteins in order to remove contaminants in the final preparations. Immunoprecipitation of IgG with healthy sap, removal of contaminants using ELISA plates previously coated with IgG against normal proteins, and affinity chromatography using Protein A and gel agarose reduced the non-specific reaction of the antiserum produced. The antiserum obtained in NCM had higher virus-specific reactions and lower non-specific reactions with healthy sap. However, the same IgG in DAS-ELISA was suitable only for coating but not for conjugation, because of its remaining non-specific reaction with healthy sap.

An antiserum to PVX-8 Pe (serotype PVX^o) was produced which simultaneously detects different PVX isolates (Andean and non-Andean).

ELISA on nitrocellulose membranes (NCM-ELISA) and NASH procedures have been established to monitor the stability of immunity to PVX and PVY worldwide, especially in regions where there are no laboratory facilities.

NARS have considerably increased their use of serological techniques for virus detection. Kits for DAS-ELISA and NCM-ELISA, and reagents commonly used in serology are supplied on request. Antisera, DAS-ELISA, and NCM-ELISA kits were distributed to national and regional programs to evaluate more than 750,000 samples for important potato viruses.

Detection of viruses using recombinant molecular probes continues with the aim of increasing the range of probes and improving existing ones.

A recombinant plasmid with a fragment of hop stunt viroid (HSVd) cDNA 151 base pairs (bp) and a fragment of PSTVd cDNA 220bp-long has been constructed. Probes prepared from this plasmid indistinctively detect HSVd, PSTVd, and Citrus exocortis viroid (CEVd). This wide-spectrum probe has potential use for the identification and detection of viroids in Andean tuber and root crops, potatoes, and sweetpotatoes.

The possibility of sweetpotato being a host for PSTVd was reported last year. However, until now no naturally infected sweetpotato plants have been found. Preliminary data indicate that the nematode *Meloidogyne* sp. can transmit PSTVd to potatoes. This transmission seems to occur only when egg masses from *Meloidogyne* females that have developed in PSTVd-infected plants are transferred to healthy plants. Because sweetpotato crops are often used as a rotation, the transmission

of PSTVd to sweetpotato seems possible and requires continuous monitoring.

A wide selection of PVX isolates grouped into two serotypes, the Andean PVX^A and the common PVX^O, has been evaluated by NASH.

Two probes, pX61 (prepared from PVXcp, serotype PVX^A) and pPVX19 (from European PVX isolate from group 3, serotype PVX^O), were selected and compared in relation to their ability to detect different PVX isolates (Figure 3-4).

Probe specificity greatly influences the detectability of the different strains or isolates. Especially at low virus concentrations, both probes revealed high specificity in detecting PVX isolates from the serotype group of the strain used for their preparation.

The exact localization of the pX61 cDNA within the viral genome has been identified by sequencing both strands of the clone. Probe pX61 corresponds to the HindIII fragment between nucleotides 3008 and 4107 (1099bp) of the genomic PVXcp RNA. The RNA sequence of PVXcp RNA reveals approximately 77% homology with the sequence reported for the European strains. Probe pPVX19 represents the region between nucleotides 2893 and 3865 in the PVX genome of the European strain. The two probes overlap significantly (around 60%) and both came from the 3' end of the ORF1 which is known to be highly conserved.

A recombinant clone (pX6119) containing cDNA sequences from both pX61 and pPVX19 has been constructed in an effort to overcome the specificity found in probes prepared from a specific strain. A radioactive nick-translated pX6119 probe detected all PVX strains and isolates tested so far. These results indicate that probes

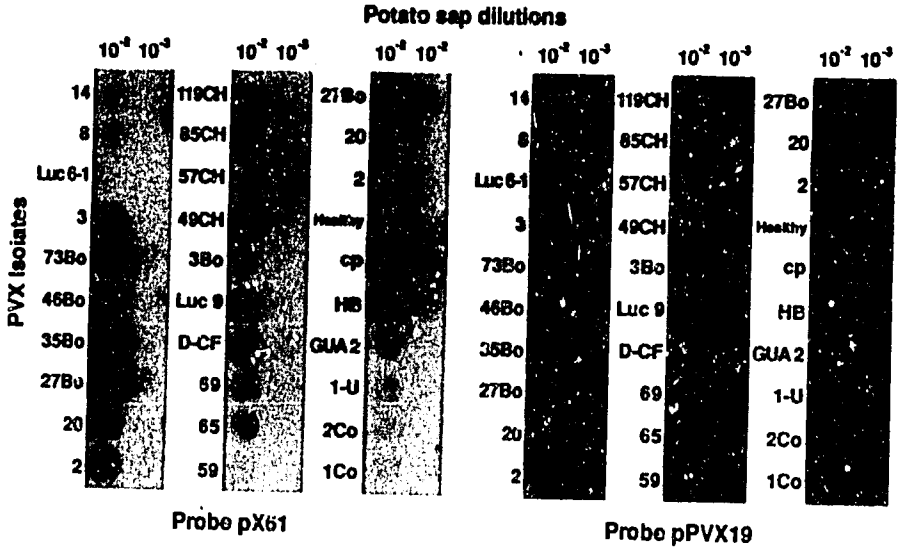


Figure 3-4. Specific detection of potato virus X isolates by NASH using probes pX61 and pPVX19.

with predetermined specificity can be constructed by a combination of highly specific viral sequences.

The preparation of a unique recombinant probe for both PSTVd and PVT has been undertaken. This should allow simultaneous detection of both pathogens in seed lots. Botanical seed transmission of PSTVd makes it necessary to test large amounts of seed, and the NASH test using a probe is the method of choice for viroid detection. Recently, the need to simplify the testing procedure and to increase the reliability of tests for viruses that are difficult to detect, led to the preparation of a cDNA probe for NASH detection of potato virus T (PVT), the only potato virus known to be transmitted through botanical seed. Seeds infected with both PSTVd and PVT have been tested by NASH with a combination of both the PSTVd and PVT probes. No interference in the detection of both pathogens occurred.

Recent experiments in collaboration with the Department of Fruit Crops of INIAA (Ministry of Agriculture, Peru) have shown that avocado *(Persea americana* L.) trees are affected by a PSTVd-like viroid. Preliminary results indicate that this disease is fairly widespread in Peru. Until now PSTVd has not been detected in field-grown potato plants in Peru.

Sweetpotato

Control of fungal and bacterial diseases

Peru. Monitoring of disease incidence continued in Peru. As a result, *Fusarium lateritium* and *Fusarium* spp. were identified as causing the symptoms described for chlorotic leaf distortion. *F. lateritium* was isolated from apical buds, folded and unfolded leaves, open and closed flowers, anthers, pistils, and ovaries of samples collected in San Ramón, Yurimaguas, Vitarte, Cañete, and Tacna. In the field, symptomatic plants show a mycelial growth, white to salmon colored in the entire blade of folded leaves. Once the leaves are unfolded, the mycelial mat is primarily on the margins of the upper surface. Sweetpotato varieties differed in their reaction, chlorotic patches occurring on the young leaves of some, necrosis and distortion in others, while still others had no symptoms.

Research continued on soft rot *(Rhizopus stolonifer)*, one of the most important postharvest pathogens. Since the fungus penetrates the storage roots through the wounds caused during harvest, a variety of inoculation methods using nails, cutting implements, and cork borers were tested.

For each treatment 20 storage roots were used. Roots were washed with running water and surface disinfected with sodium hipochlorite 2.5% for 5 min. Inoculated roots were placed in plastic trays. Evaluations were made from 2 days after inoculation up to 15 days. The best method was when small blocks of the fungus were placed on wounds made with a cork borer. No resistance to *Rhizopus* soft rot was found in the 80 entries of CIP's germplasm that were screened.

Another common disease in harvested sweetpotato storage roots is java black rot *(Diplodia gossypina)*. Very often roots coming from the field are already infected.

After a few days in storage, they become rotted. The proportion of rotted tissue depends on the variety.

Several methods have been tested to produce symptoms on artificially inoculated roots. The most effective was when roots were thoroughly washed with running water, surface disinfected for 5 minutes (then allowed to dry overnight), and inoculated with disks removed from the edge of five-day old colonies of *D. gossypina* growing on PDA (cut with a 5mm cork borer and placed on the surface of fresh wounds made with a scalpel). Inoculated roots were put in trays and incubated at 27°C for 30 days.

Resistance to *D. gossypina* was evaluated for 196 CIP germplasm entries. A second evaluation will be done in 1992. The same entries were screened for resistance to *F. solani*. *Fusarium* spp. cause surface rot and dry rot of stored roots. These fungi also enter the roots through wounds. A second evaluation of those entries that did not show symptoms will be conducted in order to determine escapes.

Additionally, a group of 29 selected entries were screened against *F. oxysporum*. One of them, DLP144, was found to be highly resistant and two others (DLP1139 and RCB95) were resistant.

Argentina. A disease survey of nursery material was made in Buenos Aires Province with a group of sweetpotato growers. The etiology of each disease was determined. A collection of sweetpotato lines was evaluated for susceptibility to foot rot caused by *Plenodomus destruens* in an infected area at EEA-INTA, San Pedro, under field conditions. Preliminary results showed the number of rotted seedlings ranged from 0-2 out of up to 10.

Indonesia. Screening for resistance to scab *(Elsinoe batatas)* was done in the sweetpotato growing area in Java where scab is prevalent during the wet season. Landraces collected in West Java were used for preliminary evaluation of resistance. At the Muara Experiment Farm in Bogor, 130 clones were planted in a lattice design with 2 replications. Disease was scored twice, 65 and 72 days after planting. Of the clones tested, 20.0 and 26.2% were highly resistant or resistant; 26.9 were moderately resistant, 20.0 susceptible, and 6.9% highly susceptible.

The list of selected clones from 130 accessions is presented in Table 3-8. Selection was based on yield (7 kg/6 m^2), harvest rate (80% or greater) and scab rating (1.0 being most resistant). Many clones collected in farmers' fields had higher yield than Southern Queen (SQ) 27, a leading variety. Some of these clones could be released as varieties after multilocation trials.

Highly significant correlation coefficients were obtained between scab rating and yield, and yield related characters. Together with the variable storage root number, scab rating provided an equation which could help predict yield very accurately. These results clearly demonstrate that scab resistance is an important factor affecting sweetpotato yield during the wet season.

In experiments on screening for storability, storage roots were stored at ambient conditions immediately after harvest. Approximate temperature range was 25-32°C, and RH 89-90%. Clones used as material for this experiment were selected based on performance in the preliminary evaluation, i.e., average yield higher than 1 kg/m^2. Weighed sweetpotato samples of around 1 kg were prepared and placed on

Table 3-8. Sweetpotato germplasm resistant to scab *(Elsinoe batatas)* in preliminary screening, Bogor, Indonesia.

Clone Nº	Name	Yield (kg)	Number of roots	Average weight(g)	Harvest rate(%)	Scab score (0-4)
B0034	Setempat	12.1	98	124.6	87.5	0.8
B00079	Bulhok	11.6	95	123.3	95.0	0.0
B0047	Genjah Rantai	11.4	63	180.2	97.5	0.3
B0088	unknown	11.4	94	125.4	97.5	0.3
B0129	Tarico Kunir	10.6	57	186.8	92.5	0.3
B0010	unknown	10.2	52	197.7	87.5	0.3
B0051	BIS 175	9.5	64	159.6	97.5	0.3
B0097	Biru	9.4	73	131.6	92.5	0.8
B0098	Putih	9.0	46	212.8	80.0	0.0
B0076	Cereu Putih	8.9	42	224.3	90.0	0.0
B0071	unknown	8.8	59	155.1	97.5	0.0
B0052	Papola	8.6	40	215.6	80.0	0.0
B0063	No. 5	8.4	46	187.8	97.5	0.0
B0127	unknown	8.4	44	196.3	97.5	0.0
B0054	BIS 173	7.7	47	175.4	82.5	0.0
B0057	No. 9	7.7	68	113.7	87.5	0.8
B0103	unknown	7.2	54	138.7	90.0	0.0
B0033	P.B.	7.1	45	158.6	87.5	0.8
B0069	Rambo	7.1	40	180.9	100.0	0.5
Checks						
B0053	BIS 183	10.0	70	138.0	100.0	0.0
B0053	BIS 183	10.0	51	198.7	95.1	0.0
B0068	SQ 27	8.9	51	188.3	90.0	0.0
B0068	SQ 27	8.0	48	167.6	100.0	0.0
Mean of unselected clones		3.9	31	126.4	80.6	1.8

wooden shelves in a storehouse with natural ventilation. Storability of harvested roots was measured in terms of weight loss and by observing root quality. Samples were weighed at 14, 28, and 41 days. Weight loss of local varieties Brol merah, Genjah rantai, and B0089 was extremely low after 41 days storage. All samples were cut in half to observe storage root quality on the final day. Scores for root quality were based on the percentage of rotten root tissue.

Kenya. The nationwide survey of sweetpotato diseases, begun August 1990, continued. Six more districts were surveyed. Some patterns of disease distribution and incidence are beginning to emerge. Though present in all districts, *Alternaria* spp. occur most frequently in the cool, wet highlands. *Fusarium lateritium* occurs at lower elevations, especially where it is hot and dry. *Erinose* also decreases in frequency at higher altitudes which are associated with cooler temperatures and higher moisture. This is not surprising for a mite-related disorder. *Phomopsis ipomoeae-batatas* was widespread. It is interesting to note that *Alternaria* blight was the only problem

found in Kericho district, a high altitude, tea-growing area.

Unknown B, a scab-like condition previously found in other districts, continued to be a problem. Its etiology remains undetermined. Unknown A, a bacterial blight-like condition that was prevalent on the coast, was again found. Cultures of the *Fusarium* sp. were sent to Pennsylvania State University, for identification and comparison with isolates from the USA. True sweetpotato seed (TSPS) from farmers' fields were sent to Louisiana State University, for isolation. *F. lateritium* was isolated from 42% of seeds in one seed lot, but not in any of the four other seed lots.

United States. At Louisiana, isolations were attempted from TSPS collected from several countries. *Fusarium lateritium* was isolated from seed from Brazil, Ghana, Kenya, Nigeria, Papua New Guinea, the Philippines, Peru, USA (including Puerto Rico), Rwanda, and Zambia, but not from Australia, China, Japan, or Taiwan (Table 3-9).

A collection of 98 isolates has been obtained from sources in the USA and other countries. Pathogenicity and other tests have separated these isolates into three groups: nonpathogenic; systemic colonizers with epiphytic mycelial growth that do not cause chlorosis; and isolates which reproduce the whole CLD syndrome. Isolates obtained during Fall 1991 have not yet been tested. All three types were isolated from USA and African samples. No CLD isolates from Asia, Australia, or South America have been isolated. However, failure to isolate the fungus from seed cannot be taken as evidence of its absence; some seed lots from areas known to be infected did not yield the fungus. Thus, there also is a need to examine sweetpotato plants growing in these areas.

The production of nitrate-nonutilizing variant strains of each of the isolates of *F. lateritium* proved useful in determininig the ability of isolates to form heterokaryons when paired on minimal medium. Formation of heterokaryons in this system is an indication of vegetative compatibility and indicates that two isolates have a common allele at the genetic locus which controls compatibility. This approach is being used widely to determine vegetative compatibility groups (VCGs) for different taxons of fungi and is an important tool in determining phylogeny and relatedness. Often, geographically isolated populations of fungi are in different VCGs. To date, variants from 42 isolates have been produced and VCGs determined for 35 of these. Thirty-three of these 35 isolates are from the USA and fall into four, or possibly five, VCGs. There appears to be an indication that VCGs differ in prevalence in different geographic locations within the USA: isolates from North Carolina were grouped in VCG-2 (9 isolates) or VCG-3 (2); isolates from Louisiana in VCG-1 (3), VCG-2 (5), VCG-3 (1), or VCG-4 (2); isolates from South Carolina were grouped in VCG-1 (1), VCG-2 (2), VCG-3 (4), and VCG-4 (2); and isolates from Puerto Rico were one each in VCG-2 and VCG-4. Isolates from Kenya and Nigeria have not yet been assigned to VCGs but they are not in the same VCGs as USA isolates.

Virus Identification

Peru. Sweetpotato or *Ipomoea setosa* scions infected with a new virus named C-4, were grafted onto virus-free cultivars of sweetpotato. Cultivars Jewel, Georgia Red, and DLP1541 showed clear whitish

Table 3-9. Germination of seed and isolation of *Fusarium lateritium* and other fungi in sweetpotato seed obtained from one or two sites in each country.

Country	Number of Seed lots	Number of Total seed	Germination[a] (%)	Isolation[a] (%) Other fungi	Isolation[a] (%) *F.lateritium*	No Seed lots[b]	Isolate type[c] CLD	Isolate type[c] EMG	Isolate type[c] Non	Isolate type[c] TBT
North America										
United States										
Louisiana & South Carolina	18	1,115	31(62)80	0(2.5)14	0(17.0)58	15	8	1	0	3
Puerto Rico	2	97	25(48)71	0(1.0)2	15(18.5)22	2	2	3	0	0
South America										
Brazil	1	96	39	1	1-3	1	0	3	0	0
Peru	12	594	51(88)100	0(1.2)8	0(0.3)2	2	0	2	0	0
Africa										
Ghana	3	113	72(83)95	5(19.7)32	7(13.7)21	3	0	0	0	6
Kenya	7	223	0(52)100	0(3.0)15	0(6.3)42	2	4	1	0	1
Nigeria	6	301	14(71)94	0(1.0)4	0(6.7)20	4	3	5	2	0
Rwanda	10	297	52(82)100	0(1.2)3	0(1.2)9	2	0	0	0	4
Zambia	5	239	31(41)56	0	0(2.0)6	3	0	0	0	6
Austral-Asia										
Australia	1	25	88	0	0	0	-	-	-	-
China (PR)	3	148	24(73)100	0(1)2	0	0	-	-	-	-
Indonesia	1	47	81	2	2	1	0	0	0	1
Japan	6	354	27(72)100	0	0	0	-	-	-	-
Papua New Guinea	1	98	55	0	1	1	0	1	0	0
Philippines	6	344	21(31)47	2(2.3)4	0(0.5)3	1	0	3	0	0
Taiwan (ROC)		89	37	0	0	0	-	-	-	-

[a] Percentages are given as "minimum (mean) maximum" for seed lots tested.

[b] Number of seed lots from which *F. lateritium* was isolated.

[c] The number of isolates obtained which either: induced all symptoms of chlorotic leaf distortion (CLD); induced epiphytic mycelial growth only (EMG); did not induce any symptoms or signs (non); or are still to be tested (TBT) in greenhouse pathogenicity tests on susceptible CLD-free mericlones of NC-845 sweetpotato.

flecks on leaves one month after grafting, under greenhouse conditions. Occasionally necrosis at the center of the flecks appeared. Symptoms on sweetpotato cultivar Jewel became less defined with time, but persisted in cultivars Georgia Red and DLP1541. Latent infection occurred in cultivars Paramonguino and S-24. The yield of storage roots of C-4 infected Jewel was about 20% less than that of virus-free plants in preliminary pot experiments under greenhouse conditions.

Macrosiphum euphorbiae transmitted the C-4 virus in a persistent manner from sweetpotato to *I. nil*. It did not transmit the virus from sweetpotato to *I. setosa* nor from *I.setosa* to *I. nil*. *Myzus persicae* and *Aphis gossypii* were not vectors of this virus. *M. euphorbiae* was viruliferous for more than a week after acquisition and feeding for 2 days.

Negatively stained dip preparations and partial purifications of infected sweetpotato and partially purified preparations

show C-4 to have isometric particles of about 30 nm diameter (See the photo introducing this section). Observations of ultrathin sections of infected sweetpotato tissue reveal the presence of virus-like particles in the phloem companion cells. Data collected recently indicate that this virus is widely distributed in Peru.

Sweetpotato chlorotic flecks virus (SPCFV), an elongated virus formerly code named C-2, was found to be widespread in Peru, Japan, and China. The virus infected the sweetpotato clones Nemañete, Jewel, Luby 3074, and IITA Tis 2498, but not Imby 3102. SPCFV was detected in 8 sweetpotato plants from Cuba (INVT-59, INVT-67), Panama (DLP 3873, DLP 3850), Bolivia (DLP 1626), Colombia (DLP 2165, DLP 2108), and Brazil (DPW 2680).

The virus code-named C-3 infected Paramonguino and Georgia Red causing mottle and interveinal mottle, respectively. Symptoms were more severe in stem cuttings of cultivars maintained for a long time. Isometric particles were observed in these plants by electron microscopy. In preliminary purification tests from *I. setosa*, plants infected with C-3, isometric, and sometimes, bacilliform particles were observed. *I. nil* grafted with C-3-infected *I. setosa* scions did not show symptoms.

An elongated virus code-named C-6 was isolated from sweetpotato cv. Sosa 29 (Dominican Republic) with chlorotic spot symptoms. Mechanical transmission was not successful. It was transmitted by grafting to *I. setosa*, *I. nil*, and *I. batatas*, but not to *D. metel*, *D. stramonium*, *L. esculentum*, and *P. floridana*.

I. nil and *I. setosa* infected with C-6 (Figure 3-5) showed symptoms of fine chlorotic spots and vein clearing on the leaves. *I. batatas* (cv. Paramonguino) infected with C-6 showed chlorotic spots initially, and then mottling followed by yellowing and leaf drop.

Figure 3-5. *Ipomea setosa* infected with sweetpotato virus C-6, showing fine chlorotic spots and vein clearing.

Virus Resistance

Peru. Thirteen accessions from the CIP germplasm collection evaluated last year as resistant when tested with four SPFMV Peruvian isolates were challenge-inoculated with three other SPFMV strains (C, YV, and RC). SPFMV strains were detected in four of the accessions tested by grafting onto the indicator plant *I. setosa*, but they were not detected by NCM-ELISA directly from sweetpotato. These 13 resistant accessions were exposed to field conditions in Ica, Peru, in a completely randomized block design to

determine stability of the resistance. Only four accessions maintained their resistance in the field. Virus isolates infecting these resistant clones, which are not serologically related to SPFMV, SPMMV, SPLV, SPCV or SPCFV, have been obtained from different sweetpotato plants by grafting to *I. setosa* and *I. nil.*

Five sweetpotato clones (Nemañete, Jewel, Luby 3074, Imby 3102, and IITA Tis 2498) from the pathogen-tested list were tested for resistance to SPFMV (C and C-1 strains), SPLV and SPMMV. All clones showed resistance to SPLV. Nemañete, Jewel, and IITA Tis 2498 were resistant to both SPFMV strains. Only IITA Tis 2498 was resistant to SPMMV.

Detection Methods

Peru. A modification of the NCM-ELISA procedure previously reported involved spotting samples onto dry nitrocelullose membranes rather than wet ones. This change prevented contamination between samples and allowed simplification of the procedure while preserving test sensitivity.

Sweetpotato plants from Mexico and the Dominican Republic were tested by NCM-ELISA for sweetpotato viruses SPFMV, SPMMV, SPLV, SPCV and SPCFV. Using membranes spotted in the two countries, it was shown that only SPFMV was present in both, suggesting that SPMMV, SPLV, SPCV and SPCFV are not common in either.

This year 54 NCM-ELISA kits and 45ml of antisera were distributed among regional and national program scientists. More than 100,000 samples were evaluated for SPFMV, SPMMV, SPLV, SPCFV infection.

Molecular clones prepared from different regions of the viral genome of SPFMV C1 were transcribed in vitro into ^{32}P-RNA molecules and used as probes against several strains and isolates of SPFMV available at CIP. The degree of hybridization reflects the concentration of the virus present in the infected plant but it is also greatly influenced by probe specificity, especially in the detection of non-homologous combinations at low virus concentration. Sensitivity in detecting strain C1 and the common strain C was satisfactory with a minimum detection level of 24 pg of purified virus and less than 1 pg of viral RNA. However, the probes analyzed did not detect (or detected with low signal) other SPFMV strains. This indicates a high strain specificity of the prepared probes.

Because of the need to have probes that detect a wide range of virus strains, analysis of hybridization reaction was performed using cDNA clones from other SPFMV strains. Double stranded cDNA clones produced from a Nigerian isolate of SPFMV (SPV-I) which infects *Nicotiana benthamiana* were labeled by nick-translation. The cDNA probes were tested against several isolates of SPFMV. All clones reacted with a high hybridization signal to strains RC, YV, SP11, SP14, SP33, SP35, SP37, and SP43 (CIP collection). Three of the probes revealed a wider detection range and reacted also to strain C and other isolates, including C1, which also infects *Nicotiana benthamiana.* The cDNA clones were also transferred into plasmid pGEM7Zf(+), containing specific promoters for SP6 and T7 RNA polymerases, and used as RNA probes. Results obtained with RNA probes were similar to those obtained with DNA nick-translated probes. Non-radioactively labelled probes, which can be effective in detecting viruses

and viroids in potato and other hosts, could not be used for sweetpotato due to a high level of background or nonspecific reactions caused by the high content of latex and other interfering substances in the plant tissue.

Training

Training on Disease Control

A training video entitled *Detection of potato viruses with ELISA* was produced. A manual describing all the techniques used in virology is under preparation.

Individual training on detection and characterization of *P. solanacearum* was provided at Rothamsted to two participants from the Philippines and the Netherlands from May 28-June 1 in collaboration with the Philippines potato program and Agrico Research. A similar course was run from October 13-17 for a participant from CENARGEN, EMBRAPA, Brazil who will produce polyclonal antisera against *P. solanacearum* for use in the plant quarantine service in Brazil.

Peru. A course on the pathology of potato seed-tuber production for Andean countries was held in Lima at CIP headquarters, February 11-27. The objectives were to exchange and update knowledge related to pathology in potato seed-tuber production. Participants were from Bolivia (2), Colombia (2), Ecuador (2), Venezuela (2), and Peru (3).

The third advanced virology course, held in Lima May 6-June 8, covered virus purification, identification, and preparation of antisera for virus detection and ELISA and NASH techniques. Trainees from Brazil (2), Chile (1), and Guatemala (1) attended.

Costa Rica. A workshop on bacterial wilt, held May 27-29, was organized by PRECODEPA and CIP Region II. Participants from Costa Rica (2), El Salvador (1) Mexico (1), and CIP (1) attended the workshop.

Panama. CIP virologists met with their colleagues from Guatemala, Mexico, Costa Rica, and Panama to evaluate antisera prepared at CIP's virology laboratory and to fine tune methodological procedures for serological detection of important viruses. The meeting was held June 30-July 7. It was hosted by IDIAP and organized by PRECODEPA.

Kenya. A workshop on integrated control of bacterial wilt of potato, was held at ILRAD in Nairobi, November 10-15. Funding came from ODA, PRAPAC and CIP. The 12 participants came from nine countries: Rwanda, Burundi, Egypt, Mauritius, Swaziland, Malawi, Zaire, Uganda (2), and Kenya (3). Also attending the workshop were CIP staff from Burundi and Rwanda. The topic was detection and identification of *Pseudomonas solanacearum*, including ecology and taxonomy, breeding and screening for resistance, and integrated control methods.

Weighing his catch of Andean potato weevils, this farmer participates in a field day competition in which farmers learned about the pest's habits while collecting them.

Program 4

Insect and Nematode Management

1991 In Review

Insect and nematode pests are among the most variable and complex problems facing potato and sweetpotato farmers in developing countries. Of the world's food crops, the potato is the largest single user of pesticides. The results of a recent priority study conducted at CIP indicated that an estimated $1.5 billion worth of insecticides, fungicides, and nematicides were used by developing country farmers to protect their potato crops. The same study projected that this amount could rise to $4.8 billion by the year 2000. Unlike potato, pesticide use on sweetpotato is neglible, but evidence suggests that it is now increasing in many locations, possibly because of imbalances created by the overuse of pesticides in other crops.

At CIP, components for the integrated management of potato and sweetpotato insect and nematode pests are developed, combined, tested, and transferred to national programs, according to the specific needs of ecoregions in which they operate. These components include improved, resistant germplasm, as well as biological and agronomic measures. The integration and evaluation of component technologies for specific agroecologies will be accomplished in Program 1 (Production Systems), in close collaboration with farmers and partners in CIP's client countries. These technologies should make it possible to substantially reduce the amount of harmful insecticides, acaricides, and nematicides in use.

In work this year, significant advances have been made in the development of insect and nematode resistant varieties. After nearly 12 years of extensive research, a potato clone with the glandular trichome type A and resistance to Colorado potato beetle (CPB) has been developed at Cornell University under a long-term research contract. This clone (NYL 235-4) has now been released as a CPB-resistant cultivar. Countries with severe CPB problems, such as Cyprus, Iran, and Turkey—as well as the USA, and the countries of the former Soviet Union, and Western and Eastern Europe—could significantly reduce the use of insecticides by growing this cultivar. Several of CIP's hybrids have been tested and promising selections made in the glandular trichome progeny with resistance to many insect and mite pests. Some progeny also express resistance to late blight (*Phytophthora infestans*).

A sweetpotato variety soon to be released in southeast Peru is a cultivar highly resistant to root-knot nematode (RKN). Local materials mature in 7 to 8 months, whereas the CIP clones are early maturing and can be harvested in 3 to 4 months. They are in high demand among members of the 5000-family Alto Urubamba Cooperative. These farmers normally grow coffee, but are hard pressed by low prices. In contrast,

they import sweetpotatoes from long distances at a high cost. The availability of the CIP clones should help to partially fill the income gap caused by the reduced price of coffee.

Advanced hybrids with resistance to potato cyst nematode (PCN) and false root-knot nematode (FRKN) have been identified. Some of these materials are now in the final stages of evaluation. In another 3-4 years, more releases from this material are expected to occur in Peru, Bolivia, and Ecuador.

Significant progress has been made in the integrated pest management of potato tuber moth (PTM) and Andean potato weevil (APW). In North Africa and the Middle East, a significant reduction has occurred in field use of insecticide for PTM control because of the adoption of cultural practices. As a result of extensive research to identify non-chemical methods of PTM control, the insecticide Parathion, previously used in Tunisia on consumption and seed potatoes, is now prohibited. The use of biological methods including *Bacillus thuringiensis* (Bt) and granulosis virus (GV) is gaining importance in this region. The sex pheromone of PTM has been accepted by several NARS worldwide to monitor PTM populations. In Central America, farmers have been able to significantly reduce their insecticide application on potato crops through the use of monitoring data obtained from sex pheromone traps. The parasitoids of PTM have been effective in Peru and Colombia. In these countries mass rearing facilities have been established for producing these beneficial insects to control PTM. Good progress has also been made on the use of GV to control this pest in Peru, Bolivia, Egypt, and Tunisia.

Work on integrated pest management (IPM) of Andean potato weevil has now been widely accepted by farmers of Chincheros, Cusco, Peru. Village authorities have passed a law mandating the use of a native fungus introduced by CIP for control of this pest. The fungus, *Beauveria brogniartii*, is replacing the mixture of dangerous insecticides used previously. Other IPM strategies used by these farmers include natural predators—in this case domestic chickens—as well as better storage and cultural practices. This program is particularly timely because there is evidence that the weevil is forcing a great many Andean farmers to abandon large tracts of their land. Evidence of this can be found in virtually every potato growing area in the Andes above 2,500 m.

In Central America and the Caribbean, the use of pheromone traps to monitor and mass trap the sweetpotato weevil *Cylas formicarius* has been adopted by farmers. There is a great demand for this technology in all countries with severe sweetpotato weevil (SPW) problems. Progress in the development of resistant cultivars to this pest has been slow. The recent discovery of Bt strains effective in controlling this pest has opened up new avenues for genetically engineering sweetpotatoes with the Bt-toxin gene. In the near future transgenic sweetpotatoes with resistance to SPW may become available. Progress has been good on biological control of this pest through the use of parasitoids and insect-killing fungi. The use of these approaches needs to be extended through collaboration with farmer cooperatives and the private sector.

Six main projects have been identified within CIP's Insect and Nematode Management Program for the successful development of integrated pest management, four on potato and two on sweetpotato:

- Potatoes with resistance to major insect and mite pests
- Integrated pest management for the control of potato tuber moth

- Integrated pest management for the control of Andean potato weevil
- Management of potato cyst nematode and false root-knot nematode
- Integrated pest management for the control of sweetpotato weevil
- Integrated pest management for the control of sweetpotato nematodes

Potatoes with Resistance to Major Insect and Mite Pests

The primary objective of this project is to develop and improve resistance in existing and new potato clones for major insect and mite pests such as CPB, PTM, leafminer fly (LMF), thrips, CPB, and mites. The secondary objective is to test these materials in regions where these pests are important. Both conventional and non-conventional methods of breeding are emphasized.

Several institutions are collaborating in screening and breeding for resistance to potato pests. They include Universidad Nacional Agraria La Molina (UNALM) in Peru, Instituto Colombiano Agropecuario (ICA) in Colombia, the University of the Philippines Los Baños (UPLB) in the Philippines, ENEA in Italy, Plant Genetic Systems (PGS) in Belgium, and Cornell University, Michigan State University (MSU), and the University of Wisconsin in the USA.

Resistance to Potato Tuber Moth

Peru. Five clones were identified with high level of antibiosis to the first instar of PTM. These were clones 83693.15, 85112.1, 85136.1, 83639.15, and 85115.1. In another study 300 diploid (2x) clones were screened for resistance to PTM damage in storage. Only clone 90.250 was selected as moderately resistant. In order to increase the genetic base, 149 accessions of wild potato obtained from the University of Wisconsin were screened under greenhouse conditions for resistance to the green peach aphid (GPA), *Myzus persicae*, and PTM, *Phthorimaea operculella*. Six species—*S. cardiophyllum* (PI 283062), *S. hjertingii* (PI 498019), *S. lignicuale* (PI 310993), *S. megistacrolobum* (PI 265879), *S. pinnatisectum* (PI 275230), and *S. sanctae-rosae* (PI 498392)—were selected as resistant to both these pests.

Colombia. Resistance identified for PTM in *S. berthaultii* was transferred to the cultivated level by crossing this species with the diploid potato (*S. phureja*) cultivar Criolla or Yema de Huevo. The F1 hybrid was resistant to PTM which indicated that resistance was a dominant character. The widely grown (in Colombia) cultivar Parda Pastusa was moderately resistant to this pest. Screening methods to identify resistance have been improved by burying 25% of tuber surface into sand placed in plastic containers.

Resistance to Leafminer Fly

Peru. Liriomyza huidobrensis was studied under greenhouse and field conditions. In greenhouse tests cultivars Kinigi, Mariva, and Monserrate exhibited high levels of antibiosis to the larva of this pest (mortality of 35-53%). In field tests, 80 clones from the CIP pathogen-tested list and 16 clones developed in the TPS breeding

program selected from two-year tests were challenged by natural LMF populations in the field. Clones P7 and F8 from the CIP pathogen-tested list were significantly less damaged (50% vs 85% for susceptible cv. Revolución). Other clones selected included the variety Tahuaquena and TM1. From the TPS population five clones 86.662, 86.136, 87.282, 86.641, and 86.040 have been selected. Of these, the first three clones had good resistance and yield (mean 0.5 kg/plant) (Figure 4-1). Several developmental parameters of this pest (oviposition, time from egg to adult, mortality of larva and pupa) were studied on clones 86.136 and 86.652. Understanding of such resistance mechanisms is essential to the success of breeding for pest resistance.

In other field trials conducted by UNALM with 48 clones, five (C-65, C-350, C-112, C-64, and C-30) were selected as promising.

Glandular Trichomes

Trichome types A and B confer resistance to a wide range of insect and mite pests. Progress has been made in combining glandular trichomes in plants with good horticultural traits. A total of 432 clones (89 from Cornell University and 343 generated by CIP breeders) were evaluated using the red spider mite (RSM), *Tetranychus urticae*. Of these, 24 clones were selected for resistance to damage by and multiplication of RSM. For LMF, 48 clones with high densities of glandular trichomes were field evaluated and 35 were selected as resistant. In other material received from Cornell University, the mechanisms of resistance provided by these trichomes to PTM, LMF, RSM, two-spotted mite (TSM), *Polyphagotarsonemus latus*, and GPA, as well as natural enemies of GPA and PTM, were studied. Resistance in clone K419.8 to GPA was highly related to the presence of both trichome types A and B. Exudate from

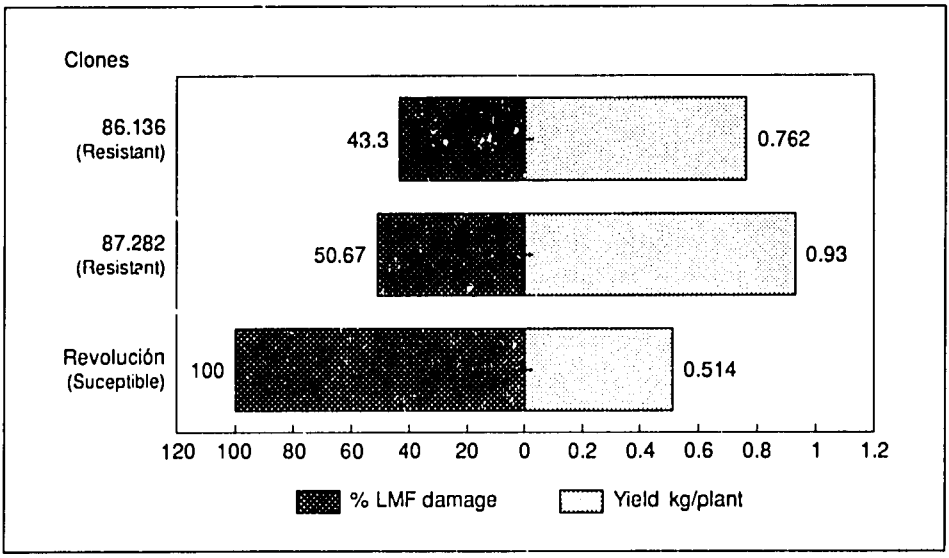


Figure 4-1. LMF damage and plant yield in one susceptible and two resistant potato clones, La Molina, Peru, 1991.

Greenpeach aphid (GPA) stuck on potato glandular trichomes.

these trichomes accumulated on the body and proboscis of these insects leading to high mortality (60% nymphal mortality) (Figure 4-2). The birth-rate of GPA nymphs was reduced by 95%. Clones K421.2, K432.5, and K434.1 exhibited a high level of antixenosis to egg laying by PTM. In clones K421.2 and 434.1, high PTM larval mortality were observed (18% more than in a susceptible clone) indicating antibiosis. LMF oviposition and longevity were reduced in clones K434.1, K419.8, and K432.5. RSM studies revealed that clone K432.5 significantly reduced RSM populations. A mortality of 26% occurred in larval stages. Oviposition was reduced by 75% and a high proportion of RSM was trapped on the glandular trichomes. Longevity of RSM was reduced by 29%. In other studies with TSM the clone K434.1 reduced oviposition by 50% and longevity by 29%. The effect of glandular trichomes on parasitoids, *Aphidius* sp. and *Copidosoma koehleri*, was studied. No adverse effect was observed.

United States. At Cornell University, studies concentrated on genetic mapping of trichome-mediated insect resistance from *S.berthaultii* and on breeding for resistance to CPB. A genetic map has been developed for one of the progenies that segregates for trichome density, sucrose ester production, and the enzymatic browning reaction associated with resistance to aphids and CPB. RFLP markers used in this study have identified the parental source of alleles at 100 loci at regular intervals along the chromosomes. The goal is to map the responsible genes by correlating RFLP variation at mapped loci with trichome phenotypes. Genetic markers for these traits will be useful for introgression of the effective wild chromosomal segments into cultivated material.

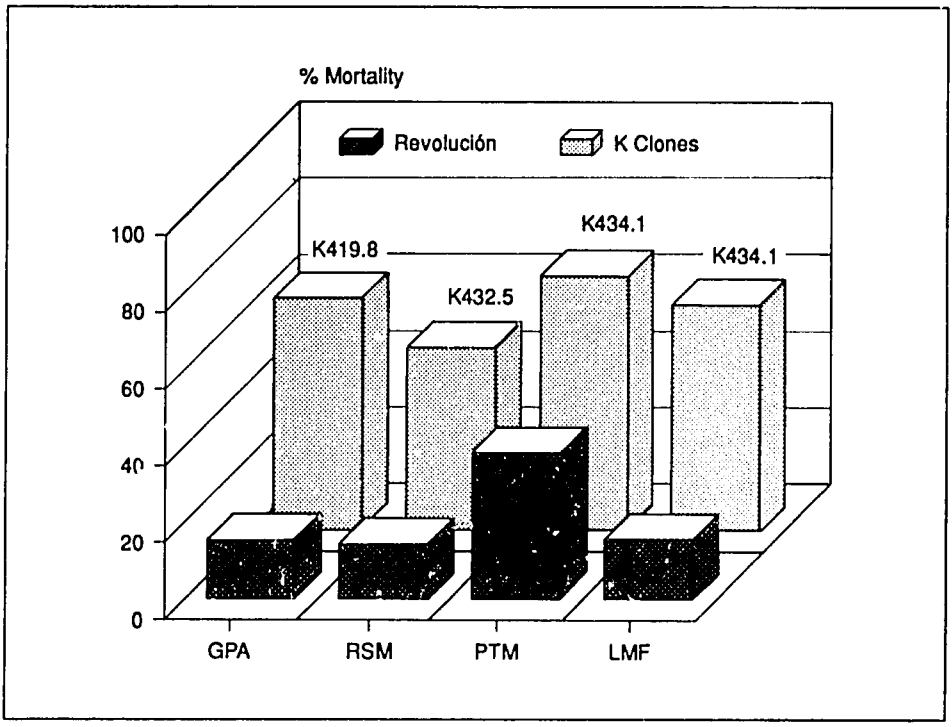


Figure 4-2. Effects of glandular trichomes in Revolución and K clones at immature stages of four major potato pests, La Molina, Peru, 1991.

After nearly 12 years of intercrosses and backcrosses following hybridization to produce tetraploid offspring of *S. berthaultii* and *S. tuberosum* clones, promising new clone NYL235-4 resistant to CPB feeding has been selected. Tuber yield, maturity, and glycoalkaloid content of NYL235-4 approach those of *tuberosum* clones. Field resistance to CPB has been evaluated for several years at both research and commercial farms by Cornell University. Results indicate at least 50% reduction in first generation densities of CPB larvae compared to commercial cultivars. In comparison to plots protected against insect attack by use of insecticides, NYL235-4 showed a 10-15% yield reduction, in contrast to 50-70% for standard commercial cultivars. Moreover, this clone and others like it currently in development can produce commercial-scale yields without significant insecticide input. Therefore, this resistance is almost equivalent to one soil application of Aldicarb or three or more applications of foliar insecticide. Cornell has now released this clone.

Italy. At ENEA, 28 CIP cross combinations (3916 progenies) with glandular trichomes were field tested near Bologna for resistance to CPB feeding damage. CPB injury was less than 50% in 28 clones; and 2 genotypes had a yield comparable with the susceptible controls. In other studies at ENEA, some CIP-developed glandular trichome clones reduced infection by late blight.

The Philippines. Five screening techniques were tested for identifying

resistance to TSM in glandular trichome progenies provided by CIP. Artificial infestation of a terminal shoot of one month-old potato plants using a leaflet containing 5-10 adult TSM was the most appropriate, and several susceptible genotypes were discarded prior to field trials. The three best clones selected for TSM resistance were 394A, 312.1, and 656. Out of the 21 clones with glandular trichomes, seven showed resistance to this pest.

Combined Resistance

In order to combine resistance to PTM, LMF, and GPA with good agronomic traits, 230 different crosses were made in Peru. Seed from these 230 families is being tested to obtain tuber families for distribution to NARS. Most of the clones selected for resistance to PTM exhibited lateness and poor tuber shape. These clones are now being crossed with a population developed for resistance to LMF to improve yield. Material from diverse sources used in this program include advanced PTM resistant genotypes, glandular trichome progeny, and LMF resistant populations.

Genetic Engineering for Pest Resistance

CIP is collaborating with ENEA, MSU, and PGS through special project funding on the development of transgenic potatoes with resistance to PTM. Work at ENEA focused on the development of two DNA sequences similar to other known Bt sequences. These were then used for transforming potato plants by *Agrobacterium* infection. MSU developed a transgenic potato (RO) expressing the Btk gene with resistance to PTM in the laboratory. PGS has engineered three different potato cultivars, Berolina, Bintje, and Kennebec using the cryIA (b) truncated gene for resistance to PTM. Several CIP advanced clones have now been selected for engineering Bt genes with resistance to PTM. Other genes of interest for transformation include the Cowpea trypsin inhibitor gene (CPTI).

Integrated Pest Management for the Control of Potato Tuber Moth

This project aims to adapt proven integrated pest management (IPM) control components to specific agroecological conditions and assist client countries in promoting IPM. Another objective is to increase the level of PTM control through better biological control and cultural practices.

Several NARS have cooperated in this global project. These include: UNALM; Centro de Cría de Insectos Utiles (CICIU); INIAA and SEINPA from Peru; ICA in Colombia; PROINPA in Bolivia; PRECODEPA in Central America and the Caribbean; the Ministry of Agriculture in Egypt; INRAT in Tunisia; the Kenyan Agricultural Research Institute (KARI) in Kenya; and the International Centre for Insect Physiology and Ecology (ICIPE).

Peru. Efforts concentrated on the use of biological control with granulosis virus (GV) and the parasitoid *Copidosoma koehleri*. The effect of GV on PTM damage to foliage of potato plants in the field

was investigated by comparing GV with the application of biological insecticide Bt and chemical insecticide (Methomyl). Only one application was made at 30 days after plant emergence. A high proportion of PTM larvae in GV treated plants was infected. Highest disease development (98%) occurred at 15 days after application of GV. At 60 days, infection in PTM larvae dropped to 70% indicating virus persistance of over two months. This virus was also tested in stores in Cusco, Cajamarca, and Huancayo, at a dosage of 5 kg of talc mixed with 100 GV-infected larvae per ton of stored potatoes. A total of 103,817 kg of basic seed (14 commercial and 3 native varieties) produced by SEINPA and other programs in Peru was used. Four months after storage a 95% reduction in damage was observed in tubers treated with GV (0.45% vs 10.72% for untreated tubers). In all stores two PTM species were found, *P. operculella* and *Symmetrischema plaesiosema*. In the Cajamarca experimental station the variety Mariva was 100% damaged, while GV-treated tubers had very low damage (%).

The effect of talc (a carrier in the GV formulation) on GPA on potato sprouts was investigated. Tubers were treated with 5 kg of talc/t. At 60 days when sprouting began, the tubers were exposed to GPA. In the first week after infestation, the GPA population was reduced by 43% (0.2 vs 2.68 GPAs in untreated tubers). Similar results were observed at four months after storage. Talc hinders GPA movement and blocks mouth parts during feeding. A similar effect of talc was observed for PTM where spiracles and mouth parts of a larva are totally covered by talc particles, causing to asphyxia and death.

The parasitoid *Copidosoma koehleri* was used for biological control of PTM at La Molina and Ancash. In La Molina, 3,685 mummies (165,825 adult wasps) were released over 2.3 ha. Pheromone traps (45/2.5 ha) were placed for mass trapping adult male PTMs. By harvest, 270,073 male PTMs were captured in pheromone traps and damage to tubers was less than 15%. Later attempts to recover the parasitoid were unsuccesful, possibly because of indiscriminate insecticide use in some plots.

In Ancash, 22,500 mummies were released in potato stores and fields at several locations. A 78-95% parasitism rate was observed at harvest. PTM-parasitized mummies have now been recovered from several localities in this region indicating good establishment. Mass rearing modules for this parasitoid are now being set up in this region to cover 3,432 ha in this region.

Colombia. Two parasitoids, *C. koehleri* and *Chelonus phthorimaeae*, have been mass reared and used in biological control of PTM. The first was released in Tibaitata and Boyaca for the control of *P. operculella* and the second in Pamplona for the control of *Tecia solanivora*, a PTM species which has spread from Venezuela to Colombia. CIP has assisted this program by building a laboratory for the mass production of this beneficial insect. Insects produced here are now being used by both Colombia and Venezuela to control PTM.

Bolivia. Surveys were conducted in the Mizque valley. In farmers' stores more than 50% of seed tubers were infested by PTM. Inadequate use of insecticides in this region prevents effective pest control. Various non-chemical alternatives developed by CIP in Peru were tried, including repellent plants such as muña

(*Minthostachys* sp.) and *Eucalyptus* sp., and GV. All these reduced PTM infestations in stores. A local strain of GV and the parasitoid *Copidosoma* sp. were identified in this region.

Tunisia. On-farm and basic research on PTM was emphasized. On-farm research concentrated on the development of PTM infestation in relation to the growth of the potato crop. The beginning of foliage infestation by PTM coincided with the end of foliage growth and did not depend on PTM caught in pheromone traps. Tuber infestations began one week after the fall of the lower leaves. This coincided with the beginning of unfavorable climatic conditions for the crop (temperatures > 20°C) which cause senescence of the plant, and migration of PTM to tubers. Studies of the circadian rhythms of this pest indicated that flight activity begins approximately two hours before sunset, reaches its maximum four hours after sunset and stops close after midnight. In storage trials, predators played an important role in controlling the number of PTM eggs.

In other studies, methods were developed to assess the market value of PTM-damaged potatoes. Damaged potatoes fall into three categories: potatoes with low infestation (only one gallery) sold at full market price; potatoes with moderate infestation (two or three galleries) sold at about 50% of full market price; and potatoes with high infestation (four or more galleries) which are discarded. The evaluation was simplified by establishing the relationship between the level of infestation in a potato lot and the distribution of damage. Thus, the economic significance of the damage can be assessed by determining the total level of infestation. Using this method, 40 farmers were interviewed and tubers were evaluated for PTM infestation. The highest level of infestation in any sample of ware potatoes was 19%. Some farmers (8%) reported that they sold their potatoes at reduced prices when they observed growing PTM infestation in their storage heaps. Thus, PTM infestation was thought to be a significant determinant of market price. Potatoes with two or more galleries per tuber typically sold at 30-50% less than clean tubers. However, potatoes with only one gallery per tuber were not price discounted. Increased farmer adoption of IPM in potato fields between 1986 and 1990 is documented by farm surveys. Results indicate that harvesting before mid-June is thought to be the best way to avoid PTM infestation. Other important control methods used by farmers include irrigation and hilling-up. Generally, farmers have avoided using insecticides for PTM control. Figure 4-3 shows the change over time of cultural practices and insecticide use.

Farmer adoption of new insecticides in rustic potato stores was documented by storage surveys. Results indicate that at the beginning of the decade, Parathion and DDT were the predominant insecticides used against PTM. Since new government regulations imposed in 1984, farmers in Tunisia have favored the use of synthetic pyrethroids. In 1990, some farmers also tried a biological insecticide (Bactospein, a formulation of Bt) for the first time. On-farm trials with a new formulation of biological insecticide GV were conducted. This biological insecticide was effective in controlling PTM infestation over four months of storage.

Egypt. PTM monitoring studies revealed that the male moth population increased in July-August and then declined. The use of light and pheromone traps in wire mesh-screened stores resulted in a decrease of

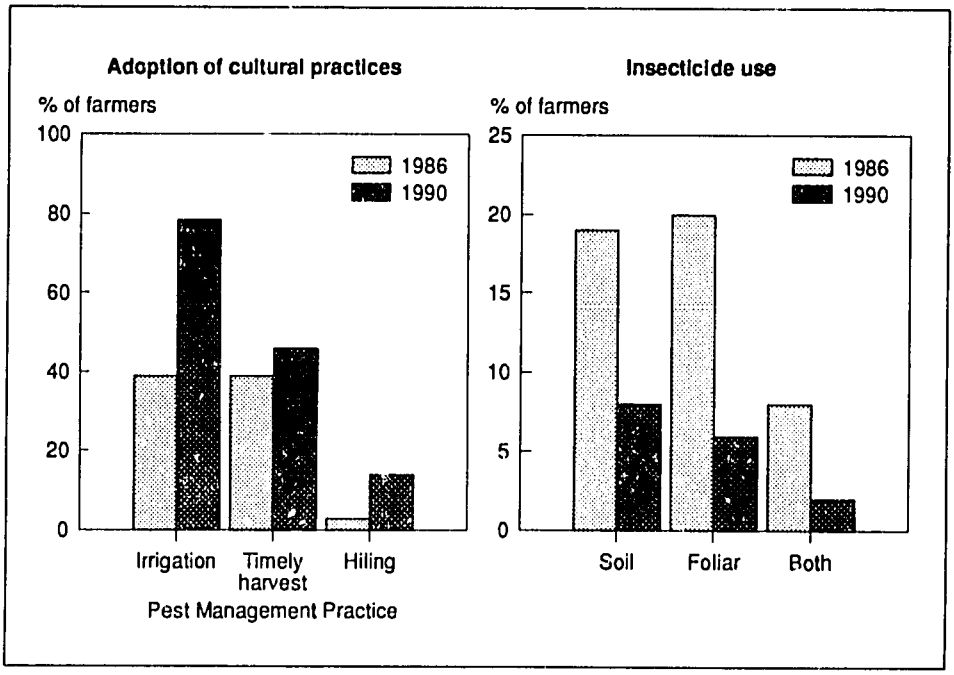


Figure 4-3. Changes in PTM management practices in potato fields in Tunisia between 1986 and 1990.

PTM infestation (8.4% damaged tubers vs 21% in non-screened stores without light and pheromone traps). The use of biological insecticides Bt and GV was effective in the control of this pest in stores.

Kenya. A naturally occurring GV that infects PTM was identified and mass rearing started for use in biological control. Low-cost pyrethrum dust will be tried as a GV carrier.

Integrated Pest Management for the Control of Andean Potato Weevil

This project aims to adapt proven IPM control components to specific agro-ecological conditions in Peru, Bolivia, Colombia, and Ecuador and assist these countries in promoting the use of IPM. Another objective is to increase the level of control of APW through improved biological control.

On-farm and storage research focused on the control of widespread APW species *Premnotrypes latithorax* in Peru, and *P. vorax* in Colombia.

Peru. In collaboration with the INIAA Andenes Experiment Station and small farmers, experiments were conducted at Huatata (3,760 m) in Cusco, including the use of *Beauveria brogniartii* as the most important component of an integrated APW management program. *B. brongniartii* isolated from infected APW adults

has been propagated in floating barley subtract. A small laboratory to manage the fungus and mass rear it has been equipped at the INIAA Andenes Experiment Station.

Farmers in this area traditionally store healthy and damaged tubers near their houses. Potatoes are usually covered with mulch for 6 to 7 months to avoid frost and greening. During the first 80 days in storage, the larvae leave the damaged tubers and enter the soil to pupate. *Beauveria* propagated in floating barley was applied in the soil before storage of infested tubers. When APW larvae enter the soil, they become infected by the fungus through contact. Mortality at three months after inoculum application reached 97%.

A total of 62 potato stores ($3m^2$ each) was treated with the fungus. Three months after *Beauveria* application, mortality of APW larvae in many potato stores reached 99% (Figure 4-4). Other methods of control tried with 10 farmers were: putting trenches around the store, manually collecting adult APW, planting barrier crops such as *Lupinus mutabilis*, using plastic sheets for sorting harvested tubers and preventing entry of APW larvae into soil, and using domestic chickens. APW damage at harvest in fields using IPM techniques was below 17%, as compared with 50% in fields with no IPM. Volunteer potatoes were demonstrated to be an important source of APW infestation. On average, 54 APW were found in those plants. APW infestation levels in stores were quantified by soil sampling of various farmer stores. An average 3,072 APW/m^2 were found. Effective cultural practices used to eliminate the pest include plowing after harvest to expose APW to solar radiation. A 53% reduction of APW population was observed in fields plowed after harvest. A total of 72 farmers participated in this large-scale cultural trial with good results.

Colombia. Three different weevil species were identified, *Premnotrypes vorax*, *Amphideritus vilis*, and *Bothynodontes* sp. The relative proportion of these three pests at Sote Panelas was determined by making collections from the cultivar Criolla. The dominant pest was *A. villis* (58%) followed by *P. vorax* (32%) and *Bothynodontes* sp. (10%). Esterase activity was determined after treating fields with Carbofuran. Higher esterase activity in *A. villis* indicates that the pest may have developed resistance to this insecticide.

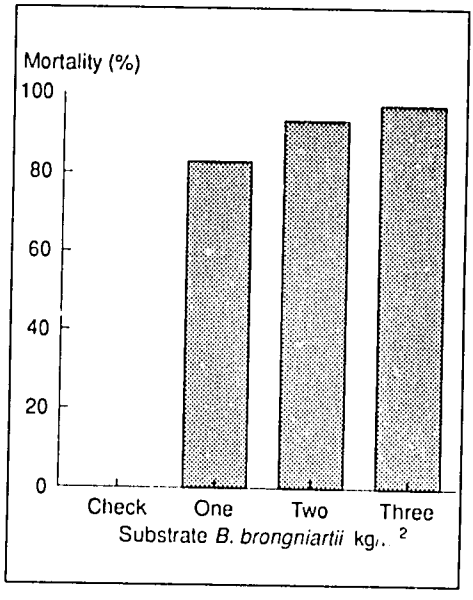


Figure 4-4. Mortality of APW larvae after one to three monthly storage treatments using *B. brogniartii* at Huatata, Cusco, Peru, 1991.

Management of Potato Cyst and False Root-knot Nematode

The primary objective of this project is to produce potato clones with resistance to all known races of potato cyst nematode (PCN). The secondary objective is to develop location specific IPM programs in collaboration with NARS.

Peru. Some 18,000 seedlings from 198 progenies were tested for resistance to PCN in the greenhouse using pot tests and in the lab using petri dish tests, and finally in PCN-infested fields. The most advanced clones selected for tolerance in the field were 377740.2, 276724.1, 377744.3, and 380426.1, yielding 43, 40, 36, and 34 t/ha, respectively. In Huancayo, 372 clones were selected for resistance to PCN races P4, P5, and P6. In Puno, 44 clones were evaluated. The cultivar María Huanca (released in 1989) continued to be the most resistant potato to this pest. Five new clones selected in this region for PCN resistance were G87555.2, G87381.2, G87554.8, G87154.10, and G874344.2.

IPM trials were conducted in Cajamarca. Resistant, tolerant and susceptible potato cultivars were integrated with the use of non-host crops (wheat, barley, lupine, ulluco, faba beans, peas, oats, quinoa, and maize), cultural methods (organic amendments with chicken and cow manure), and biological control using *Bauveria brogniartii*. Cultivar Yungay outyielded (45 t/ha) other cultivars. Chicken and cow manure at 10 t/ha increased yields and reduced PCN populations by 50% as compared to the controls. Manure application did not increase yield of María Huanca (Table 4-1). A reduction of 40-90% in PCN population was observed in all trials where potatoes were rotated with non-hosts.

Electrophoretic studies of protein patterns of *Globodera pallida* and *G. rostochiensis* eggs were conducted to determine the feasibility of using this technique for the identification of nematode species and races. There were differences in pro-

Table 4-1. Effects of several integrated management components on the *Globodera pallida* population and on the yield (t/ha) of three Peruvian potato cultivars.

	Potato cultivars					
	Revolución		Yungay		Maria Huanca	
Treatments	Pf/Pi[a]	Tuber yield	Pf/Pi[a]	Tuber yield	Pf/Pi[a]	Tuber yield
Chicken manure (10 t/ha)	6	19.6 a	3	44.2 a	1.3	38.6 a
Control	20	12.8 b	4	29.5 b	1.3	38.7 a
Aldicarb 15G (25 p.c. k/ha)	4	14.1 b	3	36.1 b	1.3	33.1 a
Beauveria brogniartii (0.5 t/ha)	8	12.4 b	5	29.7 b	1.3	32.3 a
Cow manure (10 t/ha)	7	16.9 ab	8	36.9 ab	1.7	36.3 a
NPK (160-180-100)	11	14.0 b	5	29.1 b	1.3	34.0 a

[a] Ratios of final population/initial population.
Same letter within each column indicates non-significant differences, Duncan Test (0.05).

tein patterns between the races within each nematode species at isoelectric focusing points corresponding to a pH gradient of 5.0-5.9. A protein band at isoelectric focusing point 5.7 was found in a *G. rostochiensis* population from Bolivia. This is in contrary to previous reports establishing the absence of such protein band in *G. rostochinesis* (Figure 4-5). Such discrepancy may be due to the difference in methodology in using eggs versus cysts. Clean eggs may be more valuable than the entire cysts in electrophoretic studies for the determination of races and species of the PCN using protein patterns.

Studies were conducted to determine the presence of physiological races of the false root-knot nematode (FRKN) *Naccobus aberrans* and to establish an international race classification scheme. Fifteen *N. aberrans* populations collected from Argentina, Ecuador, Bolivia, Mexico, Peru, and the USA were inoculated on 10 different plant species. Preliminary findings based on the root galling caused by this nematode indicate that there may be at least 6 races and 2 variants of 2 races of FRKN. This classification scheme requires the use of 5 differential hosts and is the first universal classification scheme that includes nematode populations from several countries.

Sequential histopathological changes caused by in vitro infection of *N. aberrans* in susceptible potato roots were examined. Data indicate that the juveniles penetrate and move inter- and intracellularly in the cortical tissue. One or more juveniles were found in the large cavities formed in the cortical tissue 7 days after infection. Cell walls surrounding these cavities were thickened. Their cytoplasm, in addition to becoming dense, contains starch granules, hypertrophied nuclei, and many vacuoles. The immature vermiform females were formed 25 days after infection. They caused more extensive cellular necrosis as compared with that caused by the infection of juveniles. In roots inoculated with immature females, galling occurred within

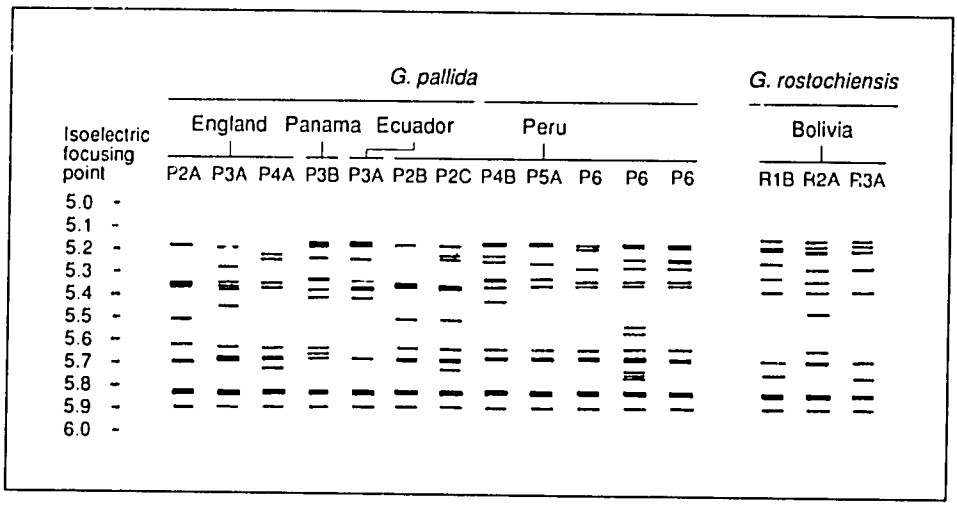


Figure 4-5. Electrophoretic differentiation of species and races of *G. pallida* and *G. rostochiensis* from various countries, as demonstrated by the presence of protein bands at isoelectric focusing points corresponding to pH gradients of 5.0 to 5.9.

2-3 days and gradually caused deformation of the vascular system. Hypertrophy was oriented on the lateral side of the root and at the infection site, giving rise to typically lateral formation of galls on roots. In other studies in Puno, the clones G.877443.8 and G.877434.2 were identified as resistant to FRKN.

Bolivia. Fifty-two clones were identified as resistant to PCN. Of them, 13 clones had no cyst associated with their roots. Cultivars Sakampayas, Wacalajra, Palis, Sutamari, and Choqueluky were the most tolerant.

The distribution of FRKN was determined by surveys in the main potato growing areas of Cochabamba, Chuquisaca, and Potosi. FRKN was more widely distributed than PCN. In resistance studies, 94 clones showed good tolerance to FRKN. Root galling did not take place in 48 clones. The most tolerant clones have been used successfully in crosses with advanced clones with high yield and resistance to late blight. Hybrids between cultivated diploids (*S. phureja*, *S. stenotomum*) and several wild species with resistance to FRKN have been obtained and will be evaluated in future. Commercial cultivars Palis, Sakampaya, Pituwaycas, Wacalajras, Chejchis, Tarackos, Jankos, Sutmaris, and Yaris showed tolerance to this nematode. Yield loss studies conducted under greenhouse and field conditions indicated that losses vary from 36-43%. Resistance of Gendarme, a native cultivar with good yield and adaptation, was confirmed. Screening methods have been improved and modified. The most effective methods appear to be pot tests and the mass-seedling tray technique. Crop rotation trials with beans and lupine were effective in increasing potato yields but had no effect on nematode population. The role of weeds in harboring FRKN populations is now being investigated. Proinpa (Bolivia) is now involved in the further testing of these IPM strategies.

Integrated Pest Management for the Control of Sweetpotato Weevil

This project aims to adapt proven IPM control components to specific agroecological conditions in Asia, Africa, and Central and South America. A secondary objective is to increase the level of control by biological methods and by producing clones with resistance to this pest.

Work in this project was done in collaboration with the NARS of Peru, the Dominican Republic, Cuba, the Philippines, India, Sri Lanka, Thailand, China, Bangladesh, Indonesia, Kenya, Burundi, and the Universities of Florida and Mississippi in USA.

Peru. Work was concentrated on developing IPM strategies for the West Indian sweetpotato weevil, *Euscepes postfasciatus*. Eighty clones identified in earlier trials were field evaluated for both stem and root damage using a 1-5 visual scale (1=no damage, 5=severe damage) and eight clones were selected. Yield loss in these clones varied 0-26%. Two clones, ARB 562 and DLP 103, showed no yield loss when infested with weevils. Another four clones selected in 1990 trials (ARB 539, DLP 1959, ARB 320, and RCB 4911) were evaluated in farmers' fields located at

Limon and Llanguat in Cajamarca. At harvest these clones were again evaluated as moderately resistant to this pest. Crossing of *I. trifida* and *I. batatas* yielded 11 hybrid progeny that were screened in the field using clip-on cages. Only the clone HH 38.4 was rated as susceptible. Of the 40 clones tested from the CIP pathogen tested list, one clone CIP 440001 was rated as resistant. Clone 440002 (Regal), reported as resistant to *Cylas formicarius*, was rated as susceptible to *E. postfasciatus*.

Biological control of this pest was attempted by making 11 liberations of the parasitoid *Eurydinoteloides longiventris*. A total of 11,000 adults were released in farmers' fields at Carabayllo, Lima. Root damage was diminished by 25%. Another parasitoid, *Heterospilus* sp., has been collected from Limon, Cajamarca. This is the first report regarding the occurrence of this beneficial insect. The prospects for mass rearing them is now being studied.

Africa. In Kenya and Burundi surveys and field trials were conducted for the control of locally present sweetpotato weevil (SPW). Two SPW species of major importance identified in this region were *Cylas puncticollis* and *C. brunneus*. Egg-laying behavior of these two pests indicates that at the end of their life cycles, *C. puncticollis* laid more eggs than *C. brunneus*. Neither species reacted to the synthetic sex pheromone of *C. formicarius*. Females of these two species appear to release a species-specific pheromone which attracts male weevils. A simple procedure was developed for collecting pheromones from these two species. After confining 200-500 virgin females in a glass jar, air was drawn over these insects and the volatiles emanating from the unit were trapped using a glass absorption trap containing Porapak Q. The pheromone was collected at 48 hour intervals by eluting the trapped volatiles with methylene chloride. These volatiles have been bioassayed using glass rods. *C. brunneus* reacted instantly to the test extract of *C. brunneus* virgin females. The insects first lifted their antennae, then moved about quickly, ocassionally flying and jumping on the test rod. The reaction of *C. puncticollis* males to the female extract of the same species was variable. Only 20 to 30% of the test males reacted wildly to the test extract. The identification of the active component of the pheromone is now being studied at the Insect Attractants and Behavior Laboratory of the US Department of Agriculture in Florida, USA. A field and laboratory test has been developed for evaluating resistance in sweetpotato cultivars grown in this region.

Central America. In the Dominican Republic, five producers in the major sweetpotato production areas (San Juan and Cibao) were selected. Current producer practices for controlling SPW were documented. Some practices, for example the use of insecticide to treat cuttings, were applied incorrectly, while other recommended techniques such as the removal of alternate hosts, hilling-up, and early harvest were not practiced by all farmers.

High plant-to-plant variability was observed in all fields, indicating a possible constraint to using random sampling to determine levels of yield and weevil damage. Resistance tests were conducted using six cultivars widely grown in this region: Cano Morada, Manicera, La Loca, Copela, Haitianita, and Tiffey. The variety Tiffey was the most non-preferred variety to adult SPW damage. Sex pheromone studies emphasized the development of a low-cost, efficient pheromone trapping

system. A trap made with a plastic jug, about a gallon in volume, that contained water to which a few drops of cooking oil or any household detergent was added, proved most effective in trapping male weevils. The trap costs less than US$0.25 and can be made using locally available materials. A dose of 10 mg per rubber septa was placed inside these traps for trapping male weevils. This dose remained effective for over 5 months. These pheromone traps, when placed in the field, were effective in the continuous trapping of male weevils, thereby lowering the damage rate at the time of harvest. The traps were particularly effective in nurseries for growing planting material. Such plots are generally small and can be protected with only a few traps.

In Cuba, the use of sex pheromone traps, *Beauveria bassiana* and a predatory ant, *Pheidole* sp., were demonstrated as effective IPM strategies for the control of SPW. On a single night each of the pheromone baited traps captured approximately 24,000 male weevils.

Asia. In the Philippines, the fungus *B. bassiana* was grown on residues of corn stalks and then applied to SPW-infested plants under greenhouse and field conditions. Root damage by *C. formicarius* on treated plants was significantly reduced (5% vs 46% for untreated plants). In other trials, a total of 23 strains of *Bacillus thuringiensis* (Bt) were isolated from SPW and were then identified into 5 crystal proteins. Efficacy tests of Bt strains against SPW revealed that six representative strains showed some level of toxicity to both the larval and adult stages of this pest. Samples with cryIA/cryIB gave the highest percent mortality (70-90%). Other control methods identified as effective for this pest include hilling-up and the use of sex pheromone traps. The clones Bangkasi, DC-1, and LO II, id No. 10, were classified as moderately resistant in a field trial.

In Bangladesh, sex pheromone traps were used for determining the population dynamics of SPW. Highest catches (100-150 male weevils/week/trap) occurred during January and February. In India, the sex pheromone has been synthesized using local facilities. This pheromone is as effective as the one produced in Europe or the USA.

In China, a total of 114 clones obtained in South China and the Xuzhou Sweetpotato Research Institute were screened for resistance to *C. formicarius* at the sweetpotato laboratory located at Guangdong, Guangzhou. Resistant clones were ZS 684, ZS 687, ZS 915 and GN 888.

In Indonesia, 274 sweetpotato accessions were tested under field conditions. Of these, four were free of any weevil damage (B0046, B0059, B0067 and B0226). Further tests are now underway to confirm resistance in these accessions.

IPM trials to compare packages of weevil control measures were conducted by SAPPRAD cooperators in Sri Lanka and Thailand. In Sri Lanka, trials included insecticide dip of cuttings, mulching, and hilling-up at six weeks. In Thailand, trials included chemical control, sex pheromone traps, and hilling-up. Effective IPM packages in both countries included insecticide dips of vine cuttings and hilling-up. In Thailand, sex pheromone traps were also components in the most effective control packages. In both countries, IPM packages reduced weevil damage, and increased storage root yields in comparison to untreated check plots.

United States. In contract research with the University of Florida, the sex pheromone of *C. formicarius* was efficacious at reducing weevil populations on plants and protecting roots from weevil damage. Efficacy of sex pheromone improved when combined with monthly applications of chemical insecticides.

Several entomopathogenic nematodes were isolated from collections made in the Caribbean. Some of these may represent a new species of *Heterorhabditis*. These nematodes varied in their infectivity to and reproduction in *C. formicarius*. Results from such studies indicated that endemic entomopathogenic nematodes from the Caribbean may be more suitable as biological control agents of this weevil than commercial, temperate-climate nematodes. In other studies conducted at Mississippi State University, additive genetic variability was found in a sweetpotato breeding population for resistance to *C. formicarius*. Progress was made in developing and refining techniques to measure genetic differences in resistance levels. These accomplishments provide a scientific basis for sweetpotato improvement by developing genotypes with resistance to the weevil.

Integrated Pest Management for the Control of Sweetpotato Nematodes

The main objective is to develop clones with resistance to the root-knot and rot nematodes. Other objectives include determining the economic importance of these nematodes in major sweetpotato growing areas and developing IPM strategies for use in countries with severe nematode problems.

Root-knot Nematode

Peru. A total of 1062 clones of the germplasm collection (originating from several countries) and 1182 clones developed by CIP's breeding program were tested for their reaction to root-knot nematode (RKN), *Meloidogyne incognita*. The most numerous resistant clones came from CIP's breeding program followed by those originating from China, USA, Japan, and Peru (Table 4-2).

In separate tests, 3102 genotypes representing 16 progenies developed as the first generation polycross of previously selected clones from the germplasm collection with tolerance to salinity were evaluated for resistance to RKN. Significant numbers of highly resistant segregating genotypes originated from five progenies. Progeny ST-15 had the highest number of highly resistant segregating genotypes (31.9%). The first generation polycross of susceptible cultivar Tambeño had 99% of its genotypes segregating as susceptible. The highly resistant genotypes selected in this test are being retested and those with confirmed resistance will be field tested for their agronomic characteristics and included in the breeding program.

In Cañete and Cusco, 35 clones (ME-1 to ME-35) previously selected for resistance to *M. incognita* and/or *M. javanica* were field tested. With the exception of six clones, all the ME clones significantly

Table 4-2. Reactions of sweetpotato breeding materials to the root-knot nematode *Meloidogyne incognita*.

	Root galling index[a]					Root necrosis index[b]					Final designated host reaction[c]				
Origin	1	2	3	4	5	1	2	3	4	5	HR	R	MR	S	Total
Bolivia	0	5	5	11	2	0	15	5	2	1	0	4	1	18	23
Brazil	0	4	13	9	3	0	18	9	2	0	0	2	1	26	29
China	7	50	54	14	3	0	97	30	1	0	6	45	6	71	128
Colombia	0	8	40	63	12	0	81	26	16	0	0	3	5	115	123
Dom. Rep.	0	7	29	26	4	0	46	19	1	0	0	2	5	59	66
Ecuador	0	1	6	15	8	0	16	9	3	2	0	0	1	29	30
Japan	6	39	67	11	1	1	92	30	1	0	6	34	7	77	124
Peru	0	88	123	216	25	0	52	90	167	143	0	25	25	402	452
USA	6	47	22	3	0	0	63	15	0	0	5	40	9	24	78
Other Countries	0	1	5	3	0	0	4	2	3	0	0	1	0	8	9
CIP's breeding material	41	591	522	27	1	4	726	322	122	8	32	355	190	605	1182
Total	60	841	885	398	59	5	1210	557	318	154	49	511	250	1434	2244

[a] 1 = no root galling and/or nematode reproduction; 5 = very severe root galling and/or very high nematode reproduction.
[b] 1 = no root necrosis; 5 = very severe and generalized root necrosis.
[c] Host reaction based on the combined root galling and root necrosis responses (HR = highly resistant, R = resistant, MR = moderately resistant, S = susceptible).

outyielded the local cultivars María Angola in Cañete and María Angola, Jewel, and Inca in Cusco in addition to being resistant to *M. incognita* and *M. javanica*. Of these clones, 16 have been selected for use in future polycrosses. Clones ME3 and ME16 were selected for excellent processing qualities as chips. Clone ME 12 was selected by the farmers in the province of La Convención, Cusco, for its resistance to *M. incognita*, high yield, and good chipping quality. This clone is now being considered for release as a new cultivar by the University of Cusco in collaboration with the Colonizadores del Alto Urubamba Agrarian Cooperative.

Rot Nematode

China. Rot nematode *Ditylenchus destructor* is an important nematode of sweetpotato in China. Infected storage roots of susceptible cultivars became completely destroyed after a month of storage (Figure 4-6). In other trials, 234 clones of the germplasm collection originating from Peru were evaluated for their resistance to *Ditylenchus destructor*. Fifty-eight clones were identified as resistant (Table 4-3). These clones can either be used in the breeding program for developing new populations or sent out for testing under field conditions in China.

At the Xuzhou Sweetpotato Research Center, 164 sweetpotato accessions were evaluated for resistance to rot nematode. Out of 13 accessions identified as resistant, 3 accessions (LU 78066, Qianshu-1, and Zhezhouhong) were highly resistant. LU 78066 is being used in the Chinese breeding program due to its high yield and resistance to this nematode.

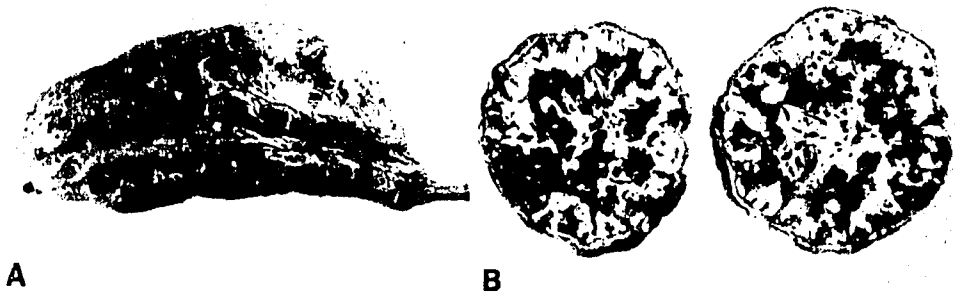


Figure 4-6. Typical symptoms in sweetpotato storage roots infected with *Ditylenchus destructor*. (A) Sunken lesions and crinkled periderm. (B) Discolored end corky textured internal.

Table 4-3. Reaction to rot nematode *Ditylenchus destructor* of some sweetpotato clones originating in Peru.

	Rot index (lab & storage test)[a]					
	1	2	3	4	5	Total
Tested clones per category	0	58	97	42	37	234
Damaged clones (%)	0	24.8	41.5	17.9	15.8	100

[a] 1 = No discoloration of flesh and/or evidence of nematode presence at or around the point of inoculation; 5 = complete and generalized discoloration and browning of the entire storage root accompanied by the presence of a very high nematode population.

The Philippines. A total of 143 accessions and cultivars was screened for resistance to *M. incognita*. At a 5,000 nematode egg innoculum level, 10 were found resistant in the first trial and 11 in the second. The clones which consistently manifested resistance included Bangkas, CM-3, DC-9, and L-52. These clones were resistant under both greenhouse and field conditions.

Identification of Other Major Pests and Natural Enemies

Work in this area contributes to potato and sweetpotato research in general. At CIP headquarters in Peru, an insect identification unit has been established. Fifty-one insect species have been identified in shipments received from Argentina, Bolivia, Colombia, Ecuador, Paraguay, Kenya, Peru, and the USA.

Growing whitefly infestation in developing countries was reported by several CIP regional scientists during the Center's annual review. Whiteflies are proving to be a problem in experiments and in farmers' fields in Egypt, China, India, Colombia, Peru, and the Dominican Republic. The problem is closely linked to overuse of pesticides. Whitefly infestation causes physical damage to plants and is a vector for virus diseases. The population dynamics of whitefly, *Bemeisia tabaci*, and

its natural enemies in sweetpotato crops were determined in contract research with the Universidad Nacional Agraria in Peru. The life cycle of this pest is completed in 26 days.

Other important pests of sweetpotato identified in this project include the aphid, *Macrosiphum euphorbiae*, leafhopper, *Empoasca fabalis*, leafminer, *Pebobs* sp., and a new pest species, *Hypena* sp. The biology of all these pests has been studied. In Kenya, the sweetpotato butterfly was identified as a sporadic, seasonal pest. The life cycle of this pest at 25°C is completed in 42-56 days.

Training

Training on Pest Management

A seminar/workshop on progress in potato pest control in the Andean zone, sponsored by PRACIPA and CIP, was held at CIP headquarters in Lima, November 17-22. The objectives were to analyze the current research on control of main potato pests in Andean countries and to plan projects on IPM for the 1992-1994 period.

The participants were from Bolivia (2), Ecuador (2), Venezuela (2), Colombia (2), Peru (3), CIP-Colombia (2), CIP-Lima (7), and PRACIPA (1). As part of this workshop, the participants visited Cusco to see an IPM project on Andean potato weevil being conducted by CIP and INIAA in Huatata.

Kenya. A course on integrated pest and disease management for sweetpotato, was held in Nairobi and Mbita Point, August 12-23. It was organized by ILRAD and the International Centre for Insect Physiology and Ecology, and sponsored by CIP Region III. The 12 participants came from Burundi, Mauritius, Rwanda, Malawi, Tanzania (2), Uganda (2), and Kenya (4).

Tunisia. A workshop about on-farm research techniques for IPM of the potato tuber moth was held at SAIDA, September 2-6. Participants were 14 scientists from the national programs in Region IV. They came from Tunisia, Egypt, Yemen, Morocco, Lebanon, Turkey, and Syria.

United States. CIP, in collaboration with Virginia Polytechnic Institute and State University, the University of Florida, and Oregon State University, organized an international conference on potato pest management October 12-17 in Jackson Hole, Wyoming. The conference addressed all current knowledge related to management of potato insects, diseases, and nematodes. Particular attention was given to advances in potato pest biology and management, applications of biotechnology in potato pest management, pesticide resistance and resistance management strategies, and alternative management approaches for potato pests. A total of 180 scientists participated. Selected papers from the meeting will be published as a book by the American Phytopathological Society (APS).

Farmers in Nicaragua are already able to produce commercial quantities of potaoes from true seed. These sell well in local markets and are often preferred to potatoes grown from traditional cultivars.

Program 5

Propagation and Crop Management

1991 In Review

The restructuring process coalesced propagation and crop management work into Program 5 which encompasses activities in former Thrusts VI (Warm-Climate Potato and Sweetpotato Production), VII (Cool-Climate Potato and Sweetpotato Production), and IX (Seed Technology).

Propagation research and seed production capabilities strenghtened worldwide as national seed schemes incorporated more efficient techniques developed through collaborative research projects. This resulted in higher quality and a lower cost for producing seed. Meanwhile, socio-economic research played an important role in the faster and more accurate identification of propagation practices suitable for adoption by seed schemes under specific farming conditions. Most significant progress was made by collaborative projects in China, Uganda, Burundi, Cameroon, Kenya, Tunisia, Venezuela, Bolivia, and Peru, among others.

Extensive adoption of True Potato Seed (TPS) seemed likely in India, Bangladesh, Indonesia, Egypt, Nicaragua, and Paraguay, while interest in the potential use of this technology continues to grow in many other countries. This higher adoption potential was based on rapid progress made by breeding for improved progenies and by development of more efficient parents and hybrid TPS production methods. Research on post-harvest handling of TPS has made important advances toward efficient management of dormancy for faster and more uniform seedling emergence and early growth. In India, official release of hybrid progeny HPS-I/13 has made commercial production of potatoes via TPS feasible. This progeny has shown superior agronomic characteristics and outyielded the local crop in many trials in countries such as Indonesia, Bangladesh, Uganda, Cameroon, and Peru, where it has been tested. In Nicaragua, results obtained by the growing number of farms using the adapted techniques–about 140 farms this year–will lead to a significant increase in the area cultivated to potatoes from TPS in the near future. TPS technology as adopted in Nicaragua is being transferred to other Central American countries. Other successful efforts are underway in Paraguay, Indonesia, and Bangladesh. In Egypt, two TPS nationally registered varieties (Serrana × DTO-28 and Serrana × LT-7) are now distributed commercially, supplying farmers with quality seedling tubers for planting. In Paraguay, the latter progeny was officially named "Villa Serrana".

Potato germplasm was distributed to 77 countries and sweetpotato to 33, for evaluation or use as breeding material. Three potato varieties were released in Uganda, four in Cameroon, and four will soon be released in Burundi and two in Zaire.

Previous Page Blank

Several collaborative projects extensively evaluated sweetpotato germplasm for tolerance to various stresses, thus selecting improved genotypes. In China, evaluation included tolerance to shade to identify improved types for intercropping, a popular practice in extensive areas of the country.

Activities in Program 5 have been divided into six main research subjects designed to respond to the research, maintenance, distribution, and monitoring needs of germplasm of CIP's mandate crops as well as to develop information on alternative propagation systems and crop management practices. These are propagation of healthy clonal potato planting materials in diverse agricultural systems, sexual potato propagation, sweetpotato production through improved planting materials and management techniques, abiotic stresses and potato crop management, and maintenance, distribution, and monitoring of advanced potato and sweetpotato germplasm.

Propagation of Healthy Clonal Potato Planting Materials in Diverse Agricultural Systems

Potato clonal propagation

Venezuela and Colombia. Application of experimental results on improved management practices established a more efficient scheme for pre-basic seed production in Venezuela. In Colombia, studies compared performance of crops grown from farmers' seeds and from certified seed. Productivity advantages of using higher quality seed tubers and factors influencing farmers' decisions on renewing their seed stocks were more clearly identified. Also, production of antisera for local use increased significantly.

Burundi. To help overcome bacterial wilt (BW) latent infection, the Burundi National Program produces and distributes about 400 t of seed per year. The Gisozi-ISABU Station produces pre-basic seed which is sent to Munanira to reduce the risk of BW infection in the field. About 36 t of pre-basic seed were produced with an average BW infection of 0.2% and 0.5%, and yields of 22.1 and 25.8 t/ha in the first and second seasons, respectively.

For basic seed production, 10 ha were planted per season with pre-basic seed tuber material from the Munanira Seed Farm and from positive selection. Production of about 165 t for the first season and 200 t for the second were obtained, with BW infection values of 0.3% in the first season and 0.2% in the second.

In 1986 and 1987, BW infection in Mwokora exceeded 60%. Introduction of an integrated control approach in the seed production program has progressively reduced BW infection to 0.7%. A production system whereby pre-basic seed tubers multiplied at Munanira are only planted once at Mwokora appears a more suitable practice for the production of high quality seed tubers free from bacterial infection. Quality seed tubers of varieties Ndinamagara, Uganda 11, Muruta, and Sangema are being distributed in increasing numbers for wider use. (Figure 5-1) Results obtained through collaborative research activities conducted with the Belgium Cooperation Agency in Burundi, indicate that this seed tuber production

Table 5-1. Evolution of potato seed production and bacterial wilt infection in seed farms, Burundi, 1985-1991.

Year	Munanira		Mwokora	
	Production (t)	Infection (%)	Production (t)	Infection (%)
1985	33.3	0.2	105.2	-
1986	48.2	1.2	191.2	64.1
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

method has proved to be practical and aceptable to resource-poor farmers.

In Mwokora, research focused on cultural practices for reducing soil borne pathogens and for developing methods for improved seed tuber storage. Management problems of harvesting, storage, and timely distribution to farmers are among the project priorities.

Kenya. Micropropagation for producing high-quality seed tubers is now fully implemented at Tigoni-NPRC. In vitro plants are transplanted at high density in wooden boxes to produce apical cuttings under extended daylength conditions (16 hours), thus maintaining mother plant juvenility for 4-6 months. Yield performance of apical cuttings taken from in vitro plants has

Critical components of the integrated approach for BW control in seed tuber production:
- a seed tuber production scheme
- 2 1/2-yr rotations with wheat and setaria, including weed-free fallow & cultivation during the dry season
- a rouging system to eliminate diseased & neighboring plants to restrict disease dissemination
- other field sanitation practices
- a simple seed-quality control method for latent infection detection
- training of personnel and farmers

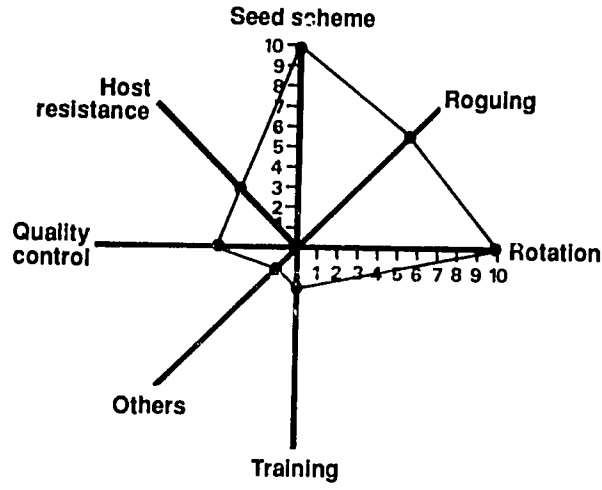


Figure 5-1. Critical components for the production of high quality seed tubers under bacterial wilt conditions.
Source: Ph. D. thesis, J.L. Rueda, University of Reading, England.

varied from 2.6 (Roslin Eburu/B53) to 9.8 (Kenya Dhamana) tubers per plant. In the field at Marindas (2,900 m), yields of 58.2 t/ha with 80% of seed size tubers were obtained. Experiments conducted in that location have shown that highest yields are obtained when tuberlets are used for propagation.

On-farm research was initiated on the use of rooted cuttings supplied by the NPRC involving farmers near Tigoni. Yields higher than 25 t/ha were obtained at several farms.

Trials at Tigone using seed tubers produced in Marindas (2,900 m) from rooted cuttings, and in Njabini (2,400 m) produced by using a traditional clonal selection scheme, did not reveal significant differences in plant growth and yield.

Uganda. At HCRS, Kalengyere (2,500 m), a program of development and production of basic seed is being implemented by adopting appropriate seed production methods as a phased program (Flush-out system) during the vector-free period. In this respect, preliminary studies indicate that aphid populations appear from late April to mid-May as rains stop and temperatures rise. Populations peak by the end of August and then decline sharply. September to March is practically aphid-free.

The two seed production schemes under study use locally adapted varieties Cruza, Sangema, Rutuku, and Marirahinda for producing basic seed. The first scheme is based on conventional clonal propagation and the second uses rooted cuttings for faster multiplication. Table 5-2 (A) shows production levels of basic seed through this program, while 5-2 (B) shows the volume of pre-basic seed produced.

Part of the approximately 50 t of basic seed supplied for multiplication was multiplied as foundation seed. The rest was

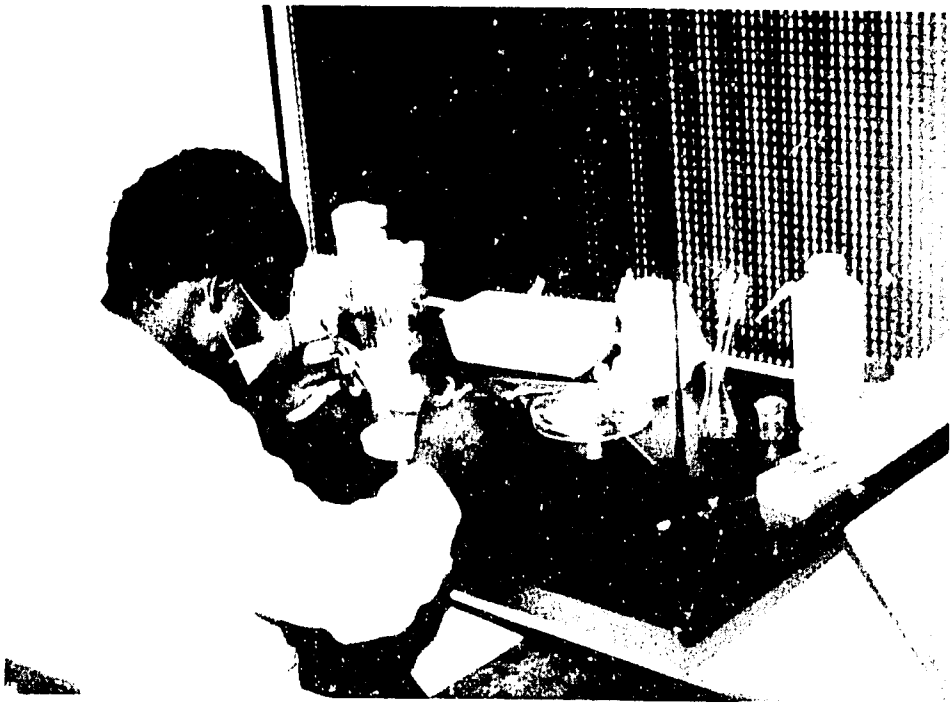
Table 5-2. Seed production of several varieties in Uganda, 1991.

A
Basic seed (t)

Variety	Stage 1 (Clonal A)	Stage 2 (Clonal B)	Stage 3 (Basic Seed)
Cruza	4	12	36
Sangema	3	10	30
Rutuku	3	10	30
Marirahinda	0.5	1	2
Total	10.5	33	98

B
Pre-basic seed (t)

Variety	No. of tubers ex-stem cuttings	Area planted m2	Total production (kg)
Cruza	10,000	1,000	3,000
Sangema	4,000	400	1,300



Tissue culture capabilities are becoming more advanced in African laboratories.

supplied to farmers through District Agricultural Officers.

Cameroon. A tissue culture unit with virus indexing capabilities and a screenhouse with 40 beds for rapid multiplication were developed at IRA-Bambui. Rapid multiplication in screenhouse was intensified by using rooted cuttings which provide high quality basic seed tubers for subsequent variety release. The first lot of basic seed tubers will be produced during the dry season (December to February) and then planted at the seed farm for field increase by mid-April.

Studies on aphid populations at four locations of the main potato producing regions, and virus surveys in the Western highlands, indicated that PVS is by far the most common virus in farmers' fields. Up to 94% PVS infection was recorded in the local cultivar Tuh-Nso in one location. Low percentages of PVX- and PLRV-infected plants were recorded at all locations.

Results of surveys for PSTV detection were negative, suggesting that PSTV may be absent from local materials.

Social science studies examined the formal and informal seed systems in the most important potato producing areas of Cameroon.

Preliminary analysis of a survey made in the northern province of Adamauoa showed that a marked decline in the area grown to potatoes followed the closing of a seed multiplication center that formerly organized potato marketing for local farmers.

Studies of formal seed systems analyzed the cost incidence of improved techniques for breaking dormancy to reduce the production period, and of producing and multiplying basic seed locally. Results point to 20% savings on tuber costs through the use of chemicals to break dormancy which in turn improves seed quality. A proposal has been made to further reduce production costs by 80% through one-time, on-station multiplication of basic seed.

The Philippines. Planting materials other than costly seed tubers are needed in developing countries. Seed tubers alone account for about 50% of the total production cost in the Philippines. Use of sprout cuttings appeared to be a feasible, low-cost alternative for the lowlands in a study that included a large number of clones. With yields of 30 t/ha of seed tubers, clones such as 2k-75, P-6, and 32k-289 yielded significantly more than the tuber propagated control. Several clones showed survival rates higher than 60%, considered acceptable under lowland conditions.

China. The scale of seed tuber production of promising potato cultivars in the Yunnan Province has expanded considerably. Cuttings from in vitro plantlets and microtubers provided by Yunnan Normal University (YNU) and Yunnan Agricultural University (YAU) have greatly increased the amount of basic seed tubers available to meet the needs of different regions.

Production at Zhanoshan City, Guangdong Province, reached approximately three million mini-tubers during the winter/spring season. In Sichuan, Fujian, and Hubei, promising cultivars are being multiplied by different propagation techniques.

Mira and Purple Skin, important local varieties, were cleaned-up from viruses by combining thermotherapy with meristem culture at YNU. Research on the influence of photoperiod, light intensity, and growth regulators on in vitro tuberization showed, under adequate daylength conditions, that an intensive light treatment benefitted in-vitro tuberization. No effect was found with the use of growth regulators. Studies at YNU have shown that biochemical and physiological changes occur during seed tuber storage, pointing to the relationship between endogenous hormones and sprouting. Changes in endogenous ABA, GA, IAA, and ZT were quantitatively measured during storage.

Peru. Various institutions integrating the national basic seed production system produced approximately 1,200 t of basic seed. Also, the program has continued active involvement in research and training at locations that produce basic seed. Growers of improved breeding materials evaluated and selected several promising genotypes.

Agronomic research focused on enhancing efficiency and reducing costs at the pre-basic stages and on developing management practices specific to the cultivars and the ecologies where the seed is produced. At the pre-basic seed stage, use of 500-1000 ppm of the growth regulating compound CCC in the in vitro tuberization media gave best results. Combined with low-cost modifications of the MS propagation media, production cost of tuberlets larger than 45 mg was cut to US$0.08. Modified substrates and cultivation methods in greenhouse seedbeds helped improve management and productivity of individual program cultivars. Virus detection techniques were also improved.

Socio-economic work continued on traditional seed distribution systems in the Peruvian highlands and the identification of alternative systems appropriate for low income farming areas. A model was designed and implemented in small farmers' communities based on multiplying and distributing high quality seed from farmers who specialize in producing seed within the highly fragmented farming sector of seed users. Local committees formed by seed multipliers are part of higher-level organizational units of the various producing regions of Peru.

Sexual Potato Propagation

TPS Adoption

Significant progress was made in the adoption rate of TPS technology. True potato seed (TPS) technology is expanding rapidly in India, Indonesia, Bangladesh, Egypt, Nicaragua, and Paraguay. In China, seedling tubers continue to be used to plant about 20,000 ha of potatoes. Improved genetic materials and seed production and handling techniques have increased the diffusion of TPS technology as well as the success rate obtained when tested in farmers' fields. TPS is increasingly regarded by the public and private sectors as a viable commercial alternative to expensive high-quality seed which limits potato production by small farmers of developing countries. Advances were also made in the areas of progeny testing efficiency, improved genetic materials, virus transmission mechanisms, seed dormancy, and post-harvest handling.

TPS Diffusion

Asia. Selected TPS progenies are being increasingly used for large-scale commercial seed production. In India, farmers have increased their demand for seed. Commercial production of TPS is now possible in India following the official release of TPS variety HPS-I/13. This progeny has outyielded the crop from seed tubers of local cultivars in Bangladesh, Cameroon, Uganda, and other countries. The superior adaptation of HPS-I/13 was confirmed by experiments in Peru. The most advanced TPS genotypes from various CIP Regional Programs were compared for transplanting and seedling tuber yields and rated for various agronomic characteristics. Interest in TPS is also increasing rapidly in Morocco, Tunisia, Kenya, and Ghana.

Indonesia. Growing numbers of interested farmers from potato growing regions are now adopting CIP's selected TPS progenies. Among the most popular progenies in use are Serrana × DTO-28 and HPS-7/13. About 100 small farmers currently use TPS in Indonesia.

Egypt. Seed of TPS registered varieties Serrana × DTO-28 and Serrana × LT-7 is being used in by private interests to produce seedling tubers to sell to farmers. An increasing number of small farmers are also using TPS to produce their own seedling tubers.

Nicaragua. TPS was used in planting approximately 140 ha of potatoes in different types of farming units, ranging from family farms to large agricultural cooperatives. About 40% of farmers used TPS for transplanting seedlings and 60% used it to

produce seedling tubers. The Ministry of Agriculture plans to use TPS for 30% of the national potato production. In Paraguay, the Ministry of Agriculture is supporting a seedling tuber production scheme developed by the national program. Farmers are buying seedling tubers at about half the price of imported seed tubers. Following results obtained in Nicaragua and Paraguay, national programs of Guatemala, Cuba, Jamaica, St. Kitts, Dominica, Venezuela, and Peru have initiated efforts to investigate the possibility of using TPS.

Genetic Improvements

The establishment of a systematic method of evaluation allowed for fast progress in selecting superior TPS progenies with wide adaptation. Newly selected TPS progenies from CIP's breeding program were evaluated for transplant and seedling tuber production under a wide variety of environments at several locations this year. A number of progenies were advanced to large-scale seed production for extensive on-farm testing next year. These new progenies showed good potential in tests conducted in several countries. In Egypt, LT-9 × 104.12LB and LT-8 × 104.12LB stood out among a large number of different TPS progenies. In Peru, transplanting and using seedling tubers of LT-9 × TS-3 produced superior tuber uniformity and yields. In China, CFK-69.2 × 7XY.1 and 379697.153 × TS-2 showed good potential. Serrana × TS-3 was well accepted by farmers for double cropping and the clone TS-3 is considered a superior parent for crossing with local cultivars. In Bangladesh, HPS-7/67 transplants outyielded Kufri Joti, a widely used cultivar. In China, the selection of TPS progenies for late blight and bacterial wilt resistance is continuing in Huize, Yunnan, Penxian, Sichuan, and Enshi, Hubei.

Virus and Viroid Transmission in TPS

Studies conducted in CIP-Peru on the possible mechanisms for PSTVd and PVT transmission showed important variations among parental clones with respect to transmission rate when pollen from infected plants was used for pollinating either infected or non-infected plants. In PSTVd, 57% of the plants became infected when pollinated from infected plants. Non-infected plants pollinated from PVT-infected plants remained non-infected.

Advances in TPS Postharvest Management

All orthodox (resistant to desiccation) seeds, such as TPS, have a critical seed moisture content (SMC) above which seeds in storage deteriorate at a logarithmic rate. The critical moisture point is not affected by the storage temperature; though seeds do deteriorate faster when stored at higher temperature.

To determine the critical point for storing TPS, seeds of Atzimba × 104.12LB were stored for two years at increasing SMC levels from 3.9 to 10.9% and under a constant temperature of 30°C. Seed quality was evaluated at 4month intervals using the coefficient of velocity and the percentage of germination under high temperature conditions (27/40°C) at 7 days in petri dishes. The results in Figure 5-2 show that TPS stored at above 6% SMC deteriorated more rapidly after 1 year of storage. Therefore, TPS should always be stored hermetically sealed at below the critical point of about 6% SMC.

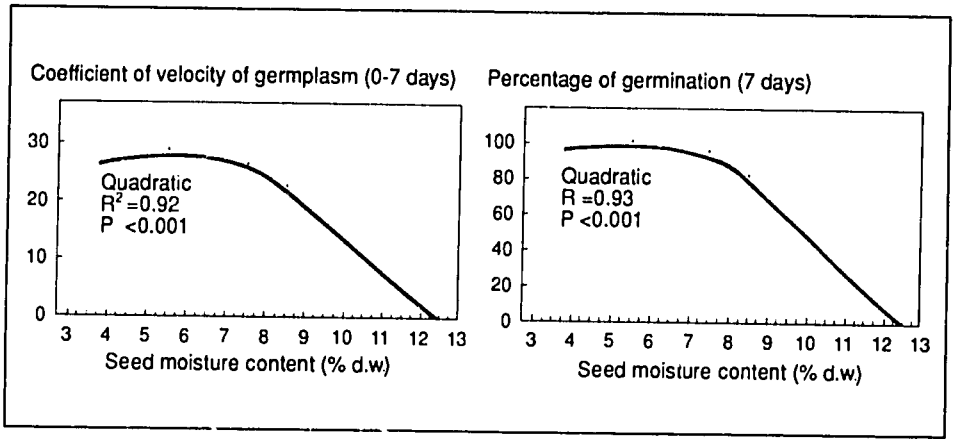


Figure 5-2. Velocity and percentage of germination under high temperatures (27/40°C) in TPS of Atzimba x 104.12LB as affected by seed moisture during 16 months of storage.

This is of particularly importance for maintaining seed quality in warm climates.

TPS Dormancy

TPS are usually considered to be "dormant" (difficult to germinate) for some time after the seeds are harvested. A TPS seed lot may be defined as being dormant if the favorable temperature for germination falls within a temporarily restricted range, which is commonly found between 10 and 20°C. As TPS afterripen in storage, seed dormancy progressively decreases until most of the seeds in a given lot become non-dormant, and are thus able to germinate freely at 27/40°C (21/3 h/day) in less than 7 days.

The effect of storage temperature (5, 15, 30°C) on the rate of dormancy loss was examined at increasing periods of storage using TPS of Atzimba x 104.12LB stored at 5% SMC. The results in Table 5-3 show that TPS germinated faster and more completely when stored

Table 5-3. Effects of storage temperature on the velocity and percentage of germination of TPS at 7 days under 27/40°C (21/4 h) tested after increasing periods of storage.

Months in storage	Velocity coefficient			Germination %		
	30°C	15°C	5°C	30°C	15°C	5°C
4	23.3	19.2	18.3	95	72	75
8	25.4	20.5	18.8	99	96	91
12	28.7	24.6	23.0	96	93	79
16	29.3	22.8	20.5	100	88	80
20	31.8	25.1	19.9	100	93	93
24	31.0	26.8	22.8	99	96	91
Linear	0.80**	0.72**	0.27**	0.21*	0.32**	0.18*
Quadratic	0.86**	0.73**	0.29*	0.25*	0.45**	n.s.

**, *, n.s. denote P< 0.01, P < 0.05, and non-significant, respectively.

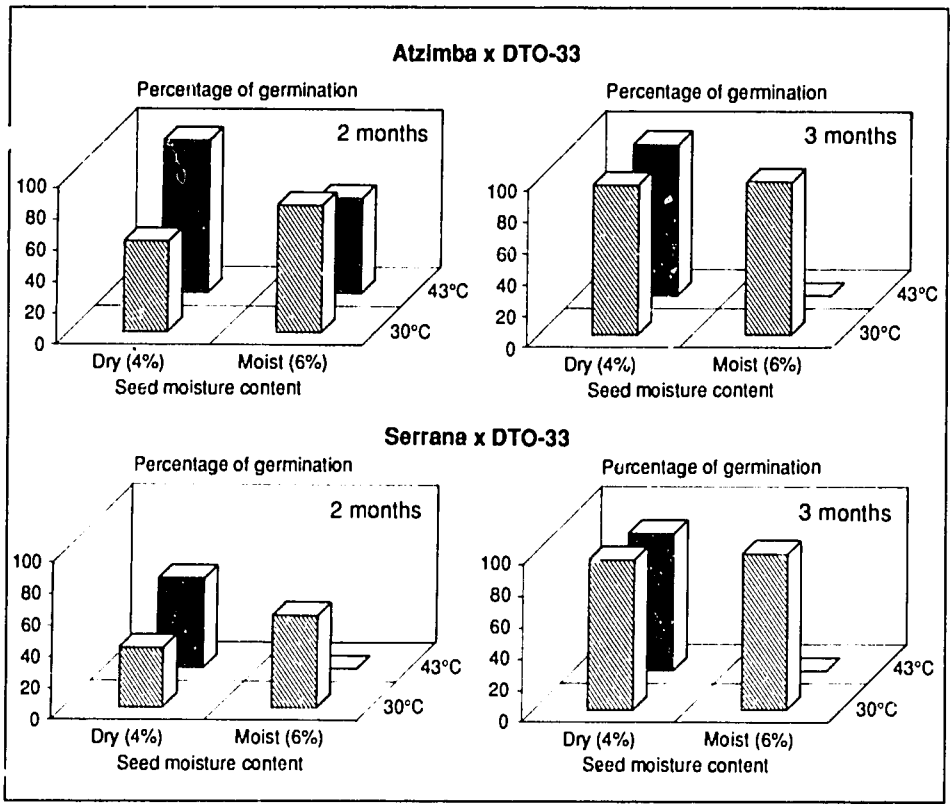


Figure 5-3. High percentages of germination show that storing TPS under high temperatures breaks dormancy.

under higher temperature conditions. Dormancy was completely lost only after 20 months of storage at under 30°C. This suggests that TPS dormancy might be "broken" in a shorter period of time if sufficiently dry TPS could resist storage at a higher temperature than 30°C.

TPS of Atzimba x DTO-33 (moderate dormancy) and Serrana x DTO-33 (high dormancy) were used to study the effect of high temperature (30 vs. 43°C) during storage, on the rate and effectiveness of dormancy loss. At each temperature, the TPS were stored "dry" (3-4% SMC) and "moist" (6%), according to the critical SMC point defined above for TPS. The results shown in Figure 5-3 show that moist TPS of Atzimba and Serrana quickly lost dormancy and died during the first 3 months of storage, while dry TPS lost dormancy but preserved most of its viability. Dry TPS of Atzimba lost dormancy sooner when stored at 43°C than at 30°C. Dry TPS of Serrana appeared to lose dormancy equally well after 3 months of storage at 30 and 43°C. However, a slight reduction in viability was observed when stored at 43°C.

The results indicate that dormant seeds do not begin to deteriorate (lose vigor), as a consequence of high moisture and/or high temperature conditions in storage,

until immediately after seed dormancy has been lost and optimum seed vigor has been attained. In order to lower the storage temperature and preserve seed quality, it is important to determine precisely when under high temperature conditions, each TPS lot has sufficiently lost its seed dormancy. The results also suggest the need to study individual progenies to determine their specific storage requirements for breaking dormancy as soon as possible after the TPS is harvested.

Abiotic Stresses and Potato Crop Management

Evaluation of Improved Germplasm

East Africa. Potato germplasm evaluations in almost all countries of Region III, with the exceptions of Angola, Namibia, and Somalia, have resulted in the release of new varieties from germplasm supplied by CIP. However, the lack of appropiate seed production programs hampers the distribution and widespread use of these varieties among farmers. An expanded Coordinated Regional Trial will be implemented including germplasm adapted to either highland or lowland environments.

China. Research on adaptability of potato genotypes focused on improved performance when intercropped with maize, a popular practice in Southwest China. Results with clones evaluated for adaptability to intercropping with maize indicated adaptability relates not only to high yields but also to disease resistance, earliness, plant type, and the conversion efficiency of intercepted radiation to plant dry matter. Creeping plants favor early light interception, but cause weak growth and low yield of maize. A prolonged growing period increases the amount of intercepted radiation but enhances competition between crops. Clone 87P48-64 was better than other cultivars for intercropping with maize.

Several advanced CIP clones were evaluated under winter cropping conditions at the Yuxi location (1,655 m) in Yunnan. Yield of clone B-71.240.2 (CIP-24) was highest at 56.5 t/ha, while the local variety yielded 39.8 t/ha. CIP-24 is a widely adapted cultivar that grows and tuberizes well under both spring/summer and winter/spring conditions.

In Yunnan, during the spring/summer planting season, more than 15 farming households planted seed tubers of selected clones in about two hectares along with their own seeds of the local variety. Selected clones CIP-24, CFK69.1, I-1085, Huinkul, and I-1039 showed excellent canopy growth and resistance to major diseases. In the early spring, similar results were obtained in Sichuan where CIP clones yielded on average 20 t/ha, a 160% increase over the Chuanyu control variety.

Bolivia. Growth-chamber tests were carried out on seedling of progenies of parental genotypes with known tolerance to frost. Tuber families of the most tolerant crosses will be tested for frost tolerance next season.

Information being developed on the inheritance of frost tolerance and its quantification should help increase the

frequency of genes for tolerance to frost in native populations and permit the selection of adapted cultivars highly tolerant to frost.

Use of Growth Regulators

India. Studies were conducted on the advantages of using growth regulators in a better partitioning of dry matter into tubers. Higher (18.5 to 26.1%) tuber yield and greater tuber weight were obtained by soaking seed tubers for 4 hours in solutions of 10 ppm triadimefon and 1 ppm uniconazole.

Intercropping and Crop Rotation Studies

China. At Enshi, Hubei (1,100 m), potato intercropped with maize using three plant densities for each crop were planted in alternating rows. The number of tubers produced per unit area and mean tuber weight were closely related to stem density of potatoes, but the effect of maize density was not significant. The treatments did not show significant differences in the conversion coefficient of intercepted radiation or dry matter partitioning in potatoes. However, the intercepted radiation increased with high stem densities, but the amount of assimilates translocated into individual tubers was lower, with a subsequent lower average tuber weight.

Egypt. Experiments conducted at Kafr El-Zayat, showed that potatoes intercropped with maize could be planted in August as an early fall crop (Figure 5-4). This will supply potatoes to the market when they are not usually available. Intercropping with maize or sunflower sown six weeks before potato planting increased plant emergence by 30% and yield, by 40%, especially for heat tolerant varieties.

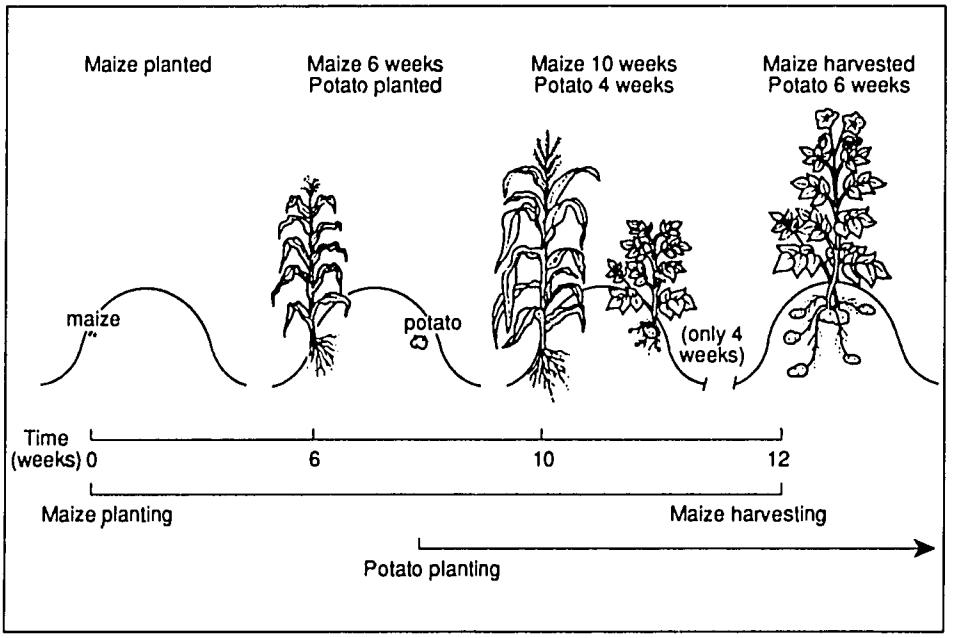


Figure 5-4. Intercropping potato and maize in Egypt led to a 40% yield increase.
Source: R. El-Bedewy, et al., 1991.

Soil Fertility and Mineral Nutrition

Peru. At various highland sites, experiments to evaluate potassium (K) sources showed KNO_3 was a better source of K than K_2SO_4, and KCl. Potato yield increased from 15.3 t/ha (control) to 25.0, 28.6, and 35.7 t/ha after application of 80, 160, and 240 kg/ha of K_2O, respectively.

Results obtained through the last several years of soil fertilization experiments have been used to formulate a local NPK-mixed fertilizer, "BAYOMIX 11-22", made with 50% rock phosphate. This fertilizer is widely used by potato growers of the Peruvian highlands.

Effect of Planting Dates

Uganda. Field experiments conducted at Kalengyere (2,500 m) studied the effect of planting dates on tuber yield of two varieties—a main season variety (Cruza) and an early maturing one (Sangema). Experiments were also conducted to study their relationship with the build-up of aphid populations and to identify vector-free periods for quality seed tuber production.

At planting dates later in the year than early September for Cruza and late August for Sangema, yield and tuber number per plant declined linearly in both varieties. Data recorded on aphid build-up showed that their population attained a critical value during February-March whereas September to January appears to be an aphid-free period, suggesting that crops for seed tuber production should be planted before the end of October in that location.

Maintenance, Distribution, and Monitoring of Advanced Germplasm

Potatoes

During 1991, potato germplasm was distributed to 73 countries from CIP Headquarters and redistribution centers located in Kenya, India, and the Philippines (Table 5-4).

Use of true seed families is increasing at the expense of tuber families as CIP's partner countries continue to develop capabilities to handle true seed segregating populations. Excluding the International Late Blight trial (which distributes only tubers) the proportion of tuber export to in vitro export is fairly stable. Egyptian needs are now being met by the private sector. CIP continues to rely on the INIA-Chile contract for supplying larger quantities of standard TPS progenies. The contract produced 7.7 kg of TPS in 1991. CIP Experimental Stations in La Molina and Huancayo, Peru, produced 25-50 g of seed of each of 65 progenies for international evaluation trials. CIP's collection of pathogen tested potato germplasm increased in 1991 (Table 5-5).

Varietal Releases

A number of new varieties were released this year:

Table 5-4. Potato distribution by seed units.

	Clones	Tuber families	True seed families	TPS (x 1000)
L. America	10,115	10,130	171,770	13,335
Africa	14,485	10,231	8,380	5,633
Asia	1,578	4,037	44,250	5,341
S.E. Asia	994	3,352	44,300	2,908
Total	27,580	27,732	251,180	27,246

- TPS variety CIP IP88001, HPS-I/13 was officially released as a variety by the Government of India.
- TPS varieties CIP 980001, Serrana x DTO-28; and CIP 985003, Serrana x LT-7 were registered and released by the Egyptian Ministry of Agriculture.
- TPS varieties CIP 978001, Atzimba x R-128.6; CIP 980003, Atzimba x 7xy.1; and CIP 985003, Serrana x LT-7, while not formally released, are being produced and grown in Nicaragua.
- TPS varieties CIP IP88001, HPS-I/13; CIP IP88004, HPS-II/67; and CIP IP88006, HPS-7/67, are being produced in Bangladesh for further trials. CIP 985003, Serrana x LT-7; CIP 978001, Atzimba x R-128.6; and CIP 980001, Serrana x DTO-28, are being used extensively for research trials.
- TPS varieties CIP 978004, Atzimba x DTO-28; CIP 985003, Serrana x LT-7; and CIP 986001, Atlantic x LT-7, are being grown by many farmers in Indonesia.
- Three varieties have been released but not named by the Ministry of Agriculture in Uganda: CIP 374080.5 (also named in past years in Peru, Bolivia, Burundi, and Guatemala); and CIP 381381.20 and CIP 381379.9 both coming from the international late blight trials.
- Cameroon has named four varieties: CIP 720055, IRA-Bambui, clone of Mexican origin; CIP 382121.27, CIPIRA, from the International late blight trial; CIP 386298.9, IRA Babungo, from tuber families with virus resistance; and CIP 386298.13, IRA 88, from tuber families with virus resistance.

Table 5-5. Pathogen-tested potato germplasm.

Potato	Pathogen tested	Being cleaned
a. Wild and primitive clones	192	77
b. Advanced clones/varieties	288	06
c. Differentials/indicator hosts	32	02
d. International late blight clones	325	-
e. Research clones/parental lines with restricted distribution	106	64

- Burundi has four candidates for release and Zaire has two.

Sweetpotato

Sweetpotato was distributed to 33 countries during the year from CIP Headquarters and Regional distribution center in the Philippines, Table 5-6. This is the first year a significant amount of sweetpotato germplasm has been available for distribution. Distribution of in vitro plantlets has proved difficult. Many countries have been unable to receive and propagate the material. Further training is necessary on receipt and recovery of in vitro plantlets.

Pathogen tested advanced clones, varieties and breeding lines have increased during the year. A total of 93 clones are pathogen tested and 129 are in the process of cleaning. In addition, about 40 pathogen-tested clones of the AVRDC collection are being rechecked.

Table 5-6. Sweetpotato distribution by planting units.

	Clonal in vitro	True seed families
L. America	546	1,219
Africa	871	11,625
Asia	392	3,710
S.E. Asia	391	8,100
Total	2,455	26,112

Sweetpotato Production Through Improved Planting Materials and Management Techniques

The development of new and improved propagation and crop management technologies for sweetpotatoes is an important aspect of CIP research.

Rapid multiplication of new or improved planting materials is an important part of sweetpotato production, especially in areas with high incidence of virus infected planting materials or where adverse weather conditions have damaged the existing planting materials. The use of single node cuttings is an extremely efficient method for rapid increase and production of stock plants under nursery conditions. The stock plants can be used to produce stem-tip cuttings for planting in the field. However, nodal cuttings produce lower yields of storage roots than stem-tip cuttings so they are only recommended for the production of stock plants.

Kenya. Trials were conducted to test the use of single node cuttings for rapid multiplication. Cuttings of five cultivars were planted in pots with the node and a portion of the stem buried beneath the surface of the soil. Survival rates ranged from 70 to 100% at 60 days after planting, and (among the cultivars tested) those with unlobed leaves had a higher survival rate than those with lobed leaves. Similar results have been obtained in India with cuttings planted horizontally producing better yields than those planted vertically.

Peru. Inexpensive materials for propagation of sweetpotato such as the use of rustic pots made from banana leaves and newsprint have been successfully tested under different conditions in Peru.

Planting and Harvesting Dates, Fertilizer Use and Planting Methods

India. A series of year round, on-farm and research station trials was conducted to determine optimum planting and harvesting dates, fertilizer needs, and planting methods for the western Indo-Gangetic plains.

Rustic pots shown in these two pictures are made from banana leaf (top, bottom) and newspaper (bottom). They are used for planting sweetpotato shoot tips which establish and grow more quickly and produce higher yields than nodal cuttings.

Results demonstrated that highest yields are obtained from July-August plantings and October-November harvests. Low temperatures from November to February resulted in the absence of storage root production in that region. The application of an NPK fertilizer did not increase yields. Spacing 60 cm between rows and 20 cm between plants produced better yields than planting at 60 x 10 cm.

Tolerance to Drought

China. Some areas in southern China have extended dry seasons without irrigation. A large number of sweetpotato cultivars was evaluated in Guangdong for drought tolerance. Of those tested, 34 were classified as tolerant to drought, 35 medium tolerant, 29 sensitive, and 3 as highly sensitive.

The Philippines. In Los Baños, 50 sweetpotato cultivars were screened for drought tolerance and to determine possible heritable morphological or yield characteristics associated to drought. Several of the cultivars, such as L076, VSP2, and N052, are considered highly tolerant to drought since no difference was obtained when grown under both drought stress and non-stressed conditions.

Shade Tolerance

Sweetpotato has been found to be extremely sensitive to low levels of solar radiation. Trials conducted in Los Baños, Philippines, demonstrated that some cultivars (Miracle and VSP-5) are shade tolerant and produce well under 60% transmitted light. Lower levels of transmitted radiation restricted yield. The use of shade tolerant cultivars would be an important addition to intercropping systems.

Adaptation

The storage root and plant top yields of 50 sweetpotato cultivars (representing a wide genetic variation within CIP's germplasm) were evaluated under diverse environments in Peru over two years, to determine a possible correlation with environmental factors and cultivation procedures. Distinct groups of cultivars were identified by growth, yield, and cultivation requirements under the various conditions. Cultivars such as RCB IN-172 (Zapallo de Quillabamba) was highly productive in various soils and climates, whereas EEY-41 (Jewel) had a significantly lower adaptation range being affected by low temperatures (Figure 5-5).

Specific cultivation procedures improved survival and growth rates as well as yield in the cool Peruvian highlands. For instance, cool pretreatment of cuttings resulted in up to 98% plant survival as compared to 40% survival without the pretreatment.

Differences in yields in three coastal desert locations of varying soil pH (5.3, 7.9, and 8.3) confirm reports that soil pH can have a strong influence on yield. In Tumbes, Peru, a high pH (8.3) resulted in very low yields.

Flowering

For sweetpotato breeding purposes, the use of trellises increased efficiency of pollinating and seed collection. In Argentina, flowers of plants grown on trellises remained dryer and had a lower incidence of fungal infection during rainy periods than those grown flat on the ground. Sweetpotato seedlings grown from seed flowered freely, 16 hours or more, in the long summer days. Several native Argentinean cultivars that normally do not

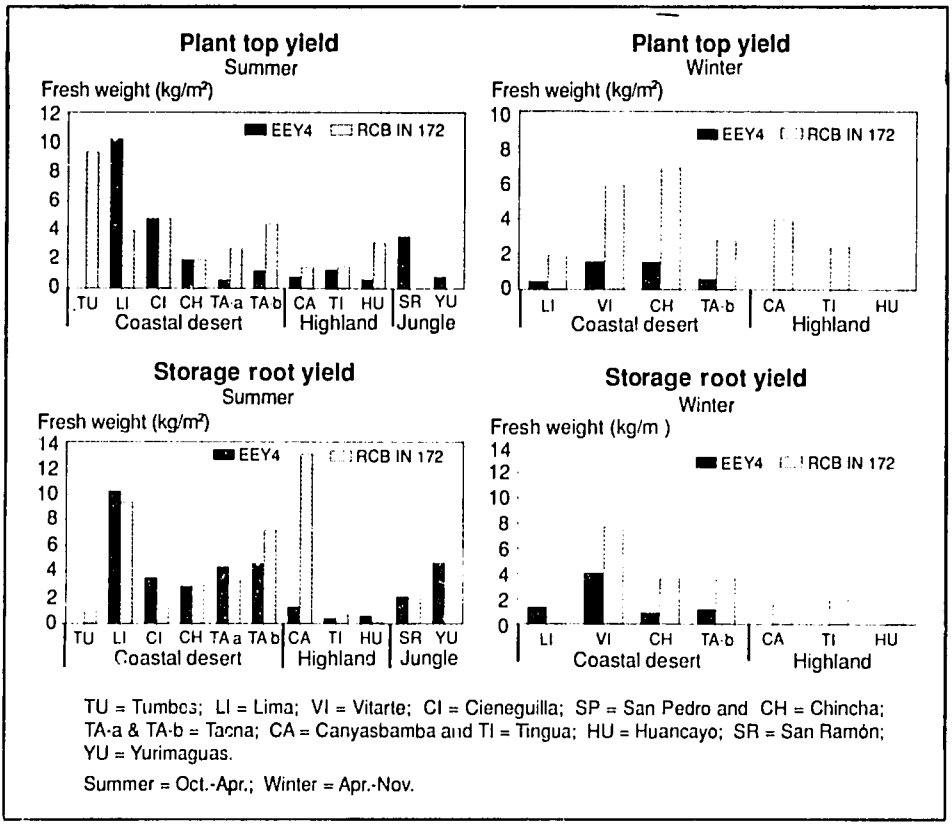


Figure 5-5. Plant top and storage root yield of two sweetpotato cultivars in various agroecologies and seasons, Peru.

flower, flowered and produced seeds when the plants were covered to reduce daylength to 12 hours and the ground was mulched with black plastic to raise soil temperatures. Cultivars evaluated in Los Baños (Philippines) also flowered under 12 hour photoperiods.

Soil Management, Fertilizers, and Mineral Nutrients

Cooperative research with national institutes in Peru and China is currently studying the yield of sweetpotato plant tops and storage roots in relation to different levels of NKP fertilizers, the residual effect of PK fertilization, liming in highly acidic soils, humid jungle conditions, and the use of organic fertilizers under various crop rotation systems. Results showed applications of various levels of nitrogen fertilizers do not increase production of storage roots over that of the control. However, the application of PK increased storage root yield. The lack of effect of nitrogen on the yield of storage roots was confirmed by results of another on-farm trial which used cow manure. In this trial, not only was the storage root yield low compared to plant top yield, but the individual storage roots of all cultivars were extremely small compared to the size of storage roots usually

produced in the area. Use of organic manure or NPK fertilizer increased the yield of plant tops over storage roots. Therefore, selecting the most effective type of fertilizer is important if plant tops, rather than storage roots, are needed for animal forage.

Training

Propagation and Crop Management

Peru. With CIP's cooperation, 4 to 5 short courses are organized every year to be held in the principal Peruvian cities (Cusco, Puno, Huancayo, Iquitos). Course programs are related to fertilizer use and soil management with an emphasis on potato. The courses are offered for local university professors, researchers, and extension agronomists of government and non-government agricultural institutions. During the development of the training courses, results of our sub-projects are presented and discussed.

Potato Breeding

Peru. A workshop on advances in potato breeding in Andean countries was held in Lima, February 4-7. It was jointly organized by CIP Region I and PRACIPA, with funding from IDRC. Participants from Bolivia (4), Colombia (4), Ecuador (3), Venezuela (3), and Peru (13) attended the workshop. Discussion topics included fungal and viral diseases, insect and nematode resistance, earliness, frost resistance, genetic engineering, quarantine regulations, and exchange of genetic materials.

Colombia. The PRACIPA network organized a breeding project's coordination meeting in Río Negro and Bogota, June 24-28. The meeting was hosted by ICA and the CIP Region I office in Bogota. Nine participants from Bolivia (2), Ecuador (1), Peru (1), Venezuela (1), and Colombia (3) attended the meeting.

Potato Production

Peru. This UNDP-funded course on national potato production was held January 20-February 2 at the Agricultural Experiment Station in Andenes, Cusco. It was organized by the Universidad Nacional Agraria La Molina and the Instituto Nacional de Investigaciones Agropecuarias y Agroindustriales (INIAA), and sponsored by CIP. Twenty participants from Peru and one from Bolivia attended.

This course covered agronomy; soil, fertilizer and water requirements and their management; breeding techniques; viral, fungal, bacterial diseases and pests; physiology of growth and development, dormancy and storage; seed production, certification and inspection; postharvest technology and visits to potato production fields.

A contract with the Universidad Nacional Agraria La Molina for training Peruvian agronomists from government and private institutions was carried on from previous years. The objective was to impart knowledge about agronomical factors of potato production with emphasis on fertilization. Under this contract, 222 participants attended courses in Huancayo, Arequipa, Ayacucho, and Puno.

Ghana. An in-country potato production course took place in Ho, July 15-20. It was jointly organized by the Ministry of Agriculture, Department of Crop Services and CIP Region V. The 21 participants were all from Ghana.

Uganda. A UNDP-funded course on vegetative propagation, was held in Kampala, September 24-27. It was organized by CIP Region III. Participants came from Uganda, Tanzania, Kenya, Ethiopia, Madagascar, Burundi, Mozambique, and Malawi.

Sweetpotato Production

Jamaica. A workshop on production and pest management of sweetpotato was held in Kingston, January 23-25. It was jointly organized and financed by the Caribbean Agricultural Research and Development Institute (CARDI) and CIP. Additional sponsors included the Canadian aluminum company Alcan and the Jamaican Ministry of Agriculture. The objectives of the workshop were to assess the market potential of sweetpotato, identify current production constraints, and review appropriate integrated pest management strategies for current production systems. Participants came from: Jamaica (23), the Dominican Republic (2), Montserrat (1), Saint Vincent (1), and the USA (1).

Saint Vincent. A regional training course on improved technologies for sweetpotato production was held in Kingstown, February 18-23. It was sponsored by the University of the West Indies in collaboration with CARDI, CIP and the Ministry of Agriculture, Industry and Labour.

Objectives of the course were to increase the understanding of factors affecting the performance of the sweetpotato crop, identify factors affecting sweetpotato production for specific markets, increase the knowledge of effective pest and disease management, and review production and postharvest technology. The 24 course participants came from: Saint Vincent (7), Barbados (1), Dominica (3), Grenada (2), Montserrat (3), Saint Kitts-Nevis (4), Saint Lucia (3), and Trinidad (1).

China. An in-country sweetpotato germplasm management workshop was held in Wandong, February 26-March 2. It was co-sponsored by IBPGR and CIP. Participants came from China, India, the Philippines, Vietnam, and Fiji.

Egypt. An in-country sweetpotato course, was held in Kafr El-Zayat, September 22-25. The four-day course was attended by 20 participants from several Egyptian provinces.

Chile. "Sweetpotato: a new agricultural alternative for Chile" was the name of a seminar/workshop organized by the Instituto de Investigaciones Agropecuarias (INIA) and CIP. It was held at La Platina Experimental Station, Santiago de Chile on October 3. Participants from Chile (41), Argentina (2), and Uruguay (1) attended the event.

Seed Production Technology and Related Disciplines

Bangladesh. A regional workshop on TPS production prospects and problems, jointly organized by the Tuber Crop Research Center (BARI) and CIP Region VI, was held at the Bangladesh Agricultural Research Institute in Joydebpur, Gazipur, January 20-25. The 18 participants came from India (7), the Philippines (2), Vietnam (3), Indonesia (1), Malaysia (1), Nepal (1), Bhutan (1), and Bangladesh (2).

Kenya. A workshop on seed potato technology and distribution systems in East

and Central Africa, was held in Nairobi, May 27-31. The 20 participants were seed specialists with management responsibility for national seed production programs. They came from Kenya (6), Rwanda (2), Burundi (3), Uganda (5), Zaire (2), Tanzania (1), and Madagascar (1).

Participants were required to submit review papers to assess current seed technology in the region. Working groups developed recommendations for implementing sustainable seed production schemes at the end of the meeting. The workshop covered topics related to propagation methods and quality control, organization and management of seed programs, policy issues, and developing sustainable seed production schemes for each country.

Chile. The first course/workshop on methodologies to improve the use, production, and storage of potato seed-tubers was held at the Carillanca Experiment Station, September 24-25, and Quilamapu Experiment Station, September 26-27. Jointly organized by INIA (Chile) and CIP Region I South Cone, the course/workshop was attended by 95 participants.

Objectives were to train extensionists in methods to improve the use, production and conservation of seed-tubers and design a strategy with potato seed producers for implementing seed quality improvement programs.

Peru. A TPS Latin American workshop, organized by CIP, was held in Lima, September 5-7. Its objectives were to review current knowledge on TPS technology at CIP, discuss and exchange experiences among countries presently using TPS (Chile, Nicaragua, Paraguay and Peru), identify limiting factors in large scale production, and establish a collaborative research network with countries interested in this technology.

The workshop was attended by 34 participants from Bolivia, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Jamaica, Mexico, Venezuela, and the USA (one participant each), Chile (3), Italy (2), Nicaragua (2), Paraguay (2), the Dominican Republic (3), Peru (2), and CIP (10).

Uganda and Ghana. Two workshops on the organization and management of vegetative seed production programs were held in Uganda (October) and Ghana (December). CIP regional personnel and IITA collaborated in organizing them.

China produces about 90% of the world's sweetpotatoes. Over the last 10 to 15 years sweetpotato production has become dramatically more market-oriented, both for fresh and processed uses.

Program 6

Postharvest Management, Marketing

1991 In Review

Postharvest activities at CIP focus largely on storage, processing–including breeding for processing, and marketing as well as related work on nutrition and consumption. During 1991, research, training, and information in these fields previously located in Thrusts II, VI, VII, VIII, and X have been consolidated to constitute Program 6. Leadership of Program 6 was also transferred back from the regions to CIP headquarters to facilitate closer collaboration with other Lima-based staff. A review of research projects, contracts, and theses in Program 6 led to the clustering of activities into two major projects: one each for potato and sweetpotato. The reduced number of projects aims to assure that a critical mass of human and financial resources is available in each project to foster more interdisciplinary work at the operational level, to encourage prioritization of activities within the projects, to minimize administrative requirements, and to promote greater transparency, hence accountability, in the Program.

As stated in the Strategic Plan, resource allocation across commodities in Program 6 will be 25% for potato and 75% in sweetpotato. This reflects as much the needs and opportunities for postharvest work in sweetpotato as the fact that past accomplishments with potato will require less core support to sustain. In the years ahead, Program 6 activities will focus more on Asia and sub-Saharan Africa with Latin America declining in relative importance.

Consumer potato storage research continues to explore the potential of alternative, low-cost storage methods. In India, experiments on both rustic storage and storage media showed promising results. Varietal evaluation in Burundi and Cameroon included testing materials for dormancy and storability. In Egypt, tubers and TPS progenies kept in cold storage and a traditional non-refrigerated store demonstrated great variability in their reaction to these different conditions. Seed storage tests in Cameroon, Uganda, and Egypt also documented differences in varietal reaction to length and type of storage. Research on natural sprout inhibitors in the Philippines found promising treatments for two different types of tubers.

Village-level potato processing research in India developed operational guidelines for specific processing activities through trials involving both labor and equipment. A Ph.D. thesis at the University of Nairobi examined the feasibility of small-scale production of solar-dried potato flour and its potential uses. A case study on improved village-level processing in Peru documented the knowledge acquired and lessons learned. A manual on processing, marketing, and use of root and tuber crops in developing countries was prepared in collaboration with CIAT and IITA and is being reviewed.

The growing importance of the fast food and snack industry for potato use in Central and parts of South America, Southeast Asia, and the potential for such processing in countries like India were documented at symposia organized by CIP. Through breeding research at CIP headquarters, clones from CIP's pathogen tested list as well as from CIP's own breeding program have been identified as having good processing characteristics (for chips and/or french fries) and adaptability to tropical growing conditions. In addition, a segregating population has been assembled that can be used by NARS interested in selecting new varieties for processing.

The marketing component of the PRACIPA project completed its first phase during 1991. This project answered specific questions about marketing problems in Bolivia, Colombia, Ecuador, Peru, and Venezuela and documented research methods and experiences that were previously unavailable. Marketing and demand research in Tunisia helped explain why average per capita consumption of potatoes rose from 10.5 to over 20 kg/yr between 1960 and 1990. Urbanization, changing tastes and preferences, and increases in incomes have all contributed to this phenomenon. Comparative analysis of potato production, marketing, and consumption trends in Latin America point out the sharp increase in per capita potato consumption in countries such as Colombia where it rose from 30.0 to 60.8 kg/yr between 1961 and 1988. CIP published a manual on methods for agricultural marketing research in conjuction with the Inter-American Institute for Cooperacion in Agriculture (IICA).

Jennifer A. Woolfe's thorough review of sweetpotato postharvest literature was also completed during 1991. Among its principal findings, the author notes the untapped potential of the crop to improve diets for low-income consumers and expand market opportunities for resource-poor farmers. In her view, low yields and low recovery rates for sweetpotato are among the most significant constraints to an expansion in processing.

Sweetpotato breeding for processing will give major emphasis in the years ahead to testing promising elite materials in selected countries. CIP's current list of pathogen tested clones contains materials from a number of countries as well as AVRDC and IITA. Breeding work conducted in Peru, United States, China, Thailand, and Colombia continued to evaluate sweetpotato clones, varieties, and breeding populations for processing characteristics.

Collaborative research projects on sweetpotato processing in China and Vietnam focused on converting sweetpotato starch into noodles. Efforts at the Crop Research Institute at the Sichuan Academy of Agricultural Sciences were devoted to keeping both wet and dried starch a white color. A Master's student at the Asian Institute of Technology, supported in part by UPWARD, analyzed noodle making in Vietnam and developed a series of procedures to produce a higher quality, more transparent final product. Experiments in Burundi and Cameroon using raw, grated sweetpotato as a partial substitute for imported wheat flour have generated promising results and considerable interest on the part of local bakeries. Several bakeries are already producing sweetpotato bread commercially.

Comparative analysis of FAO time-series data on utilization patterns for root and tuber crops in developing countries over the last 25 years found that sweetpotato

exhibited the greatest dynamism. Now 30% to 50% of national output in countries such as China and Brazil goes to animal feed. A Ph.D. thesis at Cornell University on sweetpotato marketing in Rwanda found that the crop's future as a principal staple in rural areas is secure. The capacity of the marketing system to reduce costs will largely determine sweetpotato's future role in urban diets. The thesis notes that research into storage and processing is the single most useful contribution that can be made. A consumer survey on sweetpotato bread in Lima served as the basis of a master's thesis at Wageningen Agricultural University. Results indicate the bread has promising commercial potential provided certain characteristics can be improved.

Root and tuber crop processing, marketing, and utilization was the theme of a series of workshops organized in Guatemala (Latin America), Philippines (Asia), and Nigeria (Africa) in collaboration with CIAT and IITA as part of a UNDP project on human resource development. The objectives included documenting recent trends in processing and utilization, presenting and analyzing research methods, and discussing mechanisms for addressing priority needs in this field. Active collaboration with other centers such as CIAT and IITA as well as with networks like UPWARD, SAPPRAD, PRACIPA, PRECODEPA, and PRAPAC will continue to be a key component of the Program's global strategy in the year ahead.

Expanding Utilization of Potatoes in Developing Countries

Consumer Potato Storage

India. India produces over 15 million t of potatoes a year, more than 20% of all potatoes produced in developing countries. Village-level storage of potatoes is a major problem in almost all potato producing areas of the country. The lack of inexpensive storage methods leads to excessive physiological weight loss, rottage, and sprouting. Research in India continues to explore low-cost alternatives to cold storage, including rustic stores and storage media.

Rustic storage experiments in India showed considerable promise. After sorting and grading, tubers were placed in a rustic store for 2 months beginning in April 1991. Each month, three replications weighing 565 kg each were removed from the store. Physiological weight loss after one and two months storage was approximately 4% and 9%. Average rottage after one and two months of storage was 1% and 6%.

Potatoes are traditionally stored in sand in many parts of India. Yet, lack of dry sand can be a serious constraint to this type of storage in certain places. Therefore, trials were conducted evaluating potato storage in five different locally available media: sand, brick kiln soil, wood ash, soil, and rice husks. Three replications of 10 kg each were stored in the five media. Storage began in April 1991 and lasted two months. Much less physiological weight loss was observed for tubers stored in brick kiln soil (Table 6-1). Least rottage occurred for potatoes stored in wood ash though it was not much different from those in dried soil and brick kiln soil. Tubers stored in sand had the most sprouts and those stored in husks had the least but the differences were not significant.

Table 6-1. Storage attributes of five media.

Media	Physiological Loss (%)	Rottage Loss (%)	Number of Sprouts	Sprout Length (cm)
Sand	15.4 b	20.0 a	1.7 a	1.0 b
Brick kiln soil	8.7 c	8.6 b	2.7 a	1.5 ab
Dried soil	12.7 b	9.8 b	3.0 a	1.4 ab
Wood ash	19.8 a	6.2 b	3.0 a	2.3 a
Rice husks	20.7 a	18.0 a	4.0 a	1.7 ab

Means followed by the same letter are not significantly different at p = 0.05 using the Duncan's Multiple Range test (DMRT).

Sprout length, significantly different in the two media, was shortest in sand and longest in wood ash.

Burundi. Research at two locations studied the effect of potato storage on weight loss and sprout length. The variety Uganda 11 was put in storage in early July at Gisozi (2,090 m), after being harvested at Mwokora (2,350 m) in late June, and on July 8 at Mwokora immediately after harvest. The tubers were placed in baskets surrounded by straw with 6 replications in Gisozi and 9 in Mwokora. Each basket contained 20 tubers (5 kg) and was installed in a dark, naturally ventilated wooden store (1.5 m × 1.5 m and 1.0 m ground clearance) with an 800 kg capacity. Ventilation from below was restricted during the day by closing air vents. At night, the cooler air was allowed to enter and circulate. The tubers were removed after 120 days. Average weight loss at Gisozi and Mwokora was 7% and 7.1%; sprout length was 14.3 mm at Gisozi and 45.9 mm at Mwokora.

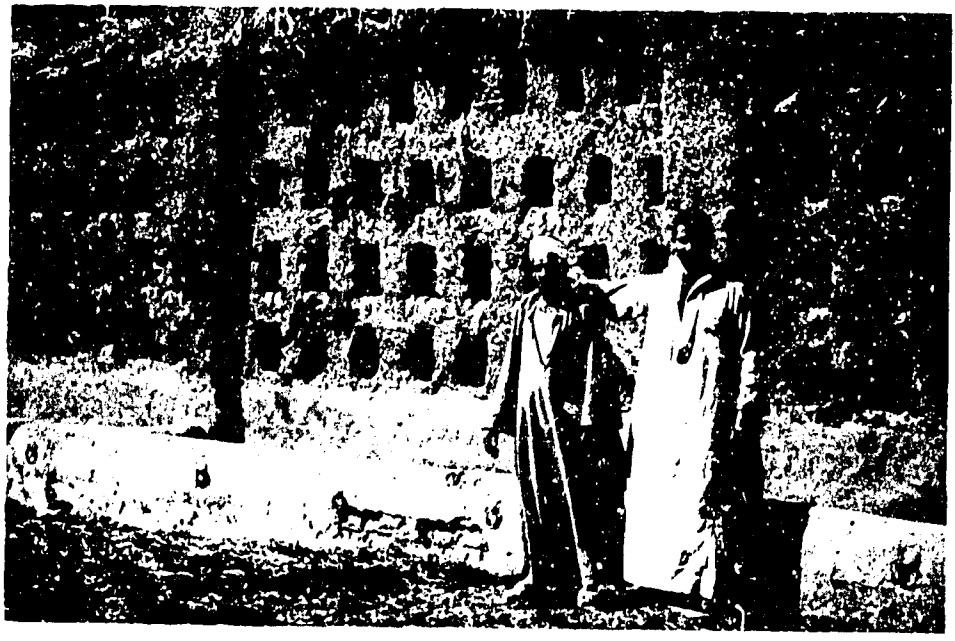
Cameroon. Evaluation of clones for selection of improved varieties also involves testing under storage conditions for dormancy and length of storability. In Cameroon, clones selected from late blight resistant materials (LBT-88A and LBT-89A) and virus resistant materials (VTF-88A) were evaluated. Tubers were stored in a diffused light store at Upper Farm (2,000 m). More than 150 tubers per clone were evaluated. Data were collected on number of rotted tubers, sprout length, and dormancy. Results indicate that for up to 90 days no tubers rotted. After 180 days, tubers from CIP 720122 had the highest percentage of rotted tubers (35.3%). Tubers from the virus resistant clones had, in general, the longest sprouts and a dormancy period of less than 90 days.

Egypt. Tubers of 13 commercial varieties and seedling tubers of two TPS progenies were stored for 3 months inside a cold store at 4°C and in a traditional non-refrigerated store (*nawalla*) at ambient temperature. All tuber lots were cured under rice straw for about 2 weeks then sorted to discard pest-infected or decayed tubers prior to storage. Each treatment consisted of 5 kg of tubers packed inside a jute sack and replicated three times. Results indicate that, in general, *nawalla* storage resulted in more decayed tubers and greater weight loss than cold storage (Table 6-2). However, the different varieties exhibited great variability under these conditions. Varieties Nicola, Draga, and Diamant showed lower losses than other varieties under *nawalla* storage conditions. Varieties Timate, Oblix, Ailsa, and King

Table 6-2. Effect of storage conditions on tuber losses of 13 potato varieties and two hybrid (TPS) progenies.

Progeny/ Variety	Nawalla[a]			Cold Store[b]		
	Loss %	Total weight loss %	Sprout condition	Loss %	Total weight loss %	Sprout Condition
Baraka	2.0	14.0	Long & weak	0.0	2.0	Free
Nicola	2.2	10.6	Short & strong	0.0	4.0	Free
Cara	1.0	14.0	Long & weak	0.0	4.6	Free
Draga	1.6	11.6	Short & strong	0.0	5.0	Free
Alpha	1.2	15.1	Short & strong	0.0	6.2	Short
Diamant	1.5	12.8	Short & strong	1.0	5.1	Short
Spunta	1.3	13.0	Short & strong	0.0	5.1	Short
Timate	3.4	23.7	Long, weak, branched	0.0	7.0	Long
Liseta	1.3	15.8	Long & weak	1.5	5.5	Long
Oblix	3.2	25.0	Long, weak, branched	2.3	7.0	Long
Mondial	1.0	11.7	Long & weak	0.0	1.5	Short
King Edward	2.0	17.6	Long, weak, branched	0.0	2.0	Short
Ailsa	1.8	21.3	"	1.1	5.4	Long
Serrana x DTO-28	1.5	11.0	Short & strong	1.3	5.4	Free
Serrana x LT-7	2.4	11.1	Long & strong	0.0	3.4	Free

[a] Nawalla: inspections at three week intervals, with the first sorting after six weeks.
[b] Cold store: one inspection only.
Duration of Storage = three months, from 9/6/91 to 9/9/91.



Potatoes in Egypt are traditionally stored in diffused-light storage structures called *nawallas*.

Edward showed higher losses. Therefore, the latter varieties should be stored under cold storage conditions. The two TPS progenies (Serrana × DTO-28 and Serrana × LT-7) showed low losses under *nawalla* conditions.

Seed Potato Storage

Cameroon. Research focused on the effect of storage periods on yield and other agronomic characteristics of seed. A trial conducted at Babungo (1,150 m) included tubers from seven advanced clones and two imported varieties. Tubers were stored for 8.5 months in a diffused light store (DLS). Part of the seed was replanted, and harvested tubers were stored again for 2.5 months. Tubers were planted in a randomized complete block design with three replications, 10 tubers per replication. Plants were harvested at 90 days. Data were collected on number of plants at harvest time, number of tubers, and average tuber yield per plant. Results indicate that tuber weight increased when tubers were stored for only 2.5 months. However, average yield per plant increased when tubers were stored for 8.5 months. The increase in yield was a result of formation of several, albeit small, tubers (Table 6-3).

Uganda. Potato varieties Sangema and Cruza were studied for their storage behavior in a replicated trial involving three grades of seed stock and three storage methods. Data for different parameters show that rottage 90 days after storage was 1.3-5.3% in different grades of seed stocks of Sangema in DLS as against 13.3-20.3% in baskets and 9.3-34.0% in bags (dark storage). In Cruza, the rottage was comparatively low. After 240 days of storage, the rottage percentage was 10.3-15.3% in Sangema in DLS, 17.9-34.0% in baskets, and 47.0-51.4% in dark storage. Sprout development, judged by sprout weight per kg, was extensive in bags and baskets, but balanced using DLS. Results suggest that Cruza can be stored three to four months in DLS and Sangema can be stored in DLS up to six months without significant deterioration.

Egypt. Tubers from 11 varieties originated from certified seeds imported from Europe and seedling tubers of five hybrids

Table 6-3. Plant stand and average tuber weight of clones stored in rustic, diffused-light store for 2.5 and 8.5 months at Babungo (1175 m) in the western highlands of Cameroon, 1991.

	Average stand count (22 days)		Average tuber weight (g)		Average yield (g/plt)	
Clone	2.5 mo.	8.5 mo.	2.5 mo.	8.5 mo.	2.5 mo.	8.5 mo.
382196.7	7.3	10	44.9	49.3	265	695
385259.5	8.7	10	69.6	46.3	780	1033
382196.1	9.3	10	76.1	53.1	829	855
386295.2	5.7	10	75.1	46.1	758	770
386290.6	10.0	10	52.6	49.9	647	783
386290.5	10.0	10	44.8	37.6	779	887
386294.4	10.0	10	58.8	42.9	682	759
Cardinal	1.0	10	65.4	51.7	301	636
Diamant	1.0	10	54.6	51.8	191	544
Mean	7.0	10	60.2	47.6	581	773

were stored for about 3.5 mo inside a cold store at 4-4.5°C and an improved *nawalla* (non-refrigerated store). All seed lots were pre-sprouted for two weeks under diffused light prior to planting in late September 1990 in 4.2 m^2 plots. The experiment was harvested in late January 1991. Yields of seedling tuber progenies Serrana × DTO-33, Serrana × LT-7, and Serrana × DTO-28 stored in traditional stores were as good as those of commercial cultivars. This suggests that seedling tubers of those progenies can be safely stored at ambient temperature for 3.5 mo instead of expensive cold storage. It also shows that *nawalla*-stored seed of Draga, Alpha, Diamant, Cara, and Spunta have yields comparable to their respective seeds kept in cold storage.

Philippines. Research on natural sprout inhibitors continued at the University of the Philippines in Los Baños (UPLB) with support from CIP. Extracts from various plants were used in experiments including oil from solasi (*Ocimum sanctum*) and patchouli (*Pogostemon cablin*). For Cosima tubers stored three months, covering with dry muña leaves followed by dipping in mint crude extract for 10 minutes (Table 6-4) seems to be the best treatment. For Granola tubers, sprouting was best controlled by pot treatment with patchouli oil.

Processing

Potato processing activities have covered three broad topics: village-level processing, industrial or semi-industrial processing in developing countries, and industrial processing in developed countries. Given CIP's mandate and comparative advantage, most research, training, and information has focused on village-level processing. On occasion, CIP provides support to local institutions working to get a better understanding of the array of processing activities that typically take place in developing countries, including industrial and semi-industrial processing. As an international center, CIP also monitors developments in industrial processing in developed coun-

Table 6-4. Effect of dipping potatoes in various plant extracts and oils on disease incidence and sprouting of tubers.

Treatments	Sprouting %	Days to sprouting %	Diseased tubers	Days to disease	Average severity
Mint extract (5)	63.3 cd	62.3 a	13.3 bc	34.7	4.3 bcd
Mint extract (10)	40.7 b	54.0 a	16.7 bc	37.0	2.8 bc
Muña extract (5)	62.3 cd	64.3 a	20.0 c	42.7	4.5 cd
Muña extract (10)	63.3 cd	68.7 a	10.3 b	35.3	5.0 d
Oregano ext. (5)	57.7 cd	63.0 a	13.3 bc	30.0	3.0 bcd
Oregano ext. (10)	73.3 cd	57.3 a	20.0 c	48.7	2.7 b
Solasi oil (10)	20.0 a	33.0 b	89.7 a	31.3	3.3 bcd
Oregano oil (10)	13.3 a	54.7 a	70.0 d	30.3	3.8 bcd
Muña dry leaves	60.0 c	68.3 a	0.0 a	-	1.0 a
Control	76.0 d	58.7 a	17.3 bc	25.0	4.3 bcd
c.v. (%)	11	31	2	64	21

Means followed by the same letter are not significantly different at 5% level using DMRT.

tries to identify important trends for developing countries (e.g., exports of processed potato products to Asia).

During 1991, research on village-level potato processing involved time-in-motion studies of operations in India, a Ph.D. thesis at the University of Nairobi on processing potato flour; preparation of a case study on experience to date and lessons learned in Peru; and completion of a draft manual (in English and Spanish) on product development for root and tuber crops.

India. Previous research on village-level potato processing in India had shown recovery rates to be a key factor influencing profitability. Current research is attempting to examine more closely the individual operations involved in processing to develop guidelines in the operational use of resources. Experiments conducted jointly with the Society for the Development of Appropriate Technology (SOTEC) studied influence of lot size, peeling duration, and number of paring laborers on recovery rates for fresh and stored (1 and 2) tubers. Results for fresh potatoes indicate that for the 30 kg lot size, 4 min peeling and 5 paring laborers is the optimal combination in terms of paring time and recovery rate. For potatoes kept for one month in a store the optimum is 30 kg, 7 min peeling, and 2 or 6 laborers; and for those kept two months, 30 kg, 4 min peeling, and 6 laborers are optimum. The larger lot size apparently reduces excessive abrasion of potato flesh in peeling, thereby raising recovery rates. The same observation applies to peeling time. Economic analysis of these technical guidelines should now be done.

Kenya. J. Kabira's thesis on the feasibility of small-scale production of solar dried potato flour and its potential uses in Kenya has three objectives: investigate the possibility of this type of flour production using different pre-processing treatments, carry out preliminary evaluations on the feasibility of incorporating potato flour into common Kenyan foods, and carry out preliminary economic assessment of technology for potato flour production. Among the major findings was that flour from all three products did not differ significantly in suitability for blending with corn flour (Table 6-5), whereas flour from raw potato slices was much more suitable for blending with wheat flour than flour from blanched slices and shreds. Preliminary economic analysis showed, depending on the market price of potatoes, potato flour could compete favorably with sorghum (or millet), cassava, and blended flours, but had difficulty with corn and wheat flours. Kabira concludes that research is now needed on the market potential of the flour, both as a convenience food for household use and as a composite flour ingredient for bakeries and related industries.

Peru. During the last 15 years, various research and development projects have sought to improve labor-intensive processing techniques for potatoes in Peru. A recent case study analyzes this experience to document the knowledge acquired. It also identified lessons learned in technology, marketing, and finance and administration. These include:

- Improving existing technologies requires time not only to transfer presumed improvements but also to develop new processes and products that will respond to changing market conditions.
- Product characteristics and the target market segment as well as sources of inputs and marketing channels of processed products must be clearly identified at the outset.

Table 6-5. Sensory properties[a] of potato flour from uncooked potato slices, blanched potato slices, and cooked potato shreds.

Sensory parameters	Raw slices	Blanched slices	Cooked shreds
Unmilled product			
Color (whiteness)	7.8 c	6.7 cd	5.2 d
Appearance	6.3 c	6.8 cd	6.3 d
Odor	7.3 c	7.0 c	6.3 c
Ease of grinding	7.2 c	5.7 d	6.8 c
Suitability for packaging in plastic bags	7.0 c	5.2 d	6.8 c
Overall acceptability	7.3 c	6.2 c	6.2 c
Flour[b]			
Color (whiteness)	7.3 c	5.5 d	5.2 d
Appearance	7.3 c	5.5 d	5.7 d
Odor	6.8 c	6.2 c	6.7 c
Suitability for blending with wheat flour	8.0 c	5.8 d	5.8 d
Suitability for blending with maize flour	6.8 c	7.0 c	6.3 c
Overall acceptability	7.5 c	6.0 d	6.0 d

Source:J. N. Kabira. 1990. Feasibility of Small-Scale Production of Solar Dried Potato Flour and its Potential Uses in Kenya. University of Nairobi. Phd. Nairobi, Kenya. 281 p.
[a] On a hedonic scale of 1 (extremely unacceptable) to 9 (extremely acceptable).
Means followed by similar letters are not significantly different at P = 0.05 by Tukey's test.

- Heavy investments in plant and equipment can generate cash-flow difficulties; more realistic cost and cash-flow estimates are needed to overcome this problem.

Product Development Manual. In response to the growing interest in processing and new processed products for root and tuber crops by National Programs in Africa, Asia, and Latin America, CIP has collaborated with CIAT and IITA to prepare a manual on product development. This document is intended to convey, in user friendly form, the wealth of experience acquired over the last 15 years by center scientists and their developing country counterparts in this field. Sections review each of the four phases successful initiatives frequently go through: assessing the potential for new or improved products, research in support of new products and processes, setting-up pilot plants, and expansion into commercial operations. The volume offers various useful guidelines for addressing the issues that present themselves during each phase of the product development process. An interdisciplinary approach is stressed throughout.

Latin America. Urbanization, female participation in the work force, shortening of lunch hours, rising incomes, advertising, and a desire by consumers to diversify their diets have all contributed to a growth in potato processing in developing countries. At the international workshop on root and tuber crop processing, marketing, and utilization in Latin America organized by CIP in collaboration with CIAT, IITA, and hosted by Guatemala's Instituto de Ciencia y Tecnología Agrícolas (ICTA), April 8-12, presentations by researchers and entrepreneurs explained the extent

and dynamism of this industry. In Guatemala, for example, a single locally-owned restaurant chain with over 25 outlets handles some 100 t of fresh potatoes a week. One-third (over 6,000 t) of annual potato production in Panama goes to processing. Recent research by the Instituto Colombiano Agrícola (ICA), backed by CIP social scientists, found that over 12% of potato production in Colombia—more than 300,000 t/yr—is for the processing industry. Local processors in Colombia have ideas stimulatingly different from those of ICA scientists about the appropriate characteristics of potato varieties used for processing and, most importantly, are eager to participate in research to improve locally available germplasm.

Asia. Many National Programs in Asia have requested information on international potato trade from CIP, particularly on imports of processed potato products. Such data are considered useful for projecting the potential for expanding domestic potato production to reduce potato imports, calculating foreign exchange savings from import substitution, and persuading policy makers to provide more support for local potato research and development activities. FAO does not publish such statistics. Hence, CIP social scientists have approached other sources to procure such figures.

Preliminary analysis of data on exports from U.S.A. to Asia shows that in recent years over 80% of frozen french fry shipments go to Japan and, to a much lesser extent, Hong Kong and Singapore. Work on Dutch trade statistics is being done by a CIP thesis student at Wageningen Agricultural University, Dept. of Agricultural Marketing. Initial findings from his research to be completed next year show that during 1988-90 Dutch processors exported some 700,000 t of processed potatoes per year. All but 40,000 t of these shipments went to other European countries. Still, according to recent research by the Centre for Research and Development of Coarse Grains, Pulses, Roots, and Tuber Crops (CGPRT), Indonesia officially imported US$1 million of processed potato products during 1989 and 1990.

CIP also supported a symposium on potato processing and storage during the Third Triennial Conference of the Asian Potato Association held June 17-18 at Bandung, Indonesia. This gathering included presentations on processing trends in Indonesia, India, and Thailand and on developments in the Dutch potato industry relevant to Asia. Of particular interest was the potential for processing in India where currently industrial or semi-industrial processing still only accounts for some 50,000 t/yr in a country that produces nearly 15 million t of potatoes annually. In contrast, Thailand processes roughly 5,000 t out of 15,000-20,000 t of potatoes harvested annually.

Breeding for Processing

Peru. Urban consumers in the developing world have increased demand for quality potatoes for a rapidly emerging snack and fast food industry. French fries, preferably long cuts, and chips are of primary interest. Potatoes for these purposes should have an oblong or round shape, shallow eyes, good texture, high dry matter, and low reducing sugar. Not all potato varieties meet these specifications. Varieties with such attributes have been bred for use in developed countries, e.g., Russet Burbank in the USA. However, differences in day length and temperature as well as susceptibility to important diseases and pests severely limit their production in

tropical environments. Hence, CIP initiated a program to select populations and clones with the appropriate agro-climatic adaptation and agro-industrial characteristics.

Two types of genetic materials were used in this project: advanced clonal material from CIP's pathogen tested list and breeding programs, and a segregating population. About 200 highly selected clones from the pathogen tested list were evaluated. The clones adequate for processing and carrying resistance or tolerance to at least one pest, disease, or stress are currently distributed to NARS. In addition 500 clones with a wide genetic base from CIP's breeding program were also evaluated for processing attributes. These clones come from a gene pool containing *S. tuberosum* spps. *tuberosum* and *andigena*, *S. phureja*, *S. stenotumum*, and a few wild *Solanum* species which have contributed resistance factors.

Segregating populations for processing consist of true seed progenies or tuber families originating from crosses of selected parents. These populations carry resistance or tolerance to several pests and diseases and to climatic and soil constraints in developing countries. They also have a wide genetic base; and, therefore, have been used to determine gene action and heritabilities for processing quality characteristics and to select the best progenitors. All materials (clonal and population) have been tested at CIP's experiment stations at San Ramon and La Molina (summer and winter seasons).

Selection criteria for french fries include: medium- to large-sized tubers over 45 mm diameter, shallow eyes, oval to oblong regular shape, cream or white flesh without blemishes, and a specific gravity from 1.079-1.086 (20-22% DM content). Reducing sugar content should be below than 0.5%. Tuber characteristics for chips are the same as for fries, except that they should be 40 to 60 mm in diameter and be round to oblong, have a specific gravity from 1.029-1.096 (21-24% DM), and reducing sugar content below 0.25%. Whether for french fries or chips, tubers should be free from diseases, cracking, secondary growth, greening, and the tendency to turn gray or black after cooking.

After 3 seasons of evaluating the pathogen tested list clones under cool and hot weather conditions, the following were found suitable for processing: 676014 (CFC 69.1), 720091 (Mex-52), 720111 (Aracy), 800827 (Atlantic), 800956 (Shuang Feng), 800957 (Pírola). Further evaluations showed that clones 378017.2 (LT-7), 378015.16 (TS-2), 379706.34 (LT-9), and 678011 (BL-2.9) were also suitable. These materials have been widely distributed to CIP's regional offices and NARS and could be tested by national programs interested in this type of potato use.

After testing, a large number of clones from CIP's breeding program have been found very adequate for processing as french fries or chips, or both. These clones have other very important characteristics (Table 6-6). Six advanced clones with high dry matter, low reducing sugars, good yield, and wide adaptation have been identified as potential processing varieties. These clones have been introduced into the pathogen-tested program for clean up and future distribution to NARS. After 5 years of breeding for processing research and the selection of good progenitors, a segregating population of more than 150 clones has been assembled for use by NARS to select new varieties for processing.

Table 6-6. Top clones from a breeding population selected for resistance to viruses and favorable processing characteristics.

Pedigree	%DM	SG	%RS	Characteristics
B71.240.2 x 7XY.1	23.10	1.085	1.66	Chips; resistant to PVY, PLRV
Serrana x LT-9	23.48	1.093	2.20	Chips; resistant to PVX, PVY and PLRV
Serrana x LT-9	24.02	1.096	2.33	Chips; resistant to PVX, PVY and PLRV
Serrana x LT-9	20.95	1.084	2.00	French fries; resistant to PVX, PVY, PLRV
B71.240.2 x 575049	22.18	1.086	1.33	Chips; resistant to PVY, PLRV
B71.240.2 x 575049	21.46	1.086	3.3	French fries; resistant to PVY, PLRV
BR63.15 x 7 XY.1	22.87	1.089	1.00	Chips; resistant to PVY, PLRV
Bzura x LT-9	25.7	1.106	1.66	Chips; resistant to PVX, PVY and PLRV
Bzura x LT-9	25.83	1.100	2.00	French fries; resistant to PVX, PVY and PLRV

DM = Dry matter, SG = Specific gravity, and RS = reducing sugars.
PLRV= Potato leafroll virus, PVY and PVX = Potato viruses Y and X.

Marketing/Demand

Work on potato marketing and demand has focused on location specific-studies of seed or table potato marketing systems, including research on consumption and demand; comparative analysis of regional or global trends in marketing and demand for potatoes; and the preparation and diffusion of methods and materials to enable national researchers to do this type of research. This year location-specific research focused on the Andean region and Tunisia. Comparative analysis of trends in potato production and use examined developments in Latin America. Methods materials were published in Spanish.

Andean Network (PRACIPA). The first phase of the marketing component of the Cooperative Program for Research on Potatoes in the Andean Region (PRACIPA) was completed. Impact of the project can be summarized as follows. In Bolivia, the project demonstrated the advantages of thinking of market (user) requirements first, then producing seed to satisfy those needs. This involved getting the National Program to produce improved quality seed for native varieties—something it had not

done before. In Ecuador, project results revealed the need for promotion of improved quality seed among small, peasant producers to demonstrate the increases in yields and incomes possible with such planting material. The project in Colombia altered National Program thinking on the importance of alternative market outlets for potatoes. Whereas most observers thought that only 5% or less production went to processing, this research found that 12% or more was used for chips, french fries, and snack foods. Work in Peru showed what could be done with limited resources to procure, analyze, and distribute information on seed and table potato marketing. The study in Venezuela enabled NARS researchers to examine marketing issues (their work had previously been confined to production research) and to gather baseline information on potatoes.

From the regional perspective, the PRACIPA-Marketing Program project accomplished three things. First, it answered questions that National Programs leaders and research scientists had about potato marketing problems in their respective countries. Second, it documented local research experience and methods previously unavailable. Third, the project developed an informal network of researchers working on marketing issues. While other potato-related disciplines have strong professional peer groups and even disciplinary association in Latin America, this was the first attempt to establish the equivalent in the marketing field to sustain such research in the future.

Tunisia. Between 1960 and 1990, average per capita consumption in Tunisia jumped from 10.5 kg/yr to more than 20 kg. Research on potato marketing and demand concluded that this jump stems from increased consumer purchasing power, urbanization, and evolving consumer preferences and consumption habits (e.g., for a more diversified, easier to prepare diet). Furthermore, analysis of existing household and marketing survey data, plus an independent consumer survey in Tunis, was used to estimate an average income elasticity of potatoes of 0.45, i.e., a 10% increase in income would result in a 4.5% increase in the quantity of potatoes demanded (consumed). Potato consumption among low income consumers would increase more in response to changes in income (about 0.60) than high income individuals (roughly 0.30). Strong consumer demand for potatoes would help explain why the long-term trend in retail prices is fairly flat (with recurrent seasonal price movements) even though total consumption has grown from 45,000 t to 160,000 t over the last thirty years (Fig. 6-1).

Latin America. Research on trends in production, marketing, and consumption in Latin America using FAO time series data found that potato ranks sixth in production (fresh weight) among the major food crops. Average potato yields have risen nearly 70% since 1960, faster than any other major food crop except tomato and sorghum. While area planted was largely unchanged for the region as a whole, this figure masks the impressive growth in area cultivated with potatoes during this period in Colombia (152%), Mexico (45%), Bolivia (30%), Ecuador (63%), and Cuba (38%). As a result, estimated per capita consumption in Colombia, for example, more than doubled from 30.0 to 60.8 kg/yr between 1961-63 and 1986-88. In Cuba, it jumped from 15.1 to 23.4 between 1961 and 1988.

Marketing Research Methods. As case studies and comparative analysis of potato

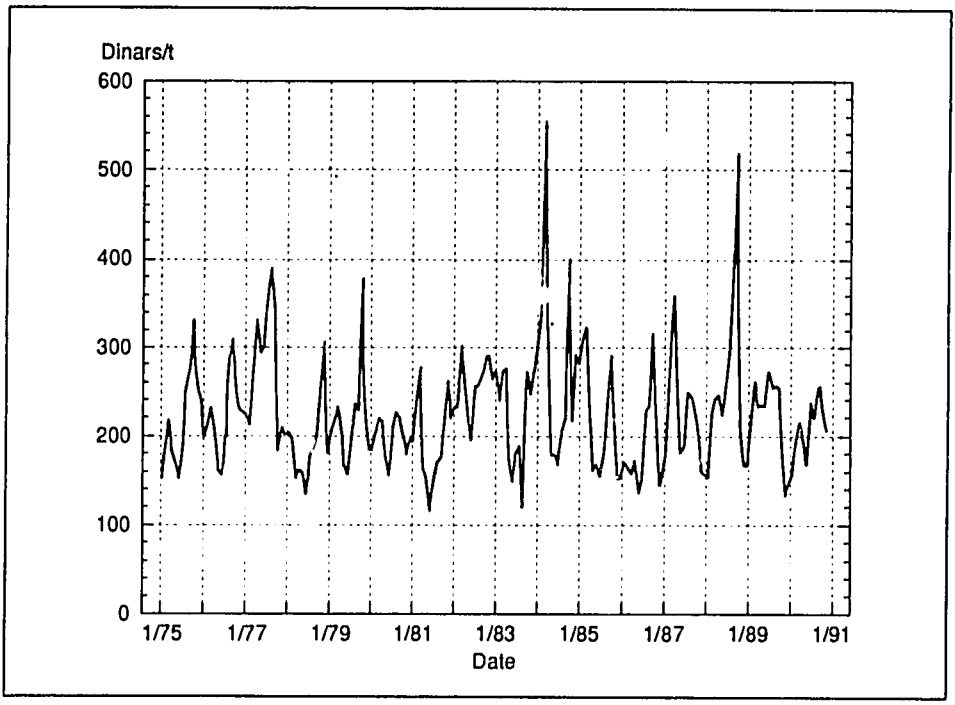


Figure 6-1. Retail potato prices in Tunis (constant 1983 prices).

marketing and demand are completed, efforts have increasingly focused on preparation of methods materials. This year CIP published, with Interamerican Institute for Co-operation in Agriculture (IICA), a manual on methods for agricultural marketing research. The manual covers producer-level marketing problems, seed marketing, consumption and demand issues, markets for processed food products, prices and marketing margins, and problems in food marketing systems and their relevance for production-oriented biological research. A similar publication is planned for English-speaking researchers in Asia and Africa in 1993.

Product Development for Sweetpotatoes in Developing Countries

Baseline Studies

Jennifer A. Woolfe completed her very thorough review of the literature on sweetpotato postharvest research in late 1991. The book has been published by Cambridge University Press in collaboration with CIP. Topics covered are: chemical composition of sweetpotato, its nutritional value, postharvest procedures for storage and processing, livestock feeding, and patterns and trends in consumption and use. Each chapter ends with an extensive list of references (the chapter on chemical

composition has over 200). The book finds a remarkably high nutritional value in sweetpotato roots and vines (Table 6-7). The book also notes that, if strategies to increase sweetpotato production are to succeed, efforts to improve the crop's agronomic characteristics must be complemented by initiatives to seek new uses for its roots and vines. In the author's view, constraints to increased sweetpotato processing may be ranked as follows:

- low-yields, low product recovery rates, and high root production costs do not allow sweetpotato to compete with other raw materials that yield similar end products (highly significant)
- lack of availability of cultivars with suitable characteristics for processing purposes (significant)
- insufficient or unstable supply of raw material (less significant)

Table 6-7. Proximate composition of sweetpotato roots and other plant foods (per 100 g).

Food	Moisture (%)	Energy (kcal)	Energy (kJ)	Protein (g)	Lipid (g)	Total carbo-hydrate (g)	Dietary fiber (g)	Ca (mg)	P (mg)	Fe (mg)
Sweetpotato										
Boiled	71	114	477	1.7	0.4	26.3	2.4	32	47	0.7
Baked	64	141	590	2.1	0.5	32.5		40	58	0.9
Flour	12	336	1406	2.4	0.7	79.2		70	98	3.2
Cassava										
Flour	13	341	1427	1.5	0.5	83.4		99	92	3.3
Rice										
Boiled, white	68	135	565	2.3	0.3	28.0	0.8	8	36	0.3
Flour	12	365	1527	6.8	0.7	80.0		17	135	1.6
Noodles, cooked	79	88	368	1.0		20.3		7	7	0.6
Maize										
Porridge	81	76	318	1.8	0.8	15.6		4		0.6
Tortilla	48	210	879	4.6	1.8	45.3		196	138	2.6
Meal	12	354	1481	9.3	3.9	73.6		19	237	3.3
Wheat										
Chaphati	46	202	860	7.3	1.0	43.7	3.4	60		2.1
Bread	33	278	1163	8.7	1.6	55.7	2.7	24	98	1.3
Noodles, cooked	75	108	452	2.7	2.1	19.4		21	25	0.8
Pasta, cooked	66	132	552	4.1	0.7	26.7		8	59	0.5
Sorghum										
Porridge	80	85	356	2.7	0.5	17.0		4	31	1.7
Meal	11	343	1435	9.5	2.8	75.5		28	238	10.0
Beans (*Phaseolus vulgaris*)										
Boiled	69	118	494	7.8	0.5	21.4	7.4	38	140	2.4

Source: Adapted from *J. Woolfe. 1992. Sweetpotato: An Untapped Food Resource. Cambridge University Press. Cambridge, U. K. 643 p.*

Harvesting sweetpotato vines for livestock feeding in China.

This publication will be a valuable reference for a broad group of agricultural professionals in both developed and developing countries.

Breeding for Processing

Breeding-related research in this program focuses on distribution and testing of elite, high yielding cultivars for processing-related uses. Research is also conducted on improvement of important quality traits and monitoring nutritional quality in elite materials.

Sweetpotato can produce high yields of carbohydrates (roots) and protein (foliage) under diverse agroecological conditions in short growing seasons without massive chemical inputs. However, demand for sweetpotato for fresh consumption has declined in several developing countries in recent years. The crop can serve as raw material for a wealth of processed food, feed, and industrial products, substituting for imported grains.

Needs assessment studies conducted by CIP (including constraints surveys, workshops, and Jennifer Woolfe's recently-published book) point out that in many countries the lack of high yielding varieties with appropriate quality characteristics is a constraint to increased use of sweetpotatoes for processing. Some breeding programs (e.g., China, Japan, AVRDC, and IITA) have successfully selected high yielding varieties or elite clones with appropriate characteristics for processing (principally high dry matter yields). Table 6-8 presents reported dry

Table 6-8. Reported fresh root yields and root dry matter contents for sweetpotatoes from four different sources, evaluated at source locations and at CIP, Peru.[a]

Source	Location of evaluation	Fresh root yield (t/ha)	Dry matter content (%)	Dry matter yield (t/ha)
AVRDC	AVRDC	22.5	38.0	8.5
AVRDC	CIP	24.6	32.8	8.1
IITA	IITA	20.3	37.3	7.6
IITA	CIP	42.3	28.3	12.0
Japan	Japan	27.2	36.2	9.8
Japan	CIP	29.0	35.4	10.3
SAP	Sri Lanka	22.9	39.6	9.1

[a] At source locations, data are for selected clones. At CIP, Peru, data are means of trials of clones selected from seed introduced from source locations.

matter yields of improved clones from various sources. These contrast with reported national averages for a number of countries (Table 6-9).

Efforts in Program 6, as reflected in CIP's Strategic and Medium-term Plans, attempt to capitalize on gains already made by breeding programs around the world, by testing promising elite materials (distributed as clones or segregating seed progenies) in selected countries. Selection and dissemination of varieties suitable for processing in those countries will complement studies of markets, policies, and technologies for sweetpotato processing which will be conducted at the same time. A subproject is being developed to help certain national programs select high yielding varieties suitable for processing. The subproject will have high priority in future breeding work on sweetpotato in Program 6. CIP breeders in Asia, Africa, and Latin America will work with colleagues in NARS and regional networks to coordinate and assist with selection and dissemination of varieties for processing.

Peru. Work was conducted at CIP experimental sites in Peru on improving native and introduced breeding populations for earliness, root dry matter content, and yield (see also Programs 1 and 2). Roots of 200 promising clones were evaluated

Table 6-9. National yields and root dry matter content of varieties from five Asian countries.

Country	National yields (t/ha)	Dry matter Variety	Yields (%)	(t/ha)
Bangladesh	11	Daulatpuri	30	3.3
China	18	Xuzhou-18	28	5.0
Indonesia	9	Various	28-37	3.3
Philippines	5	Various	23-37	1.9
Vietnam	5	Various	25-34	1.7

for fried slice quality. A number of clones with excellent chip color (non-darkening) were selected. A thesis student from the UNALM is evaluating the effects of planting and harvest dates on quality of fried slices in a select group of clones.

Non-sweet sweetpotatoes may have potential for use in processing. For example, sugars in dried sweetpotato chips cause problems with storage and handling for composite feed formulation. Several non-sweet clones with good agronomic characteristics were selected from seed introduced from Japan (progenies of Satsumahikari, a variety which lacks ß-amylase activity). An MSc. thesis student from the UNALM is investigating the influence of environment, stage of development, and storage on the sugar content of the selected clones to identify consistently non-sweet genotypes.

United States. Improvement in digestibility of sweetpotatoes could improve feed use efficiencies in animals and reduce flatulence in humans. Starch digestibility, trypsin inhibitors, and dietary fiber constituents have been identified as possible causes of low sweetpotato digestibility relative to grains. Previous work at AVRDC identified elite clones with high in vitro starch digestibility. Theses being conducted at headquarters, and under contract with North Carolina State University (NCSU), are evaluating genotypic and environmental effects on starch digestibility and trypsin inhibitor activity (TIA) of raw roots of different breeding populations. Initial results of work at NCSU have identified clones with in vitro digestibility equal to or superior to maize. In vivo feeding experiments using sweetpotatoes with varying levels of TIA and starch digestibility are planned.

United Kingdom. Starch properties influence the potential uses of sweetpotato. The Natural Resources Institute and the University of Nottingham are assisting in a collaborative investigation of genotypic and environmental influences on starch properties of breeding clones selected from introduced and Peruvian germplasm. Initial results have shown strong environmental influences on several starch parameters with some clones less influenced than others. A greater range of variation in starch parameters was found among the Peruvian clones than among the foreign introductions.

China. Fresh roots of 104 promising clones from the South China germplasm collection were evaluated for quality components as part of a contract with the Guangdong Academy of Agricultural Sciences. Boiled roots of 59 of the clones were evaluated for eating quality. The mean dry matter content was 25%, with a range from 13.8-35.2%. Soluble sugar contents ranged from 1.98-5.65%; Starch from 5.81-27.4%; and Vitamin C from 10.5-41.1 mg/100 g (fresh root).

The relatively low dry matter content of the Chinese clones reconfirms earlier reports and highlights the need for introducing germplasm with higher levels of dry matter. Several clones with excellent eating quality were selected. Root dry matter content was not clearly related to eating quality in the clones evaluated.

Thailand. During 1991, thirty-four commercial varieties were evaluated for chemical composition including protein and starch content as part of a contract with the Institute of Food Research and Product Development in Thailand. Dry matter ranged from 29-43%, protein from 3.2-12.1%, and fiber from 5-13% of dry weight. Starch recovery rates, determined

using a pilot plant, ranged 37-62% with a mean of only 52%, highlighting technical problems of sweetpotato starch extraction. Amylase content in the genotypes studied ranged 11-31% of the total. High Amylase varieties could serve as raw materials for edible films.

Philippines. Masters' thesis research through collaboration with the UPLB determined the processing potential of 17 cultivars with good agronomic characteristics and a range of root quality traits. Clones with highest consumer acceptance for fresh consumption were dry textured and moderately sweet. General acceptability of snack products (pancakes, sweetpotato/peanut bars) was not necessarily related to fresh eating quality.

Colombia. A collaborative project with ICA seeks to evaluate the potential of local and introduced sources of germplasm for potential use in the cassava-drying industry which CIAT helped establish in the Atlantic coast region. During 1991, 30 elite foreign clones were introduced from CIP. Local accessions were also evaluated. Three local cultivars were identified as promising. During 1992, selected clones will be multiplied for agronomic and processing evaluation.

During the coming years work in Program 6 on the development and dissemination of cultivars with processing characteristics will focus on developing a close association with national variety selection programs, utilization specialists, farmers, and processors in key regions of selected countries.

Processing

China. Sweetpotato processing research in China is headquartered at the Crops Research Institute (CRI), Sichuan Academy of Agricultural Sciences (SAAS). Sichuan Province produces over 20 million t of sweetpotato annually, about one-sixth of world output. CIP has had a collaborative project with CRI since 1989 focusing on improving local techniques for bleaching starch and village-level noodle processing. Major changes in agricultural policy, income levels, and eating habits among Chinese consumers over the last 15 years mean that China now uses roughly 40% of total sweetpotato production for processing, 34% for feed, 14% for direct human consumption, and 11% for other uses. Hence the interest in improving upon these achievements. Results to date include:

- Development of techniques for keeping both wet and dried starch a white color. Such starch facilitates production of the transparent noodles preferred by consumers.
- Work on low-cost equipment to reduce labor requirements and costs for noodle-making. Such efforts are also intended to ensure greater quality control for characteristics such as noodle color and cooking quality.
- Establishment of 20 small-scale, semi-mechanized processing units with plans to expand to 100 units in the next 12 months.

Vietnam. Thesis research (Master of Engineering) on the use of sweetpotato in Vietnam was completed at the Asian Institute of Technology with partial support from UPWARD and the Japanese government. Use of sweetpotato in Hiephoa district of Habac province in Vietnam was surveyed. Three popular processes for sweetpotato use—chip production, fermenting of roots for animal feed, and production of noodles—were identified and

existing procedures studied. Transparent noodles had the highest potential as a food product. However, current methods do not produce a noodle of acceptable quality (i.e., whiteness). This study developed a process to make white starch, previously unused in Vietnam. It includes liming to keep the pH of the starch slurry to about 8.6-9.2 during grating and separation processes. In addition, mixing gelatinized starch with raw starch in the proportion of 30% and 70% on a dry weight basis produces the best quality noodles. A soaking treatment following strand formation in boiling water is essential for giving a transparent appearance.

Burundi. Research on substituting raw, grated sweetpotato for imported flour in breadmaking began in Burundi in 1990 after CIP postharvest scientists demonstrated the use of such techniques, based on experience in Peru. This work is being carried out in collaboration with the Burundi National Institute for Agricultural Research and a locally-based FAO project on rustic agroindustrial technologies.

Ten different sweetpotato/wheat combinations have been tried under laboratory conditions. The most widely accepted recipe is one in which sweetpotato constitutes 30% (fresh weight) of the dough. The number of bread pieces obtained with this mixture is only slightly less than when 100% wheat flour is used. The overall savings on this type of bread production is

Preparing sweetpotato for bread making at a neighborhood bakery in Bujumbura, Burundi.

15%. A suburban bakery in Bujumbura is now producing sweetpotato bread. Other bakeries have asked for assistance and some are experimenting with the new bread.

Cameroon. In late 1991, research was initiated with a small, local bakery to study the use of sweetpotato to replace wheat flour in breadmaking. This work is being done in collaboration with the FAO Food Prevention Losses Project at Bamenda. Preliminary trials substituting fresh sweetpotatoes for wheat flour on a 30% basis (fresh weight) have indicated better income for the bakery and a lower price for consumers. Several factors are under observation and a new study will be initiated in 1992 with one of the largest bakeries in Bamenda. As the supply of sweet potatoes during the dry-season (from December to April) could be a future constraint, the FAO Pilot Processing Plant at Santa is producing dried sweetpotato materials to replace fresh sweetpotato during this period.

Marketing/Demand

Research by CIP on sweetpotato marketing and demand has focused on comparative analysis of FAO statistics on production, utilization, and consumption; and location-specific case studies focusing on particular countries, products, or processes.

Global Trends. Sweetpotato has shown the greatest dynamism, in terms of processing, of all the root and tuber crops in developing countries over the last two decades (Table 6-10). Whereas the crop was used largely for human consumption up until the mid-1970s, from 30-50% of national sweetpotato output in countries such as China and Brazil now goes to make animal feed as well as processed products for human and industrial use. In fact, some amount of sweetpotato in various forms is almost always used as animal feed wherever it is produced in developing countries. FAO statistics indicate sweetpotato use for animal feed is 40% of total output in China, 35% in Brazil, 30% in Madagascar, 17% in the Republic of Korea among other countries. The form and type of animals fed varies from country to country, although the principal pattern is roots for pigs and vines for cattle.

Rwanda. Results of a Ph.D. thesis in agricultural economics at Cornell University done in collaboration with CIP indicate that sweetpotato's future as a principal staple for the rural population is secure because of adaptability and high yields. However, sweetpotato may become an important food in urban areas, depending on the capacity of the marketing system to dramatically reduce costs. The principal contributing factors to high marketing costs for sweetpotato are: bulkiness and low unit values; perishability which increases costs and induces costly marketing strategies; uncertain availability of transport; lack of standards, weights, and measures; and government regulations such as the volume vs value-based taxation system which is biased against trade in low-value products. The thesis notes "research into storage and processing techniques is probably the single most important contribution that can be made...because it can address the twin problems of bulkiness...and perishability that underlie many of the other marketing problems." The thesis concludes that processing sweetpotatoes into dried chips or flour for bakery products is one possibility that deserves high priority.

Peru. Previous research in Peru has focused on nutritional characteristics and

Table 6-10. Changes in utilization (%) of sweetpotato in developing countries, 1961-88.

	1961-63			1973-75			1986-88		
Use	Africa[a]	Asia[b]	L. America[c]	Africa[a]	Asia[b]	L. America[c]	Africa[a]	Asia[b]	L. America[c]
Food	57	78	68	61	71	67	65	52	73
Feed	1	11	19	3	19	19	1	37	14
Processing	1	5	0	0	5	0	0	6	0
Seed	21	0	0	14	0	0	13	0	0
Waste	20	5	13	21	5	13	21	5	13
Total[d]	100	100	100	100	100	100	100	100	100

Source: FAO Food Balance Sheets, unpublished statistics.
[a] Africa - [Morocco, Algeria, Tunisia, Egypt, Libya] - [South Africa].
[b] Asia - [Israel, Japan] + Oceania - [Australia, New Zealand].
[c] North and Central America + South America - [Canada, USA].
[d] May not sum to 100 due to rounding.

current cost of production for sweetpotato bread (see Annual Report 1991). Following those studies, a consumer survey (n=386) on sweetpotato bread in Lima was the subject of a Master's thesis at Wageningen Agricultural University (Department of Marketing). This bread is produced commercially in Peru. It involves substituting fresh, raw, grated sweetpotato for wheat flour on a 30% basis (fresh weight) in the preparation of the dough. A sample of low-, low/middle-, and middle-income consumers were administered a structured questionnaire. The findings indicate sweetpotato bread has good prospects of becoming a bread consumed daily provided characteristics such as appearance (i.e., shine, parts of sweetpotato) and consistency (i.e., more toasted) can be improved (Table 6-11).

Training

Building National Capacity. Improving capabilities of national partners for research and training is a major priority of Program 6. To meet this goal, a series of workshops was organized in collaboration with CIAT and IITA as part of a UNDP Project on human resource development. The subject of these workshops was root and tuber crop processing, marketing, and use in developing countries. The proceedings for each gathering will include a wealth of information on recent developments in processing and new product development in numerous developing countries. These are to be published during 1992.

Guatemala. A workshop on processing, marketing, and product development for potato and sweetpotato was organized by CIAT and CIP in collaboration with the Instituto de Ciencia y Tecnología Agropecuaria (ICTA) in Villanueva, April 8-12. It was funded by UNDP. The meeting examined existing opportunities to expand demand for root and tubers and analyzed some specific cases with the objective of

Table 6-11. Consumer preference (%) for a particular characteristic of sweetpotato bread.

Preference	Typical Medium (n=98)	Low Medium (n=96)	Typical Low (n=192)
More shine	40	37	28
More toasted	24	12	8
Smaller pieces of sweetpotato	43	40	35
Bread type			
-Round	13	17	14
-Baguette	31	39	34
-French bread	33	12	16

Adapted from: Denen. H. El Mercado Potencial de Pan de Camote: Encuestas a Consumidores en Lima Metropolitana y Callao. Wageningen Agricultural University. The Netherlands. International Potato Center (CIP). Lima, Perú. 83 p.

channeling and promoting new efforts in this area. The objectives of the workshop were:

- to learn about developments in processing, marketing, and use of roots and tubers in Latin American countries and exchange related experiences
- to submit and analyze schemes for product development and processing of roots and tubers
- to discuss mechanisms to promote horizontal cooperation among countries as well as to increase the effectivness of the international centers, CIAT and CIP, that are headquartered in the region
- to critique a draft manual on product development for roots and tubers.

The workshop was organized in three working sessions: country reports, presentation of case studies, and discussion on areas for cooperation. Participants represented several national and international research institutions (both private and public sector) in Colombia (3), Costa Rica (4), Cuba (2), Ecuador (3), Mexico (1), Panama (3), Peru (2), and Guatemala (5).

The Philippines. A workshop on root and tuber processing, marketing and utilization in Asia, organized by CIP, CIAT, and IITA in collaboration with Visayas State College of Agriculture (ViSCA), was held in Leyte, April 22-May 1. Participants came from Vietnam (3), China (2), Indonesia (3), India (2), Korea (1), Thailand (3), Taiwan (1), the S. Pacific (1), and the Philippines (12), as well as from CIP (2) and CIAT (2). There were also representatives from research and development institutions such as FAO, NRI, and the Asian Institute of Technology. Participants submitted country reports showing the present status and future prospects for processing of sweetpotato and cassava. They also gave papers on selected topics such as product and processing research and pilot plants. Many useful comments were also received on the draft manual.

Nigeria. An international workshop on product development, production, processing, and marketing of root and tuber crops, was organized by IITA in collaboration with CIP and CIAT, and held in Ibadan, October 26-November 2. The workshop was directed at those responsible for product development in the areas of crop production, plant breeding, food processing, and marketing, with a

special emphasis on identifying new products. Participants from the Republic of the Congo (2), Kenya (3), Tanzania (1), Uganda (1), and Nigeria (8), as well as from the Philippines (1) and CIP-Lima, attended the workshop.

India. A regional workshop on postharvest handling and utilization of sweetpoato was held at the Central Tuber Crops Research Institute (CTCRI), Trivandrum, Kerala, September 9-13. It was jointly organized by the Indian Concil of Agricultural Research and CIP. The participants were from India (16), Bangladesh (2), Nepal (1), and Sri Lanka (1).

Similar events are planned for the years ahead as part of the Program's Strategy in human resource development.

Participants in the VISCA workshops at Leyte, The Philippines.

Training at CIP not only meets the demand for hands-on field experience of agricultural researchers, extensionists, and educators from developing countries, but also offers specialized programs tailored to the specific needs of users of CIP technology.

Training

One of CIP's most successful activities is strengthening the National Agricultural Research Systems (NARS) of the developing world by training their research scientists. CIP's Training Department closely collaborates with regional staff, program leaders and national scientists to determine the training needs of our research partners. This interaction keeps CIP's training program focused on research priorities as well as the needs of users.

Every year CIP offers a combination of group and individual training opportunities to selected candidates. Courses may be international, regional or in-country. Training is also classified as production-oriented or specialized. All courses and individual training take from one to four weeks.

In order to develop scientific leadership in the potato and sweetpotato programs of our research partners, CIP often supports national program scientists studying for academic degrees. Usually, CIP plays a support role to local organizations and financial institutions. In a few instances, minor financial assistance is provided to outstanding students when actual costs exceed available funding.

Training at CIP is done by our research staff. Regional and headquarters scientists instruct CIP courses and also act as resource lecturers in courses given by national and international organizations.

The Collaborative Research Networks sponsored by CIP are progressively assuming a larger responsability for regional training. Courses, workshops and individual training are organized by network participants with minor assistance from CIP and only when required in specialized areas. Most networks can now handle on their own all training in general potato production. Thanks to this, CIP's resources can now focus on priority research programs.

CIP, IITA and CIAT carried out several joint training activities in 1991 in the last year of a human resources development project sponsored by UNDP. For several years now these centers have collaborated in the organization of group and individual training programs aimed to strengthening NARS on aspects of production technology, research, training and communication skills related to root and tuber crops. Joining efforts with sister centers as well as with other international and national institutions either public or private increased CIP's effectiveness and helped share the training program cost.

In order to effectively deliver knowledge and methodologies, CIP's Training Department assisted scientists in the production of printed and audiovisual training materials. Technical bulletins, research guides, slides series and posters covering a variety of subjects were produced in 1991.

The 1991 training activities are summarized in Table 1. Descriptions of most of the courses and workshops given during the year have been integrated into the end of the appropriate research program section.

Previous Page Blank

Table 1. Summary of CIP training activities for 1991.

	No. of participants	No. of countries represented	No. of courses/ workshops
Group training			
Specialized courses and workshops	452	64	20 [a]
Production courses	336	43	14
Individual training (Lima-HQ)	32		19
Academic training			
B.S.	23	1	
M.S.	39	10	
Ph.D.	9	8	

[a] 10 workshops; 10 courses.

Developing Training and Communication Skills

Bolivia. A research and communication methodology training course, organized by PROINPA and CIP, was offered to 27 PROINPA scientists and assistants in Cochabamba, May 27-June 7. The course covered the main experimental designs used in potato research, the use of the MSTAT-C program in the planning and analysis of research data, and modern techniques for the presentation of research results.

On-farm Research and Field-level Diagnostic Skills

Peru. An in-country course on farm-level diagnostic skills for roots and tubers, took place in Chimbote, January 27-February 3. It was organized and funded by CIP, and offered to five participants from INIAA's experiment stations. The objectives were to train research scientists on planning, designing and conducting diagnostic studies on sweetpotato feeding systems and to develop participatory research skills in order to introduce the farmer's perspective into research and development programs.

Brazil. A meeting on field-level diagnostic skills, funded by the UNDP, was held in Fortaleza, Ceará, May 20-24. The participants were from Argentina (1), Colombia (5), Chile (1), Paraguay (2), Peru (4), the Dominican Republic (1), and Uruguay (1).

The course objectives were:

- to train researchers from national agricultural systems in participative diagnostic and structured interview methodologies, and
- to improve the ability of researchers to communicate with farmers.

The meeting included both theory and practical applications of these methodologies at the farm level. At the end of the course, a group of country leaders met with CIP and CIAT staff to make a final evaluation of all farm-level diagnostic skills activities carried out under the auspices

Fields, laboratories, and greenhouses at La Molina, Peru, are intensively used in individual training programs supervised by highly qualified scientific personal.

of the human resources development project sponsored by UNDP since 1988.

The group discussed the extension of application of diagnostic methods by personnel at national root and tuber research programs, evaluated the effect of project on the adoption of diagnostic methods and determined future needs for field-level diagnostic training.

Conferences, Planning and Evaluation Workshops

CIP gives support to scientific associations which deal with our mandated crops. CIP staff is encouraged to submit research papers at their meetings and substantial financial support is provided to national scientists to allow their participation. Also, CIP is frequently required to attend planning and evaluation workshops of the national and development programs of NARS in the developing world. Although this activities may not be considered training, it makes a significant contribution to the institutional development of our research partners.

The Dominican Republic. A workshop on research on potato in warm climates, sponsored by CIP Region II, was held April 22-26. The participants came from the Dominican Republic (3), Cuba (1), El Salvador (1), and Nicaragua (1).

Indonesia. The Asian Potato Association (APA) triennial conference was held in Bandung, June 17-22. As part of this conference, a workshop called "The potato

in sustainable crop systems" was sponsored by CIP. Participants were from Bangladesh (5), China (1), India (3), Japan (1), Kiribati (1), Malaysia (2), Pakistan (3), Philippines (2), Sri Lanka (1) and Vietnam (1).

Argentina. A workshop on planning and evaluation of potato research in Argentina was held at INIA Balcarce, August 7-9. Thirty-five scientists from different provinces of Argentina attended the workshop.

Peru. The XV meeting of the Latin American Potato Association (ALAP) was held in Lima, September 8-14. More than 200 potato workers from all over Latin America presented and discussed their progress in research and development of potato production and utilization. This meeting included a symposium called "The millenary potato: nutritional treasure of the Andes" which outlined the potato's contribution to human nutrition from its domestication in the Andes long ago to its worldwide use today, 500 years after the arrival of Columbus in America.

Members of CIP's Communication Unit prepare panels for an international meeting. This type of support effort helps to translate research into information that can be readily under stood by a wide public.

Information

A spirit of integrating information functions within CIP's research program was the preeminent concern during the past year. A major step forward has been the elaboration of the Program Information Plan, developed by Program Leaders, regional staff, and Information Department staff. This Plan follows through on the guidelines presented in CIP's recent Strategic Plan, closely linking information activities to research priorities. CIP has also developed CIPFORUM, a prototype electronic forum to enable headquarters and regional scientists to interact and exchange information about research projects, further facilitating integration in research administration and planning.

Information Services

In response to the concern expressed in the Third External Program Review that limited use was being made of CIP information services in Africa and Asia.

CIP has conducted specific dissemination activities to make access to information on potato and sweetpotato much easier for national programs on these continents.

The upgrading of information services provided to CIP staff and NARS has continued in 1991. During the year, 783 users received searches and/or selective disseminations of information (SDIs).

Retrospective searches conducted for CIP staff and NARS numbered 970. Bibliographic databases available at headquarters or on-line via DIALOG have been used for this purpose. CIP has subscribed to the French database, PASCAL. It is being used mainly to provide information to NARS in Francophone Africa.

Over 530 SDI profiles, designed for CIP and NARS users, are run every three months. Periodic evaluations have confirmed that the individual nature of the SDI service is highly valued by the researchers receiving it.

CIP distributes specialized bibliographies to approximately 1,000 users (CIP staff, NARS, and agricultural libraries). Two bibliographies were produced during the year in the Communications print shop: *Bibliografía de papa y batata (camote) por autores y coautores peruanos auspiciados por el CIP*, and *The potato in Africa*.

To make retrieval easier for its more than 400 users, a subject index has been added in the monthly issue of the Accessions list. Also, a survey was conducted among subscribers to update their subscriptions and evaluate their needs.

More than 5,000 photocopies selected from searches or SDI printouts were requested and delivered to users.

During 1991, 2,943 publications were processed and included in CIP's database and library collection, which presently contains over 38,000 items.

An SDI evaluation form was prepared and sent to users, as has been done previously to those who have completed four years of subscription. The evaluation will assess user interest in receiving information in the future through means other than paper.

CIP's library provides valuable resource materials to researchers.

Also, the first on-line connection to the CIP database system was established this year from the Latin American Potato Association (ALAP) meeting held in Lima. It was performed using modem and regular telephone lines to the VAX computers at CIP. This enabled participants to make computer searches in bibliographic databases available at CIP headquarters and use the VAX phone utility, which allowed interactive computer communication between the meeting and headquarters. Many participants were interested in the possibility of accessing CIP in similar manner from their work sites. It is anticipated that this procedure will be used regularly in the future, especially from CIP regional offices.

Communication Accomplishments

In addition to the production of publications, CIP has participated in several international exhibits. In April 1991, CIP's display at the VI International Euroflora Fair that took place in Genoa won the "Coppa dell'Ente Nazionale Italiano per il Turismo" prize. The exhibit was seen by a wide audience, including the Italian President. The 15-panel display, entitled "Potato: Treasure from the New World," emphasized the potato's importance as a New World crop "rediscovered" by Europe. It also presented information on the potato's use since the pre-Inca times, its nutritional value, and diverse potato processing methods used from ancient to modern times.

For the XV meeting of ALAP, which was held in Lima, CIP prepared a colorful poster exhibit. This exhibit includes six panels giving general information on CIP's mission, research outputs, collaborative bridges, and work with national programs, training, and information services. Also during the ALAP conference, a small collection of potato stamps was exhibited. This unique and interesting display was made possible thanks to James Bryan, who gave CIP access to slides and prints from his private collection.

CIP Statistics and Communication Units joined efforts in providing an integrated course for NARS in Bolivia, with the objective of improving research design and communication of research results.

Other accomplishments of CIP's communication activities are described below:

- The book *Potatoes of South America: Bolivia* by Carlos Ochoa was published by CIP in cooperation with Cambridge University Press. It is the first in a series by the renowned CIP's taxonomist, and represents the compilation of a lifetime of collection and knowledge on potato species.
- *Sweet Potato Pest Management: A Global Perspective* was published with Westview Press in the USA. It was edited by Richard K. Jansson of the University of Florida and K.V. Raman from CIP. Demand for this book has been high and it is being distributed widely.
- The color booklet titled "Twelve years of cooperation CIP/EMBRAPA" was published.
- Distribution agreements for CIP publications were signed and implemented with AGROS in Colombia, and CGPTR Center in Indonesia.
- CIP printed 19 books and booklets in English, with a total print run of 31,800 copies, and 9 books and booklets in Spanish with a total print run of 8,350.
- Translation of 33 CIP documents included: 15 to English, 15 to Spanish (including the Annual Report), and 3 to French.
- A short version of the CIP slide show with audio in English and Spanish was produced and is now in use.
- A video in Spanish on the Potato Tuber Moth was made for the ALAP meeting.
- A poster in Spanish and English versions on major insect and mite pests of the potato was created.
- Four English, 4 French, and 3 Spanish issues of CIP Circular were issued.
- The Communication Unit provided writing and editing support to headquarters and regional staff for scientific articles and documents, as well as in art, photography, and other audiovisuals.

Computer Accomplishments

Thanks to a team effort and staff esprit de corps, noteworthy developments in organizational information systems and electronic communications for CIP were achieved last year, in spite of fiscal constraints. The development of CIPFORUM, a prototype electronic meeting place developed within the main VAX system, was a key achievement. This new system permits staff to use innovative communication mechanisms internally within the center, as well as electronic conferencing worldwide. This is the first in a series of efforts to develop effective

CIP's print shop produces diverse publications, contributing to the dissemination of the Center's research in several languages worlwide.

communication mechanisms to assist in the integration of headquarters and regional offices as outlined in the Strategic Plan.

Teleconferencing has started at CIP, particularly through participation in INFORUM, the electronic conference on sustainability issues. We share with INFORUM the objective of evaluating the benefits of cooperative research through teleconferencing, and supporting scientist-to-scientist communication. CIP scientists access conference papers through the CIPFORUM application, taking advantage of CIP's local area network. Program IV on Integrated Pest Management requested support from INFORUM to set up a two-month-long electronic conference, in conjunction with the conference on potato pest management held in Wyoming, USA.

Other activities of the Computer Unit this year included the following:

- The Unit supported increased use of electronic mail through the network. It designed and developed applications for use of electronic mail via the VAX network and for users of PCs connected to the VAX. The assistance of IRRI's computer specialist was received, when CIP was offered the benefits of sharing IRRI's developments in the implementation of an electronic mail system for headquarters. This system is of particular expediency for the desk-to-desk delivery of electronic mail, linking regions and institutions throughout the world.
- Groups of CIP staff were trained on word processing, database management,

spreadsheets, and electronic communications. An intensive training course on dBase was conducted for Administration staff, as well as an introduction to DOS. A workshop on system analysis and development was given to staff involved in the design of information systems at headquarters.

- The headquarters Ethernet network was expanded by interconnecting PCs through the VAX system. The first phase of PC integration to the campus Ethernet network was completed, including 32 PCs.
- An analyst working on the development of the main center information systems has strengthened systems development.

Statistics Activities

The Workshop, Statistics and Communication Methods for Agricultural Research on Potatoes, took place in Cochabamba, Bolivia. It was organized by the Proyecto de Investigación y de Producción de Semilla Pre-básica de Papa (PROINPA) with the collaboration of the Communication and Statistics Units. A total of 27 participants attended. The workshop covered statistical methods for the planning and analysis of short- to long-term experimental designs, communication methods, exercises on the use of statistical and graphics software, and guidelines to choose and communicate oral and written research results. Relevant documents were prepared

The importance of electronic and computer communication media continues to grow at CIP, providing challenges and opportunities for the effective management and dissemination of decentralized research.

or translated for the event, including *"Introducción a los Diseños Experimentales"* by A. García and B. Eldredge, as well as various training materials on communication. Participants evaluated the workshop as well organized and applicable to their work. Around 85% said the level of the workshop was adequate, and 90% said they learned new information. The workshop's aim was to improve the quality of the research design and reports usually presented at local, regional, and international meetings. It was a follow-up to the first workshop of this type held for PRECODEPA scientists in 1990.

The Statistics Unit offered a course, Introduction to experimental design for CIP staff. The course program is similar to the above-mentioned one offered to PROINPA researchers in Bolivia. It integrates the most important experimental designs and statistical methods with the statistical software MSTAT. The course is ongoing and adjusted to the work schedule of participants. Thirty-nine CIP researchers took the course.

CIP Publications

Agroeconomic evaluation of different types of potato planting material in Egypt, by C. Crissman, R. El Bedewy, M.F. Sabaa, and M.F. Sharaf. Social Science Department Working Paper Series no. 1. 22 p.

Agroeconomic evaluation of different types of potato planting material for the spring season in Egypt, 1989, by M.F. Sabaa, R. El-Bedewy, C. Crissman, and M.F. Sharaf. Social Science Department Working Paper Series no. 2. 10 p.

Avances de investigación y uso de papa y camote, by N. Espinola. Avances en Alimentos y Nutrición Humana, Lima, Peru, Aug. 21-23. 8 p.

Batata, camote o boniato: tres nombres distintos y un mismo cultivo, by H. Rincón R. 2 p.

Best paper awards 1990, by R.E. Rhoades, V.N. Sandoval, and C.P. Bagalanon (eds.). UPWARD, Los Baños, Philippines. 96 p.

Calorías de una papa de tamaño mediano, by N. Espinola and H. Rincón 2 p.

CIP Slide Training Series Guide-Books nos. 1-5, by P. Tovar and J.H. Dodds. Translated from English to Arabic in Region IV (Egypt). 16 p.

Clasificación de las publicaciones del CIP, desde 1970, según plan de acción, departamento, autor y forma, by O. Ortiz Oblitas and H. Rincón R. 12 p.

Cost of seedling tubers produced from true potato seed: an estimate based on experimental production in Egypt, by R. El-Bedewy and C. Crissman. Social Science Department Working Paper Series no. 3. 10 p.

Cost of seedling tubers produced from true potato seed in the spring season in Egypt, 1989, by R. El-Bedewy, M.F. Sabaa, C. Crissman, and M.F. Sharaf. Social Science Department Working Paper Series no. 4. 13 p.

Cultivo de tejidos para la eliminación de patógenos, by R. Lizárraga, A. Panta, U. Jayasinghe, and J. Dodds. Guía de Investigación no. 3. 21 p.

Descriptors for sweetpotato, by Z. Huamán (ed.). (also in Spanish and French) Published in collaboration with IBPGR and AVRDC in Rome, Italy. 134 p.

Dos gigantes de la conservación de germoplasma, by H. Rincón R., N.I. Vavilov, and C.M. Ochoa. 6 p.

Early blight of potato: **Alternaria solani**, by R. Backman. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 17. 20 p.

Effect of stem density on potato production, by S.G. Wiersema. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 1. 18 p.

El futuro de la costa central peruana en lo referente a trabajos en camote, by R. del Carpio Burga. 2 p.

El tarwi o lupino: su efecto en sistemas de cultivos, by J. Franco. Final Report of a Cooperative Project between CIP and GTZ. 154 p.

Evaluación de la resistencia de la papa al nematodo del quiste **Globodera pallida**, by J. Franco, A. Gonzáles, and A. Matos. (1990) 64 p.

Food for the future: a new chapter in Peruvian agriculture. Papers from the workshop held Apr. 22-23. 190 p.

Identifying yield constraints in potato production by means of on-farm field trials in Carchi, Ecuador, by J. Korva. Physiology Department. 13 p.

In-country training workshop for farm household diagnostic skills, by R.E. Rhoades, V.N. Sandoval, and C.P. Bagalanon (eds.). The workshop was held in Los Baños, Philippines, Sep. 25-28, 1990. UPWARD, Los Baños, Philippines. 103 p.

Late blight of potato: **phytophthora infestans**, by J.W. Henfling. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 4. 28 p.

L'utilisation des semences botaniques, une méthode alternative pour la production de pommes de terre, by A. Devaux. Ph.D. Thesis, Université Catholique de Louvain. Fac. Sciences Agronomiques, Louvain-La-Neuve, Belgium. 274 p.

Mercadeo agrícola: metodologías de investigación, by G.J. Scott and J.E. Herrera (eds.). Taller Latinoamericano sobre Métodos para Estudiar la Comercialización Agrícola, Lima, Peru, June 11-13, 1990. Published in collaboration with IICA. 503 p.

Molecular methods for potato improvement. Report of the planning conference, Application of Molecular Techniques to Potato Germplasm Enhancement. Meeting held Mar. 5-9, 1990. 188 p.

Monitoring aphid populations, by K.V. Raman. Translated from English to Arabic in Region IV (Egypt). Slide Training Series no. IV-2. 18 p.

Oca (**Oxalis tuberosa** *Molina*) *in southern Chile: a report on a germplasm exploration in February 1991*, by M. Hermann and R. Gonzáles. 12 p.

On-farm agroeconomic evaluation of different types of potato planting material in Egypt, 1990, by A. Rizk, M.F. Sabaa, and R. El Bedewy. Social Science Department Working Paper Series no. 5. 9 p.

Physiological development of potato seed tubers, by S.G. Wiersema. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 20. 15 p.

Planting potatoes, by R. Cortbaoui. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 11. 16 p.

Potato seed production in the Mediterranean region: present situation and perspectives, by R. Cortbaoui. Region IV (Tunis, Tunisia). 7 p.

Potato seedling screening for resistance to potato viruses X and Y by the mass inoculation technique with spray gun, by E.N. Fernandez-Northcote. Research Guide no. 37. 12 p.

Potato tuber moth, by K.V. Raman. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 3. 12 p.

Pourriture molle et jambe noire de la pomme de terre: **Erwinia** *spp*, by J.G. Elphinstone. Translated from English to French. Bulletin d'Information Technique no. 21. 18 p.

Rouging potatoes, by R. Cortbaoui. Translated from English to Arabic in Region

IV (Egypt). Technical Information Bulletin no. 5. 12 p.

Sweet potato pest management: a global perspective, by R.K. Jansson and K.V. Raman (eds.). Published by Westview Press, Boulder, CO, USA. 458 p.

Sweet potatoes as animal feed in developing countries: present patterns and future prospects, by G.J. Scott. Consultation on the Use of Roots, Tubers, Plantains and Bananas in Animal Feeding, Cali, Colombia, Jan. 21-25, 1991. 23 p.

Systematic botany and morphology of the potato, by Z. Huamán. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 6. 20 p.

The demand for potatoes in Tunisia, by K.O. Fuglie. Social Science Department Working Paper Series. 28 p.

The development and adoption of integrated pest management of the potato tuber moth, **Phthorimaea operculella** ***(Zeller) in Tunisia***, by K.O. Fuglie, H. Ben Salah, M. Essamet, Ben Temime A., and A. Rahmouni. Social Science Department Working Paper Series. 48 p.

The potatoes of South America: Bolivia, by C.M. Ochoa, (1990) Published by Cambridge University Press, Cambridge, UK. 512 p.

Tissue culture for elimination of pathogens, by R. Lizárraga, A. Panta, U. Jayasinghe, and J. Dodds. Research Guide no. 3. 21 p.

Transmission of potato viruses by aphids, by K.V. Raman. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 2. 21 p.

Transport, receipt, and propagation of in vitro sweet potato plantlets, by J.H. Dodds, A. Panta, and J.E. Bryan. In English and Spanish. Research Guide no. 38. 17 p.

Virus detection in potato seed production, by L.F. Salazar. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 18. 12 p.

Water management in potato production, by A.J. Haverkort. Translated from English to Arabic in Region IV (Egypt). Technical Information Bulletin no. 15. 28 p.

Journal Articles

Alcázar, J., S.A. Raymundo, and R. Salas. 1991. Influencia del tiempo de exposición, grosor del plástico, plástico usado o nuevo y profundidad del suelo en la eficiencia de la solarización en el control de *Meloidogyne incognita* (Kofoid y White) Chitwood. Fitopatología (Peru) 26(2):92-99.

Aley, P. and E.R. French. 1990. Rapidez de marchitamiento por *Pseudomonas solanacearum* y su efecto estructural en papa. Fitopatología (Peru) 25(1):15.

Almekinders, C.J.M. 1991. Flowering and true seed production in potato (*Solanum tuberosum* L.). 2: Effects of stem density and pruning of lateral stems Potato Research 34(4):379-388.

Almekinders, C.J.M. and S. Wiersema. 1991. Flowering and true seed production in potato (*Solanum tuberosum* L.). 1: Effects of inflorescence position, nitrogen treatment, and harvest date of berries. Potato Research 34(4):365-377.

Anguiz, R. and M. Canto-Sáenz. 1991. Reaction of sweetpotato cultivars (*Ipomoea batatas* (L.) Lam.) to *Pratylenchus flakkensis Seinhorst*. Nematropica 21(2):197-201.

Arcos, J., M. Canto Sáenz, and P. Jatala. 1990. Extraction methods for *Nacobbus aberrans*. Nematropica 20(1):1.

Arcos, J., M. Canto Sáenz, and P. Jatala. 1990. Influence of extraction methods on hatching and infestivity of second-stage juveniles of *Nacobbus aberrans*. Nematropica 20(1):1.

Austin, D.F., F. de la Puente, and J. Contreras. 1991. *Ipomoea tabascana*, an endangered tropical species. Economic Botany 45(3):435-438.

Bhargava, N., A. Bhargava, S.N. Bhargava, K.C. Thakur, and M.D. Upadhya. 1991. An efficient potato pollen extractor for bulk pollen collection. American Potato Journal 68(9): 581-584.

Brodie, B.B., R.L. Plaisted, and M.M. de Scurrah. 1991. The incorporation of resistance to *Globodera pallida* into *Solanum tuberosum* germplasm adapted to North America. American Potato Journal 68(1):1-11.

Canto-Sáenz, M. and A. González. 1991. Gasoline: an alternative medium to separate organic matter from cysts of *Globodera pallida* extracted from soil. Nematropica 21(2):123-124.

Chandra, R., D.R. Chaudhari, and M.D. Upadhya. 1991. A low cost medium for micropropagation of potato. American Potato Journal 68(9):599-600.

Chandra, R., G.J. Randhawa, D.R. Chaudhari, and M.D. Upadhya. 1991. Efficacy of triazóles from in-vitro production of microtubers in potato. American Potato Journal 68(9):600.

Chaudhury, E.H., M. Eunus, and L.C. Sikka. 1991. Development of nursery techniques for raising seedlings from true potato seed (TPS) for transplanting. Journal of the Indian Potato Association 18(1/2):74-78.

Cisneros Vera, F. 1991. A propósito de los insecticidas y sus problemas. Agro Enfoque (Peru) 6(44):16-17.

Coca Moranti, M. and P.J. Franco. 1991. Aspectos sobre identificación, dispersión, hospedantes y control de *Meloidogyne* spp. en el valle de Mizque, Dpto. de Cochabamba. Revista de Agricultura (Bolivia) 48(18):2-6.

Delgado de la Flor, R., E. Guevara, and P. Jatala. 1991. Bioensayo: prueba simple y eficiente para determinar el grado de infestación del nemátodo del nódulo de la raíz (*Meloidogyne* sp.) en el campo. Agro Enfoque (Peru) 6(45):15-16.

Delgado de la Flor, R. and P. Jatala. 1991. Distribución del nematodo quiste de la papa (*Globodera* spp.) en el Departamento de Cusco, Peru. Nematropica 21(2):137-146.

Delgado de la Flor, R. and P. Jatala. 1991. Identification of races of the potato cyst nematode (*Globodera* spp.) from Cusco, Peru. Nematropica 21(2):217-222.

Delgado de la Flor, R. and P. Jatala. 1991. Efecto de *Meloidogyne incognita* en el incremento de algunas enfermedades de tubérculo de papa en almacenes rústicos. Nematropica 21(2):124. AP.

Delgado de la Flor, R., P. Jatala, and A. González. 1990. Comportamiento de papa cultivar María Huanca a poblaciones del nematodo quiste de la papa (*Globodera pallida*) del Departamento del Cusco. Fitopatología (Peru) 25(1):12.

Estrada Ramos, N. 1990. Híbridos triploides derivados de *Solanum stoloniferum* y su valor en el mejoramiento de la

papa. Revista Latinoamericana de la Papa (Colombia) 3(1):80-87.

Fernández-Northcote, E.N. and C. Lizárraga. 1991. Distribución geográfica de serotipos del virus X de la papa. Fitopatología (Peru) 26(1):13-18.

Franco, J. and A. González. 1990. A new race of *Globodera pallida* attacking potatoes in Peru. Revue Nematologie 13(2):181-184.

Franco, J., A. González, A. Matos, and R. Delgado de la Flor. 1991. Efecto de la irradiación gamma en la sobrevivencia del nematodo quiste de la papa *Globodera pallida*. Fitopatología (Peru) 26(2):63-65.

French, E.R. and J. Arango. 1990. Edema de la papa bajo condiciones ambientales controladas. Fitopatología (Peru) 25(1):14.

Freyre, R., M. Iwanaga, and G. Orjeda. 1991. Use of *Ipomoea trifida* (HBK) G. Don germplasm for sweet potato improvement. 2: Fertility of synthetic hexaploids and triploids with 2n gametes of *I. trifida*, and their interspecific crossability with sweet potato. Genome 34:209-214.

Fuglie, K.O. 1991. Vent for surplus as a source of agricultural growth in northeast Thailand, 1958-1980. The Journal of Developing Areas 25:331-346.

González, A. and M. Canto-Sáenz. 1991. Effect of organic amendments in the control of *Globodera pallida*. 23rd Annual Meeting of ONTA, San Antonio, Texas, USA, July 21-26. Nematropica 21(2):126.

González, A., J. Franco, and A. Matos. 1990. Hongos asociados con el nematodo del quiste de la papa *G. pallida*. Fitopatología (Peru) 26(2):63-65.

González, A., J. Franco, and A. Matos. 1991. Desarrollo de *Nacobbus aberrans* (Thorne, 1936) Thorne y Allen 1944, en placas petri: método alternativo para la evaluación de resistencia en *Solanum tuberosum* L. Nematropica 21(2):155-160.

Haddad, R. and P. Jatala. 1990. Histopathological responses of potato roots infected with an undescribed sedentary endoparasitic nematode. Nematropica 20(1):7-8.

Holwerda, H.T. and I.J. Ekanayake. 1991. Establishment of sweet potato stem cuttings as influenced by size, depth of planting, water stress, hormones and herbicide residues for two genotypes. Scientia Horticulturae 48(3/4):193-203.

Huamán, Z. 1991. International Potato Center safeguards plant genetic resources in Peru. Diversity 7(1/2):16.

Huamán, Z., W. Collins, and F. de la Puente. 1991. Genetic conservation of sweet potato in Latin America and the genebank of CIP, the International Potato Center. Diversity 7(1/2):47-48.

Huamán, Z. and P. Schmiediche. 1991. The importance of ex situ conservation of germplasm: a case study. Diversity 7(1/2):68-69.

Iwanaga, M., R. Ortiz, M.S. Cipar, and S.J. Peloquin. 1991. A restorer gene for genetic-cytoplasmic male sterility in cultivated potatoes. American Potato Journal 68(1):19-28.

Iwanaga, M., R. Freyre, and G. Orjeda. 1991. Use of *Ipomoea trifida* (HBK) G. Don germplasm for sweet potato improvement. 1: Development of synthetic hexaploids of *I. trifida* by ploidy-level manipulations. Genome 34:201-208.

Iwanaga, M., R. Freyre, and K. Watanabe. 1991. Breaking the crossability barriers between disomic tetraploid *Solanum acaule* and tetrasomic tetraploid *S. tuberosum*. Euphytica 52(3):183-191.

Jatala, P., R. Delgado de la Flor, and A. González. 1990. Occurrence of *Heterodera longicolla* in coffee plantations of San Ramón, Department of Junín, Peru. Nematropica 20(1):8.

Jatala, P., R. Delgado de la Flor, M. Querci, L. Salazar, and V. Lazarte. 1991. Possible implication of *Meloidogyne incognita* in the dissemination of potato spindle tuber viroid. Nematropica 21(2):127.

Jatala, P. and L. Garzón. 1990. Estudio morfológico de un nematodo fitoparásito aún no descrito con el microscopio de rastreo. Fipatología (Peru) 25(1):12.

Jatala, P. and L. Gavilano. 1991. Electrophoretic studies of protein patterns of the *Globodera pallida* and *G. rostochiensis* eggs. Nematropica 21(2): 127.

Jatala, P. and Gavilano, L. 1990. Estudios electroforéticos de los patrones de proteínas del huevo y cutícula del quiste de *Globodera pallida*. Fitopatología (Peru) 25(1):12-13.

Jatala, P. and E. Guevara, 1990. Effect of temperature on the expression of resistance to *Meloidogyne incognita* in potatoes. Nematropica 20(1):8.

Jatala, P., E. Guevara, R. Espino. 1990. Integrated management of *Meloidogyne incognita* on potatoes and sweet potatoes under field conditions. Nematropica 20(1):8-9.

Jatala, P., G. Manrique, and L. Gavilano. 1990. Eficiencia nematicida de algunos metabolitos de hongos y su especificidad en controlar nematodos fitoparásitos. Fitopatología (Peru) 25(1):13.

Jatala, P., K. Watanabe, and E. Guevara. 1991. Advances in breeding and screening potatoes for resistance to *Meloidogyne incognita*. Nematropica 21(2):128.

Jatala, P., K. Watanabe, and E. Guevara. 1991. Role of plant growth promoting rhyzobacteria in the control of *Meloidogyne incognita* on potatoes and tomatoes. Nematropica 21(2):128.

Jatala, P., M. Zegarra, and I. Bartolini, 1990. Actividad nemastica y nematoxica de extractos de *Areca catechu* en nematodos fitoparásitos y bacteriófagos. Fitopatología (Peru) 25(1):13-14.

Kapur, K.K. Suman and M.D. Upadhya. 1991. Effect of growth retardants on yield and tuber quality of potato. American Potato Journal 68(9):619-620.

Llontop, J., J. Franco, and M. Scurrah. 1989. Variación en virulencia y agresividad de *Globodera pallida* en clones de papa resistentes a las razas P4A y P5A en Perú. Nematropica 19(2):111-124.

Llontop, J., M. Scurrah, and J. Franco. 1989. María Huanca, nueva variedad de papa resistente al nematodo de quiste de la papa (*Globodera pallida*). Revista Latinoamericana de la Papa (Colombia) 2(1):77-89.

Luján, L., P. Corzo, and O. Hidalgo. 1991. Pasado, presente y futuro de la semilla de papa en Colombia: análisis de la situación de la producción de semilla de papa en Colombia. Revista Papa-FEDEPAPA (Colombia) 3:4-6; 8-15; 18-28.

Manrique, G.G., P. Jatala, and R. Delgado de la Flor. 1990. Antagonistic effect of metabolites extracted from some exotic plants to *Globodera pallida*. Nematropica 20(1):10.

Mayorga, A. and P. Jatala. 1990. Utilization of polyacrylamide P.1 electrophoresis for

detecting differences in protein patterns of twenty *Nacobbus aberrans* populations. Nematropica 20(1):11-12.

Ñústez L., C.E., N. Estrada Ramos, and R. Martínez Becerra. 1990. Selección de híbridos de especies de papa por resistencia a *Phytophthora infestans* (Mont) De Bary, fertilidad masculina y potencial productivo. Agronomía Colombiana, Universidad Nacional de Colombia. Facultad de Agronomía. 7:3-16.

Ochoa, C.M. 1991. The Andes, cradle of the potato. Diversity 7(1/2):45-47.

Orjeda, G., R. Freyre, and M. Iwanaga, 1991. Use of *Ipomoea trifida* germplasm for Sweet potato improvement. 3: Development of 4x interspecific hybrids between *Ipomoea batatas* (L.) Lam. (2n=6x=90) and *I. trifida* (H.B. K) G. Don. (2n=2x=30) as storage-root initiators for wild species. Theoretical and Applied Genetics 83(2):159-163.

Ortiz, R., R. Freyre, S.J. Peloquin, and M. Iwanaga. 1991. Adaptation to day length and yield stability of families from 4x × 2x crosses in potato. Euphytica 56(2):187-195.

Otazu, V. and W. Amoros. 1991. Potato berry blackening and premature drop due to boron deficiency. American Potato Journal 68(12):849-856.

Pallais, N. 1991. Effects of temperature and seed moisture content during storage of true potato seed. American Potato Journal 68(9):627.

Pallais, N. 1991. Origin of the International Potato Center. HortScience 26(3): 230, 323.

Pallais, N. 1991. True potato seed: changing potato propagation from vegetative to sexual. HortScience 26(3):239-241.

Pallais, N.E., N.Y. Espinola, R.M. Falcon, and R.S. García. 1991. Improving seedling vigor in sexual seeds of potato under high temperature. HortScience 26(3):296-299.

Pérez, W., L. de Lindo, and E.R. French. 1990. Incidencia de marchiteces y pudriciones fungosas de papa en la sierra central del Perú. Fitopatología (Peru) 25(1):9.

Rhoades, R. 1991. The world's food supply at risk. National Geographic Magazine (April):74-105.

Salinas M., R., A. Gutiérrez R., R. Alvarez G., and J.H. Dodds. 1991. Regeneración de plantas a partir de embriones somáticos de camote (*Ipomoea batatas* (L.) Lam.). Agronomía (Peru) 39(1): 21-31.

Sánchez, G.E., S.A. Slack, and J.H. Dodds. 1991. Response of selected *Solanum* species to virus eradication therapy. American Potato Journal 68(5):299-315.

Sánchez, G.E., S.A. Slack, H.M. Griffiths, and J.H. Dodds. 1991. Virus elimination from heat-sensitive potato plantlets using a reduced therapy period. Phytopathology 81(10):1244.

Scott, G.J. 1991. Wall-to-wall fieldwork: some guidelines for secondary data collection in developing countries. Naga, International Center for Living Aquatic Resources Management (Philippines) 14(3):3-5.

Silva R., H., E.R. French, and J. Elphinstone. 1990. Interacción de *Erwinia carotovora* ssp. *carotovora* con especies de *Fusarium* que infectan tubérculos de cuatro cultivares de papa en el Perú. Fitopatología (Peru) 25(1):3.

Siri, C. and F. Sala de Cabrejos. 1991. CIP's Information Unit: harvesting potato and sweet potato research findings. La Unidad de Información del CIP cosecha los resultados de investigación

en papa y batata. CIP Circular, International Potato Center (Peru) 18(1):1-5.

Smit, N.E.J.M., T. Holo, and J.E. Wilson, 1991. Sweetpotato seedling test for resistance to leaf scab disease (*Elsinoe batatas*). Tropical Agriculture 68(3): 263-267.

Taja, H. and P. Vander Zaag. 1991. Organic residue management in the hot tropics: influence on the growth and yield of *Solanum* potato and maize. Tropical Agriculture 68(2):111-118.

Torres, E. and E.R. French. 1990. Cultivar BR 63.15 de papa resistente a *Pseudomonas solanacearum, Phytophthora infestans, Spongospora subterranea,* PLRV y calor. Fitopatología (Peru) 25(1):15.

Trognitz, B.R. 1991. Comparison of different pollen viability assays to evaluate pollen fertility of potato dihaploids. Euphytica 56(2):143-148.

Valkonen, J.P.T., G. Brigneti, E. Pehu, R.W. Gibson, and L.F. Salazar. 1991. Resistance in *Solanum brevidens, S. etuberosum* and *S. fernandezianum* to potato viruses. American Potato Journal 68(9):638-639.

Vargas, C.O., M. Querci, and L.F. Salazar, 1991. Identificación y estado de diseminación del viroide del "manchado solar" del palto (*Persea americana* L.) en el Perú y la existencia de otro viroide en palto. Fitopatología (Peru) 26(1): 23-27.

Rincón R, H., N.I. Vavilov, and C.M. Ochoa. 1991. Dos gigantes de la conservación de germoplasma. Agro Enfoque 7(47):4-8.

Watanabe, K., S.J. Peloquin, and M. Endo. 1991. Genetic significance of mode of polyploidization: somatic doubling on 2n gametes? Genome 34:28-34.

Watanabe, K. and S.J. Peloquin. 1991. The occurrence and frequency of 2n pollen in 2×, 4×, and 6× wild, tuber-bearing *Solanum* species from Mexico, and Central and South America. Theoretical and Applied Genetics 82(5):621-626.

Watanabe, K. and J.H. Dodds. 1991. Gene mapping to improve potatoes: tools of molecular biology expand use of CIP genetic resources. CIP Circular, International Potato Center (Peru) 18(2):1-5.

Watson, G.A. 1991. Cuellos de botella en adopción y difusión de nuevas tecnologías agropecuarias. Procampo (Bolivia) (Suppl) (Aug) pp. 1-8.

Conference Papers

Accatino, P. 1991. Colaboración entre los países y el CIP: estrategias y progresos. *In* (IBTA/CIP/COTESU) Memorias de la Reunión del Programa Nacional de la Investigación de la Papa. Cochabamba, Bolivia, Sep. 24-26, 1990. IBTA, PROINPA, Cochabamba, Bolivia. pp. 3-9.

Alcázar, J. and K.V. Raman. 1991. *Baculovirus phthorimaea* para el control biológico de la polilla de la papa, *Phthorimaea operculella* (Zeller). *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 53.

Amalin, D.M., P. Vander Zaag, and R. Aguda. 1991. Mass production of white muscardine fungus, *Beauveria bassiana* Bals. and its efficacy against sweet

potato weevil *Cylas formicarius* Fabr. Pest Management Council at the Philippines, Manila, Philippines, May 8-10. CIP, IRRI, Manila, Philippines. 1 p.

Amalin, D.M., E. Chujoy, C. Oña, and I. Oña. 1991. Stem resistance to the sweet potato weevil, *Cylas formicarius* Fabr. in synthetic 6x *Ipomoea trifida*. 7th Scientific Meeting of the Federation of the Crop Science Societies of the Philippines, Quezon City, Philippines, Nov 7-9. CIP, Manila, Philippines. 1 p.

Amorós, W., M. Ato, and H.A. Mendoza. 1991. Selección y evaluación de clones para procesamiento. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 67.

Anguiz, R., H. Mendoza, and H. El-Nashaar. 1991. Habilidad combinatoria general (HCG) y específica (HCE) para resistencia a la marchitez bacteriana (*Pseudomonas solanacearum*) en papa. (ibid) p. 70.

Arbizu, C., A. Calderón, R. Castillo, P. Cruz, R. Estrada, M. Hermann, C. Nieto, A. del Río, J. Tello, J. Toledo, and U. Jayasinghe, 1991. Avances de los trabajos colaborativos del Centro Internacional de la Papa (CIP) en raíces y tuberosas andinas. 7mo. Congreso Internacional de Cultivos Andinos, La Paz, Bolivia. Feb. 4-8. CIP, Lima, Peru. 41 p.

Arbizu, C., M. Jackson, P. Schmiediche, M. Querci, L. Salazar, and K. Watanabe. 1991. Estudios preliminares sobre la resistencia genética al viroide del tubérculo ahusado (PSTVd). *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 75.

Arcos, J. and M. Canto. 1991. Interacción entre *Nacobbus aberrans* y *Globodera pallida*. (ibid) p. 84.

Aromin, F.B., B.S. Malab, and P.A. Batugal. 1991. A review of the Philippine lowland potato program. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 38-39.

Beaufort-Murphy, H. 1991. Respuesta de floración de clones parentales seleccionados de semilla sexual de papa bajo un rango de condiciones controladas de iluminación. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 64.

Benavides, M. and H. Fano. 1991. Metodología para comprender costumbres y preferencias alimentarias. In G.J. Scott, and J.E. Herrera (eds.) Mercadeo agrícola: Metodologías de investigación. Taller Latinoamericano sobre Métodos para Estudiar la Comercialización Agrícola, Lima, Peru, June 11-13, 1990. IICA/CIP, Lima, Peru. pp. 43-56.

Berrios M., D. and A. Rubirigi, 1991. Evaluation et selection du germoplasme pour la resistance a la bacteriose vasculaire: cas Burundi. Cours de Formation sur la Gestion du Germoplasme, Bukavu, Zaire, June 9-14. ISABU/CIP, Bujumbura, Burundi. 7 p.

Bertschinger, L., C. Gessler, E.F. Keller, F. Ezeta, E. Franco, and A. Hidalgo. 1991. Epidemiología de virus de papa en diferentes zonas agroecológicas del Perú. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 90.

Brown, K.J. 1991. Can increasing productivity be compatible with sustainable production. *In* L.J.C. Autrey, et al. (eds.) Proceedings of the 2nd triennial meeting of African Potato Association, Réduit, Mauritius. pp. 161-164.

Cabello, R., J. Alcázar, K.V. Raman, and S. Wiersema. 1991. Efecto del enfriamiento del almacén de papa para consumo sobre el peso de tubérculos y el daño por la polilla de la papa *Phthorimaea operculella* Zeller en los trópicos. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 53.

Cabello, R., D. Berríos, J. Bryan, and P. Malagamba. 1991. Evaluación de progenies avanzadas de semilla botánica de papa. (ibid) p. 109.

Calúa, L. and J. Landeo. 1991. Aptitud combinatoria general para resistencia a tizón tardío (*Phytophthora infestans*) y rendimiento en papa. (ibid) p. 67.

Canto-Sáenz, M., A. Matos, and A. Gonzáles. 1991. Importancia del material resistente y tolerante generado en el CIP para el control del nematodo quiste de la papa. (ibid) p. 84.

Carli, C. 1991. Applied potato research with special reference to the seed potato production. Workshop on Review of Seed Potato Technology and Distribution Systems in East and Central Africa, Nairobi, Kenya, May 27-31. CIP Region III, Nairobi, Kenya. 5 p.

Carli, C. 1991. Examples of seed potato multiplication schemes. (ibid) 4 p.

Carli, C. 1991. Traditional seed potato production methods versus the adoption of innovative technologies. (ibid) 7 p.

Carli, C. and P.K. Njoroge. 1991. The utilization of rapid multiplication techniques for potato basic seed production in Kenya. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial meeting of the African Potato Association. APA, Réduit, Mauritius. pp. 51-58.

Castillo, R. and M. Hermann. 1991. Andean root and tuber crops: a case study. Instituto Nacional de Investigaciones Agropecuarias, Quito, CIP, Ecuador. 8 p.

Cañedo, V. and K.V. Raman. 1991. Servicio de identificación de insectos y ácaros en el Centro Internacional de la Papa. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 50.

Chujoy, E., F. Aquino, L. Duna, and A. Tumapon. 1991. Field screening of potato genetic material for resistance to *Pseudomonas solanacearum* in Mindanao, Philippines. *In* Proceedings of the 3rd triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 120-121.

Chujoy, E. and K. Hoang. 1991. Sweet potato genetic resources in Vietnam. *In* Sweet potato cultures of Asia and South Pacific: proceedings. 2nd Annual UPWARD International Conference, Laguna, Philippines, Apr. 2-5. UPWARD, Los Baños, Philippines. pp. 89-96.

Collins, W.W. and Mendoza, H.A. 1991. Breeding sweet potato for weevil resistance: future outlook. *In* R.K. Jansson, K.V. Raman (eds.) Sweet potato pest management: a global perspective. Westview Press, Boulder, CO, USA. pp. 399-406.

Corzo C, P., O.A. Hidalgo, and L. Luján. 1991. Análisis de la situación de la producción de tubérculos-semillas en Colombia. Bogota, Colombia. 49 p.

Corzo, C.P., O. Hidalgo, and C. Sánchez de Luque. 1991. Comparación de muestras de tubérculos-semillas certificada y común del agricultor en Colombia. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 104.

Crisci, C., F. Vilaro, and O. Hidalgo. 1991. Efecto de la infección secundaria de PLRV y PVY sobre el rendimiento del cultivo de la papa en el Uruguay. (ibid) p. 89.

Crissman, C.C. 1991. Análisis comparativo de sistemas de producción y distribución de semilla de papa. *In* Aspectos tecnológicos del cultivo de papa en el Ecuador. Documento Técnico No. 4. FUNDAGRO. Quito, Ecuador. pp. 27-58.

Cruz, P. and M. Hermann. 1991. Manipulaciones promisorias para una mayor obtención de semilla botánica en ulluco (*Ullucus tuberosus*). *In* 7mo. Congreso internacional sobre cultivos andinos: resúmenes, La Paz, Bolivia, Feb. 4-8. Instituto Boliviano de Tecnología Agropecuaria, CIID, La Paz, Bolivia. p. 54.

De la Puente, F., A. Boy, M. Lenscak, and M. Elechosa. 1991. Exploración, recolección, conservación y evaluación de recursos genéticos de la batata (*Ipomoea batatas* (L.) Lam.) en la república Argentina. INTA, CIP, Mar del Plata, Argentina. 17 p.

De la Puente, F., J. Díaz, and D.F. Austin. 1991. Desarrollo de un banco de germoplasma de camote o batata [*Ipomoea batatas* (L.) Lam.] en el CIP. 2do. Simposio Latinoamericano sobre Recursos Genéticos de Especies Hortícolas, Mar del Plata, Argentina, Sep. 22-25. CIP, Lima, Peru. 15 p.

Del Río, A. and M. Hermann. 1991. Polimorfismo isoenzimático en oca (*Oxalis tuberosa*). *In* 7mo. Congreso internacional sobre cultivos andinos: resúmenes, La Paz, Bolivia, Feb. 4-8. Instituto Boliviano de Tecnología Agropecuaria, La Paz, Bolivia. p. 58.

Demonteverde, V., D. Simongo, G. Opeña, T. Gerpacio, R. Muyco, and E. Chujoy. 1991. Potato germplasm evaluation using apical cuttings. 7th Scientific Meeting of the Federation of the Crop Science Societies of the Philippines, Quezon City, Philippines, Nov. 7-9. CIP, Manila, Philippines. 1 p.

Destéfano Beltrán, L., P.G. Nagpala, J. Kim, J.H. Dodds, and J.M. Jaynes. 1991. Use of synthetic genes to enhance nutritional quality and disease resistance in plants: application to potato. *In* Molecular methods for potato improvement. Application of Molecular Techniques to Potato Germplasm Enhancement, Lima, Peru, Mar. 5-9, 1990. CIP, Lima, Peru. pp. 49-64.

Dodds, J.H. 1991. Application of molecular methods at CIP, potato improvement through gene identification and gene transfer. *In* Molecular methods for potato improvement. Application of Molecular Techniques to Potato Germplasm Enhancement, Lima, Peru, Mar. 5-9 1990. CIP, Lima, Peru. pp. 45-48.

Dodds, J.H., C. Merzdorf, V. Zambrano, and C. Sigüeñas, and J.M. Jaynes. 1991. Potential use of Agrobacterium-mediated gene transfer to confer insect resistance in sweet potato. *In* R.K. Jansson, K.V. Raman (eds.) Sweet potato pest management: a global perspective. Westview Press, Boulder, CO, USA. pp. 203-219.

El-Nashaar, H.M. and L. de Lindo. 1991. Reacción de esquejes de papa generados a partir de yemas axilares a la infección por *Pseudomonas solanacearum*. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 41.

Espinola, N. and N. Pallais. 1991. Hidratación parcial de la semilla sexual de papa en una solución osmótica para aumentar su vigor durante la germinación.

In Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 103.

Estrada, N. 1991. Mejoramiento genético de la papa en los andes: prospectos y estrategias para Bolivia. *In* (IBTA, CIP, and COTESU) Memorias de la Reunión del Programa Nacional de la Investigación de la Papa. Held in Cochabamba, Bolivia, Sep. 24-26, 1990. IBTA, PROINPA, Cochabamba, Bolivia. pp. 11-13.

Ewell, P.T. and J. Mutuura. 1991. User's perspectives on potatoes and sweet potatoes: Challenges for interdisciplinary research. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial meeting. African Potato Association, Reduit, Mauritius. p. 189. (Poster).

Ezeta, F. 1991. Perspectivas de investigación de la papa en Puno durante la década de 1990. *In* L. Argüelles, R.D. Estrada (eds.) Perspectivas de la investigación agropecuaria para el Altiplano. INIAA, PISA, and CIID. pp. 273-284.

Fabres, F., J. Santos Rojas, and P. Accatino, 1991. Producción y uso de semilla botánica de papa: un video de televisión. *In* Programa y Compendios. 15a. Reunión de ALAP. Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 101.

Falcón, R. 1991. Efecto del pesticida methamidophos (tamaron) sobre la viabilidad de polen y la calidad de la semilla sexual de papa. (Es). (ibid) p. 102.

Franco, J. 1991. Estrategias para el manejo integrado del *Naccobus aberrans* (Thorne, 1935), Thorne & Allen 1944. *In* (IBTA, CIP, and COTESU) Memorias de la Reunión del Programa Nacional de la Investigación de la Papa. Held in Cochabamba, Bolivia, Sep. 24-26, 1990. IBTA, PROINPA, Cochabamba, Bolivia. pp. 15-27.

Franco, J., A. Gonzáles, and A. Matos. 1991. Desarrollo de *Nacobbus aberrans* en platos de petri: una alternativa para el tamizado por resistencia en *Solanum tuberosum*. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14, 1991. ALAP, Lima, Peru. p. 84.

Gass, T., C. Martin, and J. Lekunze. 1991. Aphid population monitoring at two locations in the North Western highlands of Cameroon. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial meeting of APA. African Potato Association, Réduit, Mauritius. pp. 107-110.

Gastelo, M., E. Roncal, and J. Landeo. 1991. Canchán-INIAA: una nueva variedad de papa para el Perú con resistencia de campo al tizón tardío. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14, 1991. ALAP, Lima, Peru. p. 69.

Gavilano, L. and K.V. Raman. 1991. Estudio de las proteínas totales de la polilla de la papa por electroforesis. (ibid) p. 52.

Gerpacio, M.T.L., G.B. Opeña, A.L. Demagante, and P. Vander Zaag. 1991. Growth and yield analysis of sweet potato under photoperiods. 7th Scientific Meeting of the Federation of the Crop Science Societies of the Philippines, Quezon City, Philippines, Nov. 7-9. CIP, Manila, Philippines. 1 p.

Golmirzaie, A.M., H.A. Mendoza, R. Vallejo, J. Espinoza, and F. Serquén. 1991. Breeding potatoes for warm tropics. *In* N. Govinden, M.H.R. Julien, G.L.T. Hunt, L.J.C. Autrey (eds.) Production, post-harvest technology and utilization of potato in the warm tropics. From the meeting held in Réduit,

Mauritius, July 23-27, 1990. Mauritius Sugar Industry Research Institute, Réduit, Mauritius. pp. 12-21.

Golmirzaie, A.M., J. Tenorio, and F. Serquén. 1991. Organelle transfer (mitochondria) for the production of cybrid potatoes and their possible use as TPS parental lines. *In* Molecular methods for potato improvement. Application of Molecular Techniques to Potato Germplasm Enhancement. From the meeting held in Lima, Peru, Mar. 5-9, 1990. CIP, Lima, Peru. pp. 121-128.

Golmirzaie, A.M., J. Tenorio, and F. Serquén. 1991. Evaluación de progenies provenientes de esquemas de apareamiento 4x-4x y 4x-2x en una población de semilla sexual. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14 1991. ALAP, Lima, Peru. p. 71.

Gómez, R.A., Z. Huamán, and M. Palacios. 1991. Selección de cultivares nativos de papa con resistencia al gorgojo de los Andes (*Premnotrypes* spp.). (ibid) p. 154.

González, A., J. Franco, and A. Matos. 1991. Evaluación de resistencia de la papa a *Globodera pallida*, en la prueba en platos de petri. (ibid) p. 82.

Hayward, A.C., L. Sequeira, E.R. French, H. El-Nashaar, and U. Nydegger. 1991. Variante tropical del biovar 2 de *Pseudomonas solanacearum*. (ibid) p. 92.

He, W., Q. Meng, and V.E. Demonteverde. 1991. A survey on potato viruses in Sichuan, China. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 7-8.

Hermann, M. 1991. Andean roots and tubers: research priorities for a neglected food resource. (in Spanish and English) CIP Seminar held in Lima, Peru. CIP, Lima, Peru. 30 p.

Hermann, M. 1991. La exploración de los recursos genéticos de tubérculos y raíces andinas: una nueva iniciativa del Centro Internacional de la Papa (CIP). 2do. Simposio Latinoamericano sobre Recursos Genéticos de Especies Hortícolas. Held in Mar del Plata, Argentina. CIP, Quito, Ecuador. 1 p.

Hermann, M., C. Nieto, R. Castillo, and A. del Río. 1991. Identificación de duplicados clonales con descriptores morfológicos e isoenzimáticos en la colección de melloco (*Ullucus tuberosus*) del Ecuador. *In* 7mo. Congreso internacional sobre cultivos andinos: Resúmenes. La Paz, Bolivia, Feb. 4-8. IBTA, CIID, La Paz, Bolivia. p. 56.

Hermann, M. and C. Arbizu. 1991. Perspectivas de un banco de germoplasma internacional de tubérculos y raíces andinas en el CIP. (ibid) p. 55.

Hernández, E., E. Wissar, and H. Mendoza. 1991. Parámetros genéticos de los factores de calidad para procesamiento en papas autotetraploides. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 68.

Herrera, J. and G. Scott. 1991. Sistemas de comercialización rural en América Latina: El caso de la semilla de papa en los países del área andina. (ibid) p. 45.

Hidalgo, O.A., J.L. Zapata, B. Eldredge, and A. García. 1991. Consideraciones sobre un programa para analizar datos de campo del tizón tardío (*Phytophthora infestans*) y correlaciones entre los valores resultantes. (ibid) p. 94.

Horton, D.E. and P.T. Ewell. 1991. Sweet potato pest management: a social science perspective. *In* R.K. Jansson,

K.V. Raman, (eds.) Sweet potato pest management: a global perspective. Westview Press, Boulder, CO, USA. pp. 407-427.

Hu, Q., J. Wang, B.F. Song, and P. Vander Zaag. 1991. Potato germplasm evaluation for adaptation, resistance to *Phytophthora infestans* and yield in Yunnan, China. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. p. 112.

Huamán, Z. 1991. Electrophoretic characterization of potato germplasm at CIP. *In* Molecular methods for potato improvement. Application of Molecular Techniques to Potato Germplasm Enhancement. From the meeting held in Lima, Peru, March 5-9, 1990. CIP, Lima, Peru. pp. 129-134.

Huamán, Z., E. French, C. Aguilar, and L. de Lindo. 1991. Avances en el mejoramiento para resistencia a pudrición blanda (*Erwinia chrysanthemi*) en papa. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 93.

Huanco, V., J. Landeo, and H.A. Mendoza. 1991. Estudio de tipo de acción génica para resistencia a heladas en clones tetraploides de papa. (ibid) p. 72.

Huang, X., C. Li, Q. Meng, V.E. Demonteverde, J. Wang, and P. Vander Zagg. 1991. An assessment of the indigenous seed potato production systems in Yunnan province, China. *In* Proceedings of the 3rd triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 469-475.

Hunt, G.L.T. 1991. Low cost potato storage and processing. *In* N. Govinden, M.H.R. Julien, G.L.T. Hunt, L.J.C. Autrey (eds.) Production, postharvest technology and utilization of potato in the warm tropics, Réduit, Mauritius, July 23-27, 1990. Mauritius Sugar Industry Research Institute, Réduit, Mauritius. pp. 82-85.

Jansson, R.K. and K.V. Raman. 1991. Sweet potato pest management: a global overview. In R.K. Jansson, K.V. Raman (eds.) Sweet potato pest management: a global perspecti ve. Westview Press, Boulder, CO, USA. pp. 1-12.

Jansson, R.K., K.V. Raman, and O.S. Malamud. 1991. Sweet potato pest management, Future outlook. *In* R.K. Jansson, K.V. Raman (eds.) Sweet potato pest management: a global perspective. Westview Press, Boulder, CO, USA. pp. 429-437.

Jatala, P. 1991. Biology and management of plant-parasitic nematodes on sweet potato. (ibid) pp. 359-378.

Jatala, P. 1991. Reniform and false root-knot nematodes, *Rotylenchulus* and *Nacobbus* spp. *In* W.R. Nickle (ed.) Manual of agricultural nematology. Marcel Dekker, New York, NY, USA. pp. 509-528.

Jatala, P., H.M. Niemeyer, G. Manrique, and S.V. Copaja. 1991. Relación entre contenido de glicoalcaloides y la resistencia a *Meloidogyne incognita* en papa. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 81.

Jatala, P. and L. Gavilano. 1991. Estudio electroforético de los patrones proteícos de los huevos de *Globodera pallida* y *G. rostochiensis*. (ibid) p. 82.

Jatala, P., K. Watanabe, and E. Guevara. 1991. Evaluación, selección y utilización de resistencia al nematodo del

nódulo de la raíz *Meloidogyne incognita*. (ibid) p. 81.

Kanzikwera, R., M. Mukandutiye, J. Komayombi, and L.C. Sikka. 1991. True potato seed development in Uganda. *In* N. Govinden, M.H.R. Julien, G.L.T. Hunt, L.J.C. Autrey (eds.) Production, postharvest technology and utilization of potato in the warm tropics. From the meeting held in Réduit, Mauritius, July 23-27, 1990. Mauritius Sugar Industry Research Institute, Réduit, Mauritius. pp. 39-44.

Kidane-Mariam, H.M. and S. Nganga. 1991. Progress in potato germplasm utilization in tropical Africa. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial meeting of APA. African Potato Association, Réduit, Mauritius. pp. 47-48.

Kihurani, A.W., R.W. Gatumbi, and L.G. Skoglund. 1991. Storage diseases of sweet potato (*Ipomoea batatas* L.) in Kenya. 9th Symposium of the ISTRC, Accra, Ghana, Oct. 21-28. NARL; CIP, Nairobi, Kenya. 5 p.

Lee, D., A. Guarderas, and G. Scott. 1991. La integración del análisis de la demanda de alimentos y la comercialización agrícola en la formulación de políticas alimentarias: Estudio de un caso ecuatoriano. *In* G.J. Scott, J.E. Herrera (eds.) Mercadeo agrícola: metodologías de investigación. Taller Latinoamericano sobre Métodos para Estudiar la Comercialización Agrícola. Perú, June 11-13, 1990. CIP; IICA, Lima, Perú. pp. 164-182.

Lizárraga, A. and N. Mujica. 1991. Recuperación de endoparasitoides para el control de la mosca minadora *Liriomyza huidobrensis* B. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 54.

Lizárraga, R. 1991. Conservación ex situ de especies de propagación vegetativa: Método in vitro. *In* R. Castillo, T.J. Estrella E., C. Tapia B. (eds.) Técnicas para el manejo y uso de los recursos fitogenéticos. 1er. Curso Internacional de Entrenamiento sobre Recursos Fitogenéticos. INIAP, Departamento de Recursos Fitogenéticos, Quito, Ecuador. pp. 97-103.

Lopes, C., J.A. Buso, P. Schmiediche, and P. Accatino. 1991. Potato germplasm evaluation for bacterial wilt resistance: present status of the CNPH/EMBRAPA-CIP research contracts. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 70.

Malagamba, P. 1991. Sistemas de uso de semilla sexual de papa para diferentes ambientes. Taller de Semilla Sexual de Papa en Latinoamérica, en Lima, Peru, Sep. 5-7. CIP, Lima, Peru. 4 p.

Malagamba, P., J. Bryan, and R. Cabello. 1991. Producción de semilla híbrida de papa en condiciones de trópico. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 109.

Malagamba, P. and R. Cabello. 1991. Producción de semilla sexual en diferentes ambientes. Taller de Semilla Sexual de Papa en Latinoamérica, Lima, Peru, Sep. 5-7. CIP, Lima, Peru. 2 p.

Malamud, O. 1991. Colaboración con PRECODEPA y los Programas Nacionales de Centroamérica y el Caribe: un análisis. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 44.

Manrique Klinge, K. and F. de la Puente. 1991. El CIP y los recursos genéticos. Curso-Taller CIED, Arequipa, Peru, Dec. 10-12. CIP, Lima, Peru. 4 p.

Mariano, J.S., V.E. Demonteverde, J. Pérez, and P. Vander Zaag. 1991. Viruses: Have we exaggerated their significance? *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. p. 6.

Martin, C., T. Gass, and D. Njualem. 1991. Evaluation of potato germplasm for conditions of North-Western Cameroon. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial meeting of the African Potato Association. APA, Réduit, Mauritius. pp. 31-36.

Maza, N., C. Barrera, P. Malagamba, and L.F. Salazar. 1991. Resultados preliminares en transmisión de PSTVd y PVT a través de semilla sexual de papa. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 64.

Mehra, S.K. and M.D. Upadhya. 1991. Strategies for village level processing of potatoes in India. *In* Proceedings: symposium on developments in potato processing and storage in Asia. Meeting held in Bandung, Indonesia, June 17-18. Asian Potato Association, Bandung, Indonesia. pp. 64-67.

Mendoza, A. and H.A. Mendoza. 1991. Producción de papa con tolerancia al calor en la zona del Alto Huallaga, Huánuco-Perú. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 69.

Mendoza, H., R. Chávez, J. Espinoza, N. Arévalo, and L. Díaz. 1991. Avances en el mejoramiento genético de papa para zonas áridas-salinas. (ibid) p. 67.

Midmore, D.J., I.J. Ekanayake, J.S. Benz, and F.V. Payton. 1991. Contribution of recent physiological studies to the improvement of potato production in warm climates. *In* N. Govinden, M.H.R. Julien, G.L.T. Hunt, L.J.C. Autrey, (eds.) Production, postharvest technology and utilization of potato in the warm tropics. From the meeting held in Réduit, Mauritius, July 23-27, 1990. Mauritius Sugar Industry Research Institute, Réduit, Mauritius. pp. 45-52.

Mok, I.J. and H.M. Cho. 1991. Induction of haploid through parthenogenesis in potatoes. 2: Markers for selection of haploids. *In* Proceedings of the 3rd triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 101-102.

Morales, C., G. Watson, and J. Bustamante. 1991. Relación entre problemas agro-socio-económicos y rendimientos. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 44.

Moreno, U. 1991. Impacto del fotoperíodo en la floración y otros procesos morfogenéticos de plantas de papa. (ibid) p. 61.

Muyco, R. and E. Chujoy. 1991. Selection of potato clones and parents with long tuber storability. 7th Scientific Meeting of the Federation of the Crop Science Societies of the Philippines, Quezon City, Philippines, Nov. 7-9. CIP, Manila, Philippines. 1 p.

Muyco, R. and E. Chujoy. 1991. Selection of potatoes for long storability. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 128-129.

Nganga, S. 1991. Strategy for CIP Region III collaboration with NARS for potato and sweet potato research and development. *In* N. Govinden, M.H.R. Julien,

G.L.T. Hunt, L.J.C. Autrey (eds.) Production, post-harvest technology and utilization of potato in the warm tropics. From the meeting held in Réduit, Mauritius, July 23-27, 1990. Mauritius Sugar Industry Research Institute, Réduit, Mauritius. pp. 7-10.

Nguyen, T.D., S.P. Milagrosa, E. Chujoy, J.S. Luis, J.C. Pérez, and P. Vander Zaag. 1991. Powdery scab (*Spongospora subterranea*) of white potato: survey, screening for resistance and control. 7th Scientific Meeting of the Federation of the Crop Science Societies of the Philippines, Quezon City, Philippines, Nov. 7-9. CIP, Manila, Philippines. 1 p.

Njualem, D., C. Martin, and C. Ntonifor. 1991. Evaluation of seedling-tubers for potato production in the North-Western highlands of Cameroon. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial meeting of the APA. Meeting held in Réduit, Mauritius. African Potato Association, Reduit, Mauritius. pp. 65-69.

Noel, G.R., P. Jatala, and J. Franco. 1990. Screening for resistance to cyst nematodes, *Globodera* and *Heterodera* species. *In* J.L. Starr, (ed.) Methods for evaluating plant species for resistance to plant-parasitic nematodes. The Society of Nematologists, Maryland, USA. pp. 24-32.

Ntonifor, C., C. Martin, and D. Njualem. 1991. Studies on seed potato storage under different conditions in the northwestern Cameroon. *In* N. Govinden, M.H.R. Julien, G.L.T. Hunt, L.J.C. Autrey (eds.) Production, postharvest technology and utilization of potato in the warm tropics. Meeting held in Réduit, Mauritius, July 23-27, 1990. Mauritius Sugar Industry Research Institute, Réduit, Mauritius. pp. 92-96.

Núñez, M.A., F. de la Puente, and R. Cerrato. 1991. El camote (*Ipomoea batatas* (L.) Lam) un cultivo etnobotánico de gran variabilidad en el litoral Atlántico de Honduras. Ministerio de Recursos Naturales, Tegucigalpa, Honduras. 8 p.

Oña, I. and E. Chujoy. 1991. Shade tolerance of some sweet potato clones intercropped with corn. 7th Scientific Meeting of the Federation of the Crop Science Societies of the Philippines, Quezon City, Philippines Nov. 7-9. CIP, Manila, Philippines. 1 p.

Opeña, G., A.L. Demagante, M.T.L. Gerpacio, and P. Vander Zaag. 1991. Response of sweet potato to shading during various growth stages. (ibid) 1 p.

Otazú, V. and P. Aley. 1991. Manejo de la marchitez bacteriana en terrenos experimentales de papa de uso intensivo. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 92.

Pacheco, M.A. and J. Landeo. 1991. Avances en la selección de clones de papa resistentes a la rancha (*Phytophthora infestans*) en las zonas paperas del Cusco. (ibid) p. 95.

Palacios, M. and K.V. Raman. 1991. Resistencia a insectos y ácaros en el cultivo de papa. (ibid) p. 51.

Pallais N. 1991. New developments in TPS technology. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. p. 27.

Pallais, N. and R. Falcón. 1991. Importancia del contenido de humedad de la semilla sexual de papa para su almacenamiento en los países tropicales. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 102.

Parker, B.L., G.L.T. Hunt, and A. Mzingirwa. 1991. Low altitude storage trials with natural plant materials for pest management. *In* N. Govinden, M.H.R. Julien, G.L.T. Hunt, L.J.C. Autrey (eds.) Production, postharvest technology and utilization of potato in the warm tropics. Meeting held in Réduit, Mauritius, July 23-27, 1990. Mauritius Sugar Industry Research Institute, Réduit, Mauritius. pp. 97-102.

Pham, X.T., J.G.T. Hermsen, P. Vander Zaag, and P. Schmiediche. 1991. Resistance to *Pseudomonas solanacearum* in potato: effect of heat-tolerance on expression of resistance. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22, 1991. Asian Potato Association, Bandung, Indonesia. pp. 123-124.

Potts, M.J. 1991. Is the potato sustainable in Asian cropping systems? (ibid) pp. 54-55.

Prain, G. 1991. El estudio de un sistema "informal": el caso de la semilla de papa. *In* G.J. Scott, J.E. Herrera (eds.) Mercadeo agrícola: metodologías de investigación. Taller Latinoamericano sobre Métodos para Estudiar la Comercialización Agrícola. Meeting held in Lima, Peru, June 11-13, 1990. CIP, IICA, Lima, Peru. pp. 114-136.

Prain, G. and H. Fano Rodríguez. 1991. Sweet potato in the food systems of Latin America and the Caribbean. *In* Sweet potato cultures of Asia and South Pacific: proceedings. 2nd Annual UPWARD Conference. Meeting held in Laguna, Philippines, April 2-5. Los Baños, Philippines. pp. 28-32.

Querci, M., I. Bartolini, L.F. Salazar, and E.N. Fernández-Northcote. 1991. Detección de los serotipos PVXA y PVX0 por hibridación de ácidos nucleicos utilizando una sonda recombinante de amplio espectro. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 89-90.

Raman, K.V. 1991. Estrategias para la investigación en manejo de las plagas de la papa en el año 2000. (ibid) p. 48.

Raman, K.V. and E.H. Alleyne. 1991. Biology and management of the West Indian sweet potato weevil, *Euscepes postfasciatus*. *In* R.K. Jansson, K.V. Raman (eds.) Sweet potato pest management: a global perspective. Boulder (USA). Westview Press, Boulder, CO, USA. pp. 263-281.

Recharte, J., E. Franco, and R. Wissar. 1991. Recursos campesinos locales para la multiplicación y distribución de semilla de calidad en medioambientes de montaña: experiencias y modelos del Proyecto SEINPA. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 46.

Reifschneider, F., P. Accatino, and H. Rincón (eds.). 1991. Twelve years of cooperation for the technological development of potato (*Solanum tuberosum*) production. (also in Portuguese and Spanish) CNPH, Brasilia, Brasil; CIP, Lima, Peru. 14 p.

Roca, J.L., D. Midmore, and M. Palacios. 1991. Respuesta fisiológica de la papa al ataque de la mosca minadora (*Liriomyza huidobrensis*). *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 60.

Roncal, E., M. Gastelo, M. Figueroa, J. Landeo, and L. Calúa. 1991. Impacto de la evaluación y selección para resistencia al tizón tardío de la papa en campo de agricultores. (ibid) pp. 68-69.

Roy, S.K. and M.D. Upadhya 1991. The role of village level processing in meeting the demand for potato products. *In* Proceedings: symposium on developments in potato processing and storage in Asia. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 68-78.

Rueda, J.L., A. Autrique, P. Pozy, and C. Bweyo. 1991. El uso de una encuesta de visita única en la formulación de programas de control integrado de la marchitez bacteriana en campos de agricultores. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 41.

Rueda, J.L., P. Pozy, C. Muvira, Z. Nzoyihera, C. Turner, and E. Niyongabo. 1991. The development and acceptance of potato seed production under farmer conditions in Burundi. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial APA meeting. African Potato Association, Réduit, Mauritius. pp. 71-76.

Rueda, J.L., D. Simeya, and P.M. Harris. 1991. Control integrado de la marchitez bacteriana en producción de semilla de papa en Africa Central. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 107.

Sala, F. 1991. Sur les problemes de la diffusion de l'information agricole. Le cas du Centre International de la Pomme de Terre: une évaluation. Université Paris-Nord. U.F.R. des Sciences de la Communication (France) Mémoire (M.S.T., Communication). Paris, France. 81 p.

Salazar, L.F. 1991. Detección de viroides y virus con técnicas de ADN recombinante. *In* W.M. Roca, L.A. Mroginski (eds.) Cultivo de tejidos en la agricultura: fundamentos y aplicaciones. CIAT, Cali, Colombia. pp. 877-885.

Sánchez de Luque, C., O.A. Hidalgo, and L.F. Salazar. 1991. Producción y sensibilización de antisueros para diagnóstico de virus de papa y su distribución a países de la zona andina. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 88.

Santos Rojas, J., N. Pallais, J. Kalazich, P. Malagamba, and P. Accatino. 1991. Desarrollo de la tecnología para producir comercialmente semilla botánica de papa. Colaboración CIP-INIA, Chile. (ibid) p. 101.

Sawyer, R.L. 1991. Programming the potato to serve a changing world. *In* L.J.C. Autrey, et al. (eds.) Proceedings of the 2nd triennial APA meeting. African Potato Association, Réduit, Mauritius. pp. 15-19.

Sawyer, R.L. 1991. The opportunities created by change. *In* Food for the future: a new chapter in Peruvian agriculture. CIP, Lima, Peru. 17 p.

Scott, G. and J. Herrera. 1991. Factores limitantes en la producción y uso de la papa: resultados de la encuesta a los Programas Nacionales en América Latina. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 43.

Scott, G. and J. Herrera. 1991. Tendencias en la producción y uso de la papa en América Latina: un análisis comparativo. (ibid) p. 33.

Scott, G.J. 1991. A pilot market information system for potatoes in developing countries The Peruvian experience. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial APA meeting. African Potato Association, Réduit, Mauritius. p. 192. (Poster)

Scott, G.J. 1991. CIP's mission and molecular techniques for germplasm enhancement: some strategic considerations for future impact. *In* Molecular methods for potato improvement. Application of Molecular Techniques to Potato Germplasm Enhancement. Meeting held in Lima, Peru, March 5-9, 1990. CIP, Lima, Peru. pp. 12-22.

Scott, G.J. 1991. Potatoes in the food systems of sub-saharan Africa: present patterns and future prospects. *In* N. Govinden, M.H.R. Julien, G.L.T. Hunt, L.J.C. Autrey (eds.) Production, postharvest technology and utilization of potato in the warm tropics. Meeting held in Réduit, Mauritius, July 23-27, 1990. Mauritius Sugar Industry Research Institute, Réduit, Mauritius. pp. 122-129.

Scott, G.J. 1991. La investigación de mercadeo agrícola y los institutos nacionales de investigación agrícola. *In* G.J. Scott, J.E. Herrera, (eds.) Mercadeo agrícola: metodologías de investigación. Taller Latinoamericano sobre Métodos para Estudiar la Comercialización Agrícola, Lima, Peru, June 11-13, 1990. CIP; IICA, Lima, Peru. pp. xvii-xxx.

Scott, G.J. 1991. Desarrollo de productos para procesamiento rústico: métodos de investigación socioeconómica. (ibid) pp. 207-239.

Scott, G.J. 1991. Preparación, corrección y difusión: tres claves para el éxito de un informe de investigación. (ibid) pp. 471-482.

Scott, G.J. 1991. Trabajo de campo entre cuatro paredes: recopilación de información secundaria para la investigación sobre sistemas alimentarios. (ibid) pp. 307-341.

Simongo, D.K., V.E. Demonteverde, P. Tandang, P. Vander Zaag, and E. Chujoy. 1991. Assessment of potato clones using apical cuttings by farmers in Benguet. 7th Scientific Meeting of the Federation of the Crop Science Societies of the Philippines, Quezon City, Philippines, Nov. 7-9. Northern Philippines Root Crop Research and Training Center, Benguet, Philippines. 1 p.

Siri, C. 1991. The International Potato Center (CIP): communications and information systems for national potato and sweet potato programs. *In* L.J.C. Autrey et al. (eds.) Proceedings of the 2nd triennial APA meeting. African Potato Association, Réduit, Mauritius. pp. 179-186.

Siri, C. 1991. El papel de la información en el pasado, presente y futuro de la investigación en papa en América Latina. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 41.

Skoglund, L.G., R.W. Gatumbi, and A.W. Kihurani. 1991. Results of a survey on non-viral pathogens and disorders of sweet potato in Kenya. 9th Symposium of the ISTRC, Accra, Ghana, Oct. 21-28. NARL; CIP, Nairobi, Kenya. 6 p.

Song, B.F., X. Gong, and G. Wang. 1991. Screening of TPS progenies for virus resistance. *In* Proceedings of the third triennial conference: Plenary papers and abstracts. Held in Bandung, Indonesia, June 17-22, 1991. Asian Potato Association, Bandung, Indonesia. pp. 116-117.

Song, B.F., H. Yang, M. Fan, Z. Yan, G. Wang, and E. Chujoy. 1991. Evaluation of potato varieties for drought tolerance in northwest China. (ibid) pp. 113-115.

Stegemen, H., A.A. Shah, R. Estrada, M. Galvez, N. Hilschman, L. Schilde, Z. Huaman, P. Schmiediche, S.C.S. Tsou, and R. Wilckens. 1990. Protein-, Esterase- und DNA-Fragment-Muster von Süsskartoffeln und hochandinen

Knollenfruchten (*Ipomoea batata, Oxalis tuberosa, Tropaeolum tuberosum, Ullucus tuberosus*) aus Genbanken des CIP (International Potato Center), und des AVRDC (Asian Vegetable Research and Development Center). (De). *In* Biologische Bundesanstalt für und Forstswirtschaft. Jahresbericht, Braunschweig, Germany. p. 86.

Tantidham, K., W. Panuampai, P. Jirathana, and S.G. Wiersema. 1991. Evaluation of potato clones for processing and consumption quality in Thailand. *In* Proceedings: symposium on developments in potato processing and storage in Asia. Held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 82-96.

Tello, J., M. Hermann, and A. Calderón. 1991. La maca (*Lepidium meyenii* Walpers) cultivo alimenticio potencial para las zonas altoandinas. *In* 7mo. Congreso internacional sobre cultivos andinos: resúmenes. Held in La Paz, Bolivia, Feb. 4-8. Instituto Boliviano de Tecnología Agropecuaria, La Paz, Bolivia. p. 57.

Torres, H. and M.A. Pacheco. 1991. "Gabriela" y "Esperanza" dos cultivares de papa, resistentes a roña (*Spongospora subterranea*). *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 96.

Trinca, S., C. de Pace, R. Caccia, G. Scarascia Mugnozza, J.H. Dodds, and J. Jaynes. 1991. Transformation of potato (*Solanum tuberosum* L.) leaf disc using A. tumefaciens-mediate transfer of DNA sequences coding for lytic peptides. *In* Molecular methods for potato improvement. Application of Molecular Techniques to Potato Germplasm Enhancement. Meeting held in Lima, Peru, March 5-9, 1990. CIP, Lima, Peru. pp. 85-95.

Túpac Yupanqui, A., J. Elphinstone, and E. French. 1991. Efecto sinergístico de *Erwinia* spp. y *Fusarium* spp. en la pudrición de tubérculos. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 94.

Túpac Yupanqui, A. and S.G. Wiersema. 1991. Efecto de la selección y tratamientos químicos en los tubérculos sobre las pérdidas de almacenamiento. (ibid) p. 98.

Valencia, V.L. 1991. Fitomejoramiento a insectos plagas de la papa en la región andina. Avances en el Mejoramiento Genético de la Papa en los Países Andinos. Lima (Peru). Feb. 4-7 CIP. Lima, Peru. 18 p

Wambugu, F.M., A.A. Brunt, and E.M. Fernández-Northcote. 1991. Viruses and virus disease of sweet potato (*Ipomoea batatas*) in Kenya and Uganda. *In* L.J.C. Autrey, et al. (eds.) Proceedings of the 2nd triennial APA meeting. African Potato Association, Réduit, Mauritius. pp. 91-96.

Wang, J., B. Li, and B.F. Song. 1991. Commercial in-vitro tuberlet production: Meeting the needs of a tropical climate and beyond. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. p. 21.

Watanabe, K. 1991. Generation of new diploid potato germplasm and simultaneous selection in agronomic characters, 2n gametes and resistances. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia,

June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 99-100.

Watanabe, K. 1991. Present status of germplasm enhancement at CIP and application of biotechnology. *In* Molecular methods for potato improvement Application of Molecular Techniques to Potato Germplasm Enhancement, Lima, Peru, March 5-9, 1990. CIP, Lima, Peru. pp. 135-140.

Watanabe, K., J.H. Dodds, F. Buitron, A. Panta, R. Salinas, C. Sigüeñas, and V. Zambrano. 1991. Genetic engineering applied to potato for bacterial disease resistance. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 92-93.

Watson, G.A., A. Dimyati, Bahagiawati, A.H. Malian, and J. Wargiono. 1991. Sweet potato production, utilization and marketing in commercial centers of production in Java, Indonesia. *In* Sweet potato cultures of Asia and South Pacific: proceedings, 2nd Annual UPWARD Conference. Held in Laguna, Philippines, April 2-5, 1991. UPWARD, Los Baños, Philippines. pp. 361-381.

Wiersema, S.G., A. de Buck, and M.D. Upadhya, 1991. Low-cost storage of consumer potatoes in the North Indian plains. *In* Proceedings: symposium on developments in potato processing and storage in Asia. Held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 112-117.

Zapata, J.L., E.N. Fernández-Northcote, and H.A. Mendoza. 1991. Combinación de la inmunidad a los virus X e Y de la papa y la resistencia a *Phytophthora infestans* en clones de papa. *In* Programa y Compendios. 15a. Reunión de ALAP, Lima, Peru, Sep. 8-14. ALAP, Lima, Peru. p. 90.

Zapata, J.L., O.A. Hidalgo, J. Landeo, and G. Forbes. 1991. Evaluación de clones de papa por su resistencia a *Phytophthora infestans* en las condiciones de Rionegro (Antioquía) Colombia. (ibid) p. 95.

Zhang, H., X. Cao, X. Ma, and B.F. Song, 1991. Incidence of PSTVd infection and strategy of its control in seed potato and TPS production in China. *In* Proceedings of the third triennial conference: plenary papers and abstracts. Meeting held in Bandung, Indonesia, June 17-22. Asian Potato Association, Bandung, Indonesia. pp. 28-29.

Research Projects and Contracts

Program 1. Production Systems

Collaborative

Agronomic and Physiological Studies on Sweetpotato in Warm Climates: Philippines and Vietnam. *H. Taja* (Institute of Biology, Philippines)/*N. Van Uyen* (HCMC, Vietnam)/*M. Potts.*

Agronomy of Potato Production in Cameroon and Other Countries with Similar Agroecological Conditions. *Dominic Nyualem* (IRA, Cameroon)/ *T. Gass, C. Martin.*

Develop Sustainable Cropping Systems on Upland Eroded Soils with Sweetpotatoes in S. China. *Song Bofu.*

Development of Cultural Practices for Potato Production from Seed Tubers and Seedling Tubers. *A. Sharara* (Ministry of Agriculture, Egypt)/*R. El Bedewy, R. Cortbaoui.*

Ecophysiology of Potato Production in the South Region of Chile. *J.S. Rojas* (INIA, Chile)/*P. Malagamba, P. Accatino.*

Evaluation of Sweetpotato Clones in Various Environments in Peru. *H. Goyas* (INIAA)/*E. Carey/ O. Hidalgo.*

Farmer Participatory TPS Research. N. Gunadi (LEHRI, Indonesia)/*M. Potts.*

Improvement of Sweetpotato in Egypt. *S. Doss* (Ministry of Agriculture, Egypt)/*R. El-Bedewey.*

Intercropping Studies on Potato with Maize and other Annual Crops. *L. Jiemin* (S. China Potato Research Center)/*Song Bofu.*

Introduction, Screening, Multiplication and Redistribution of Potato Germplasm. (The Philippines) *E. Badol/E. Chujoy, V. Escobar.*

Introduction, Screening, Multiplication and Redistribution of Sweetpotato Germplasm. (The Philippines) *Chujoy.*

On Farm Trials to Introduce Cultivars to Improve Potato Production in Burundi and Yield Improvements Through Agronomic Practices. *Ch. Muvira, Z. Nzoyihera* (ISABU, Burundi)/*D. Berrios.**

Research on Socio-Agro-Economics, Production, Varieties, Utilization and Marketing of Sweetpotato in Chile. *P. Accatino/C. Covarrubias, J. Kalazich, J. Santos Rojas, H. López* (INIA, Chile).

Socioeconomic Studies on Sweetpotato in India. *T.K. Pal, K.R. Lakshmi* (CTCRI, Trivandrum)/*M.S. Jairth, M.D. Upadhya, T.R. Dayal.*

Studies on the Effect of Potassium Nitrate on Potato Production and Processing. *F. Payton/S. Villagarcía* (Sociedad Química y Minera de Chile S.A.).

Sustainable Potato Production in Dominican Republic. *National Scientists/F. Payton.*

Use of Plant Growth Substance in Improving Quality and Quantity of Potato Yield. *National Scientists of CPRI, India/M. Upadhya.*

Contracts

Consultancy on Sweetpotato Production and Utilization. *A. Boy.* Instituto Nacional de Tecnología Agropecuaria, Argentina.

* denotes projects receiving complementary funding

Development of Potato Varieties for Lowland Tropical Conditions. *N. Govinden.* Mauritius Sugar Industry Research Institute, Nairobi, Kenya.

Evaluation of Sweetpotato Germplasm for Tolerance to Certain Abiotic Stresses Under Arid Conditions. *N. Arévalo.* Universidad de Tacna, Perú.

Selection of Potato Genetic Materials Adapted to Suboptimal Temperatures. *J. Santos Rojas.* Instituto de Investigaciones Agropecuarias, Chile.

Soil Management, Fertilizers and Mineral Nutrition of the Potato and Sweetpotato Under Adverse Conditions of Soil and Climate. *S. Villagarcía.* Universidad Nacional Agraria, La Molina, Perú.

Sweetpotato: An Uptapped Food Resource. *J.A. Woolfe.* England.

World Potato Geography. *R. Rhoades.*

Cooperative Activities

Health Effects of Pesticides Use in Ecuadorian Potato Production. *C. Crissman/ J. Antle.* Montana State University, USA (Rockefeller Foundation).

Departmental

Agricultural Chemical Use and Sustainability of Andean Potato Production. *C. Crissman/J. Antle, S. Capalbo* (Montana State University).

Breeding Sweetpotato Populations Having Short Duration and High Stable Yields for Tropical and Sub-Tropical Regions of South Asia. *T.R. Dayal.*

Global Trends and Constraints to Root Crop Production and Use. *G. Scott.*

Potato Production in the Cropping Systems of the Warm Climate Zone of Asia. *M. Potts.*

Socioeconomics of Germplam Evaluation. *G. Prain.*

Sweetpotato in African Food System. *P. Ewell.*

Sweetpotato in Asian Food Systems. *G. Prain.*

Sweetpotato in Food Systems of Latin America. *G. Prain/A. Swindale.*

Sweetpotato Populations for Hot, Humid Environments. *E. Carey.*

Special Projects

Special Project. *N. Bezençon.* Swiss Development Cooperative (PROINPA).

User's Perspective with Agriculture Research and Development. *R. Rhoades.* Ministry Development Cooperation, The Netherlands.

Theses

Intercropping with Sweetpotato, Improvement of Crop Productivity in Sub-Optimal Environments. *A. Oswald.*

Irrigation Requirements for Sweetpotato. *E. Ríos (P. Malagamba).*

Study of the Inheritance of Frost Tolerance in Native Potato Clones of *S. tuberosum* ssp. *andigena* from Bolivia. *E. Carrasco.*

Program 2. Germplasm Management and Enhancement

Collaborative

Characterization of Sweetpotato Germplasm in Dominican Republic. *O. Malamud, P. Gómez* (CESDA)/*Z. Huamán.*

Collection, Characterization and Evaluation of Native Sweetpotato Germplasm. *M.A. Mannan, K.R. Bhuiyan* (Bangladesh Agricultural Research Institute)/ *T.R. Dayal.*

Collection, Characterization and Maintenance of Sweetpoato Genetic Resources in Brasil. *I. Sias Costa, J. Cabral de Miranda* (EMBRAPA)/*P. Accatino/F. De la Puente.*

Collection, Characterization and Maintenance of Sweetpotato Germplasm in Several Regions in Argentina. *A. Boy, P. Bianchini, M. Lenskak* (INTA, Argentina)/*F. de la Puente/P. Accatino.*

Conservation, Evaluation and Utilization of Potato Landraces and Wild Species in situ and ex situ. *R. Ortega* (CICA, Peru)/ *C. Quiros* (UC Davis)/*K. Watanabe, J. Dodds.*

Introduction, Evaluation and Multiplication of Sweetpotato Germplasm. *IRA Scientists*, Cameroon/*C. Martin.*

Introduction, Maintenance and Distribution of Potato Advanced Genetic Materials. (Kenya) *C. Carli/ H.M. Kidane-Mariam/S. Nganga.*

Production of Materials with Resistance to *Erwinia* Through Genetic Manipulation by Agrobacterium. (*P. Oliger/ J. Dodds/P. Accatino* (Facultad de Ciencias Biológicas/Agronomía, Pontificia Universidad Católica, Chile).

Contracts

Characterization of Genetic Variation in Tuber-Bearing *Solanum* Species by Use of RFLP Markers. *K. Hosaka/K. Watanabe, J. Dodds.*

Resistance to Potato Insect Pests by Means of Conventional and Innovative Technologies. *A. Sonnino.* Ente Nazionale de Energie Alternative, Italy. (Italian Government).

Evaluation of a Sweetpotato Germplasm for the Warm Tropics. *Feng Zu-Xia.* Guangdong Academy of Agricultural Sciences, China.

Maintenance of the Potato Germplasm In-Vitro Collection. *G. García/J. Dodds.* Instituto Nacional de Investigaciones Agropecuarias, Ecuador.

The Utilization of Increased Genetic Variability in the Potato Breeding Program. *M. Huarte/P. Accatino/K. Watanabe/ H. Mendoza.* Instituto Nacional de Tecnología Agropecuaria, Balcarce, Argentina.

Maintenance of In-Vitro Sweetpotato Germplasm in Venezuela. *L. Villegas* (IDAE, Venezuela)/*J. Dodds.*

Breeding and Adaptation of Cultivated Diploid Potato Species. *W. W. Collins.* North Carolina State University, USA.

Pathogen Elimination of Potato. *J. Schmidt,* Austria.

Use of Genetic Engineering Methods to Confer Fungal Disease Resistance to Potatoes. *C. di Pace.* Universita Degli Studi Della Tucsi Viterbo, Italy. (Italian Government).

In-Vitro Selection of Potato Mutant Tolerant to Abiotic Stress. *L. Monti.* Universita di Napoli, Italy. (Italian Government).

Evaluation of a Sweetpotato Germplasm Collection. *Sheng Jialian.* Zuzhou Institute of Sweetpotato, China.

Departmental

Adaptation and Utilization of Potato and Sweetpotato Populations in Breeding. *H. Mendoza.*

Adaptation and Utilization of Potato Populations in Breeding. *H. Mendoza.*

Biosystematic Studies of Selected Wild Species and Their Utilization in Breeding. *P. Schmiediche.*

Collection of the Sweetpotato Genetic Resources. *F. de la Puente/Z. Huamán.*

Development of Improved Sweetpotato Germplasm for Warm and Cool Tropics of S.E. Asia. *E. Chujoy, R. Muyco, I. Oña* and *D. Amalin/L. Tandang, E. Badol, B. Anselmo, H. Taja, J. Bacusmo, E. Orolfo* (Dept. of Agriculture, Philippines, and NPRCRTC).

Evaluation and Selection of Sweetpotatoes in Cool Environments. *J. Landeo.*

Exploitation of *S. acaule*, *S. stoloniferum* and Other Polyploid Species. *K. Watanabe.*

Germplasm Enhancement Through the Use of Haploids and 2n Gametes. *K. Watanabe.*

In Vitro Potato Germplasm Collection. Introduction, Maintenance and Analysis. *R. Lizárraga/J. Dodds.*

In Vitro Sweetpotato Germplasm Collection. Introduction, Maintenance and Analysis. *R. Lizárraga/J. Dodds.*

Introduction of Potato Wild Species Germplasm from the Series *Conicibaccata* and *Piurana* into the Genepool of the Cultivated Potato Generating Tuberosum-Haploid × Wild Species Hybrids. *B. Trognitz.*

Ploidy Manipulations for Exploitation and Enhancement of Sweetpotato Germplasm. *G. Orjeda/P. Schmiediche.*

The Maintenance, Documentation, Distribution and Evaluation of Potato Germplasm. *Z. Huamán.*

The Maintenance, Documentation, Distribution and Evaluation of Sweetpotato Germplasm. *Z. Huamán.*

Use of Innovative Tissue Culture Techniques to Improve Potato Germplasm. *J. Dodds.*

Special Projects

Germplasm Exploration, Conservation and Utilization of Several Under-Utilized Andean Tuber Crops. *M. Hermann.* GTZ.

Breeding Potato for Processing in Tropical Countries. *H. Menaoza.* PEPSICO Food Int., McDonald's.

Thesis

Comparison of Methods for Selection for General Combining Ability for Yield. UNA, La Molina, Perú. *J.L. Marca* (*H. Mendoza*).

Crossability Between *Ipomoea* Species of Section *Batatas*. UNA, La Molina, Perú. *J. Díaz* (*F. De la Puente*).

Estimation of Genetic Variation and Development of Representative Collections in 2× Wild Species of Tuber Bearing *Solanum*. UNA, La Molina, Perú. *J.A. Mont Neyra* (*J. Dodds, K. Watanabe*).

Inheritance of Earliness in Auto tetraploid. UNA, La Molina, Perú. *L. Calúa* (*H. Mendoza*).

Quantitative Variation in Potato Breeding. UNA, La Molina, Perú. *J. Tenorio* (*A. Golmirzaie*).

Regulation of Media Components for In Vitro Conservation of Sweetpotato. UNA, La Molina, Perú. *A. Baltazar* (*J. Dodds*).

Program 3. Disease Management

Collaborative

Control of Bacterial Wilt on Potatoes. *He Liyuan* (CAAS, China)/*Song Bofu.*

Development and Utilization of Virus Detection Techniques. *Zhang Heling* (University of Inner Mongolia, China)/ *Song Bofu.*

Efficacy of Binucleated *Rhizoctonia* for the Biological Control of Pathogenic *Rhizoctonia* on Potato. (Argentina) *A. Escande, H. Torres, P. Accatino.*

Erwinia Disease in Different Phases of the Tunisian Potato Seed Program. *M. Mahjoub* (ESH, Tunisia)/*R. Cortbaoui.*

Etiology and Epidemiology of Bacterial and Fungal Pathogens Affecting Sweetpotato in Kenya. *R.W. Gatumbi* (NAL, Kenya)/*L. Skoglund.*

Evaluation of Advanced CIP's Potato Genetic Materials and Four Andean Countries. *R. Pineda, E. Hernández* (ICA, Colombia)/*M. Sola, J. Revelo* (INIAP, Ecuador)/*R. Egúsquiza* (UNA, Peru)/ *A. Hidalgo* (INIAA, Peru)/*R. León, E. Ortega* (FONAIAP, Venezuela)/ *O. Hidalgo, J. Landeo, H. Mendoza, J. Bryan.*

Evaluation of Advanced Potato Breeding Material in Southern South America. *Balcarce breeder* (INTA, Argentina), *J. Buso* (CNPH-EMBRAPA, Brazil), *J. Kalazich* (INIA, Chile), *A. López* (Min. Agr., Paraguay), *F. Vilaró* (CIAAB, Uruguay)/*CIP Breeders.*

Evaluation of Advanced Potato Genetic Materials for Cameroon and Neighboring Countries with Emphasis of Disease Resistance. *National Breeders of China* (CAAS, China)/*Song Bofu.*

Evaluation of Advanced Potato Genetic Materials in Egypt. *L. Anrity* (Min. of Agriculture)/*R. El-Bedewy.*

Evaluation of Advanced Potato Genetic Materials with Emphasis of Virus Resistance. *M. Fahem* (CPRA, Tunisia)/ *R. Cortbaoui.*

Evaluation of Clones for PLRV Resistance Immunity to PVY and PVX and Adaptation to the Center West Region of Brazil. *J.A. Buso* (CNPH-EMBRAPA, Brasil).

Evaluation of Potato Germplasm for Earliness and Resistance to PVY, PVX, PLRV and *Alternaria solani. F. Vilaró, C. Crisci* (INIA, Uruguay)/*P. Accatino, H. Mendoza.*

Genetic Control of False Root-Knot Nematode, Frost and Black Wart by the Use of Resistant Varieties in Bolivia. *N. Estrada/Bolivian National Scientists.**

Introduction and Utilization of Potato Germplasm. *National Scientists of China* (CAAS, China)/*Song Bofu.*

Management of Bacterial Wilt. *A.O. Michieka* (NAL, Kenya)/*L. Skoglund.*

Managing Bacterial Wilt through Resistant Germplasm and Appropriate Farming System. *A. Tumapon, L. Duna, N. Balanay* (Min. of Agriculture, Philippines)/ *Fe Aquino, E. Chujoy.*

Research on the Control of Bacterial Wilt of Potato in Piura Department of Peru. *M. Delgado.*

Selection of Advanced Clones for Resistance to Late Blight, Combined with Earliness. *E. Badol* (NPRCRTC, Philippines)/*E. Chujoy.*

Selection of Potato Cultivars with Late Blight Resistance, Adaptation and Quality. (Kenya) *H.M. Kidane Mariam.*

Studies of Potato Yellow Vein in Colombia. *C. Sánchez de Luque, Grupo Multidisciplinario de Papa* (ICA, Colombia).

Studies of Yellow Vein Virus. *A. Saldarriaga* (UNM, Colombia)/*O. Hidalgo.*

Test Application of Modern Technology for Detection of Potato Pathogens. *A. M. Escarra* (Argentina)/*L. Salazar.*

Virology of Andean Tuber and Root Crops. *R. Estrada* (Universidad Nacional Mayor de San Marcos)/ *U. Jayasinghe, M. Hermann.*

Contracts

Breeding Potatoes Resistant to the Potato Leafroll Virus, PLRV. *K.M. Swiezynski.* Instytut Ziemniaka, Institute for Potato Research, Poland.

Consultancy on Sweetpotato Breeding. *F. Vilaró.* Centro de Investigaciones Agrícolas, "A. Boerger".

Early Blight of Potatoes: Specialization of *Alternaria* spp. *T. Ames de Icochea.*

Etiology of Sweetpotato Chloritic Leaf Distortion. *C.A. Clark/R.A. Valverde/ D.R. La Bonte.* Louisiana State University, USA.

Evaluation of CIP Advanced Clones for the National Potato Program of Peru. *A. Hidalgo.* Instituto Nacional de Investigación Agraria, Perú.

Evaluation of Genetic Material for Resistance to PVX, PLRV, *Alternaria* and Earliness Under Field Conditions. *C.Crisci/F.Vilaró.* Centro de Investigaciones Agrícolas "A. Boerger".

Evaluation of Genetic Material from CIP for Resistance to Late Blight and Bacterial Wilt. *J.L. Zapata* and *O. Trillos/ G.Forbes, O.Hidalgo* and *H.M. El-Nashaar.* Instituto Colombiano Agropecuario, Rionegro, Colombia.

Evaluation of Potato Germplasm for Resistance to *Alternaria*, PVX and PVY in Brazil. *F. Reifschneider.* Centro Nacional de Pesquisas de Hortaliças, EMBRAPA, Brazil.

Fundamental Research to Develop Control Measures for Bacterial Pathogens of the Potato. *L. Sequeira.* University of Wisconsin, USA.

Potato Germplasm Evaluation for Resistance to Bacterial Wilt. *C. A. Lopes.* Centro Nacional de Pesquisas de Hortaliças, Brazil.

Germplasm Evaluation with Emphasis on Earliness and Virus Resistance. Aegean Regional Agricultural Research Institute, Turkey.

Potato Germplasm Evaluation and Multiplication. *N. Kuzman.* Aegean Regional Agricultural Research Institute, Turkey.

Selection of Resistance to Late Blight of Potato. *F. Flores.* Instituto Nacional de Investigaciones Forestales y Agropecuarias, México.

Strategic and Applied Research to Control *Erwinia* Diseases of Potatoes. Detection of Seed Contamination, and Nature of Disease Resistance. *M. Perombelon.* Scottish Crop Research Institute, Dundee, Scotland.

Survey and Control of Diseases of Sweetpotato in Argentina. *I. de Mitidieri/ M. Scandiani/P. Aley.* Estación Experimental Agrícola, INTA, San Pedro, Argentina.

The Accumulation of Sweetpotato Feathery Mottle Virus, dsRNA and Selected Viral Proteins in Sweetpotatoes; and the Development of Testing Procedures for Sweetpotato Viruses. *J. Moyer.* North Carolina State University, USA.

The Utilization of *Solanum tuberosum* spp. *Andigena* Germplasm in Potato

Improvement and Adaptation. *R.L. Plaisted/H.D. Thurston/ W.M. Tingey/B.B. Brodie/E.E. Ewing.* Cornell University, Ithaca, USA.

Transformation Methods for Possible Resistance to Bacterial Diseases. *A. Brandolini, C. Montanelli, G. Nascari.*

Virus Diseases of Sweetpotatoes. *G. Loebenstein/ H.J. Vetten* (Israel/ Germany).*

Departmental

Antiserum Production and Improvement of Serological Techniques for Virus Detection. *V. Flores/L. Salazar.*

Breeding and Selection of Potato Clones with Disease Resistances and Other Appropriate Horticultural Characteristics. *H.M. Kidane Mariam.*

Breeding for Early Blight Resistance, and the Variation of the Normal *Alternaria* spp. *H. Mendoza* and *H. Torres.*

Breeding for Late Blight Resistance with Populations A and B. *J. Landeo.*

Breeding for Resistance to Bacterial Wilt. *R. Anguiz, H.M. El-Nashaar, H. Mendoza, P. Jatala,* and *K. Watanabe.*

Characteristics of the Transmission of Potato Viruses and Viroids Through TPS. *P. Malagamba, C. Barrera, L. Salazar, N. Maza.*

Development of Improved Native Potato Germplasm. I. Selecting Resistance to *Erwinia* spp. *Z. Huamán, L. de Lindo,* and *E. French.*

Development of Potato Germplasm for Resistance to Diseases and Insect Pests in South East Asia. *Il Gin Mok.*

Development of Sweetpotato for Resistance to Diseases and Insect Pests in South East Asia. *Il Gin Mok.*

Ecology, Taxonomy and Strategy to Control of *Pseudomonas solanacearum. H. M. El-Nashaar.*

Evaluation for Horizontal Resistance to *Phytophthora infestans. L. Skoglund/ P. Tegera.*

Exploitation in Potato Genetic Resources for Control of *Pseudomonas solanacearum. K. Watanabe/H.M. El-Nashaar.*

Fungal and Bacterial Diseases of Sweetpotato in Peru. *P. Aley.*

Genetic Studies and Breeding for Virus and Viroid Resistance in Sweetpotato. *H. Mendoza/L. Salazar.*

Identification and Characterization of Sweetpotato Viruses. *S. Fuentes/ L. Salazar.*

Identification of Sweetpotato Whitefly-Borne Viruses. *M. Nakano.*

Identification, Physiology, Pathogenicity and Control of *Alternaria* spp. Associated with Early Blight. *H. Torres.*

In Vitro Eradication of Sweetpotato Viruses and Viroids. *J. Dodds.*

Mechanism of Resistance and Variability of Potato Leaf Roll Virus (PLRV). *U. Jayasinghe.*

Molecular Analysis of Genetic Resistance of Potato to Viruses and Development of Molecular Probes. *M. Querci/ L. Salazar.*

Molecular Analysis of Genetic Resistance of Sweetpotato to Viruses and Development of Molecular Probes. *M. Querci/ L. Salazar.*

Search for Genes for Resistance to Viruses in Wild *Solanum tuberiferous* Species. *C. Lizárraga, A. Salas, L. Salazar.*

Studies of Potato Virus Y and Potato Virus X. *E. Fernández-Northcote.*

Study of *Phytophthora infestans* Isolates in Kenya, Rwanda and Other East

African Countries. *L. Skoglund/ R. Mibey/ P. Tegera/A. Rubigiri.*

Special Projects

Conferring Resistance to Potato Virus and Viroid by Molecular Interference Sequences Incorporated into Potato Via Agrobacterium Vectors. *J. Jaynes/ J. Dodds.* Louisiana State University, USA, USAID.

Inheritance of an Screening for Components of Resistance to Potato Leaf Roll Virus in Potato. *H. Baker.* Scottish Crop Research Institute (ODA Holdback Fund Facility).

Technology Development for Control of Bacterial Wilt of the Potato (*Pseudomonas solanacearum*). *J. Elphinstone/ H.M. El-Nashaar.* Rothamsted Experimental Station, U.K. (ODA Holdback Fund Facility).

FINNIDA Expert Project. *J. Korva.* Finnish International Development Agency.

Theses

Application of Immunological Techniques in Electron Microscopy for the Detection of Potato Viruses. UNA, La Molina, Perú. *M. T. Trefogli* (*U. Jayasinghe*).

Biological Control of Bacterial Wilt. UPLB, Philippines. *Hongqi Zeng* (*E. Chujoy*).

Characterization, Compatibility and Incompatibility Reaction of Differentials to *Phytophthora infestans.* UNA, La Molina, Perú. *W. Galindez* (*G. Forbes*)

Comparison of Methods to Uniformly Infest Fields with *Pseudomonas solanacearum.* Universidad Nacional del Centro, Huancayo, Perú. *E. Ponce López* (*H.M. El-Nashaar/V. Otazu*).

Detection and Quantification of Pectolytic *Erwinias* in Tuber Seed and its Effect on Disease Incidence in Different Environments. UNA, La Molina, Perú. *A. Villantoy Palomino* (*H.M. El-Nashaar, E. French*).

Development and Standardization of Effective Screening Procedures to Determine Resistance to Blackleg and Soft Rot. UNA, La Molina, Perú. *L. Gutarra de Lindo* (*H.M. El-Nashaar*).

Development of a Heat Tolerance Potato Population with Resistance to PLRV and Immunity to PVY and PVX. UNA, La Molina, Perú. *G. Mendoza/ H. Mendoza,* U. Jayasinghe.

Efficiency of PLRV Transmission by Different Species of Aphids. UNA, La Molina, Perú. *G. Brignetti* (*U. Jayasinghe*).

Fusarium Species Pathogenic to Sweetpotato (*Ipomoea batatas*) in Peru. UNA, La Molina Perú. *W. Pérez Barrera/ E. French, .. Ames.*

General (GCA) and Specific (SCA) Combining Abilities for Resistance to Bacterial Wilt (*Pseudomonas solanacearum* E. F. Smith) in a PVX and PVY Immune Autotetraploid Potato Population. *R. Anguiz* (*H. Mendoza*-Supervisor, *H. El-Nashaar*).

Genome Structure and Expression of Sweetpotato Feathery Mottle Virus. University of Birmingham, U.K. *J. Nakashima* (*R. Wood*).

Identification of Viroids in Sweetpotatoes. UNA, La Molina, Perú. *A. Hurtado* (*L. Salazar*).

Inheritance of Horizontal Resistance to Late Blight in Advanced Potato Hybrids. INIAA, Huánuco, Perú. *E. Roncal* (*J. Landeo*).

Pathogenic Variation in *Pseudomonas solanacearum*. UNA, La Molina, Perú. *J. Marín Horna (H.M. El-Nashaar)*

Potato Powdery Scab (*Spongospora subterranean*): Screening for Resistance and Assessment of Control with Fungicides. Benguet State University, The Philippines. *Nguyen Duc Tri/ P. Vander Zaag, E. Chujoy, M. Potts* (UPLB, the Philippines).

Races of *Phytophthora infestans* in the Philippines. *Tran Xuan Ai/E. Chujoy, M. Potts* (UNDP).

Recurrent Selection for Late Blight Resistance. Region VII. UPLB, Philippines. *Dao Huy Chein (E. Chujoy)*.

Studies on the Heredity of the Resistance to Sweetpotato Feathery Mottle Virus. *E. Mihovilovich (H. Mendoza/ L. Salazar)*.

Studies on the Mechanisms of Resistance of Potatoes to Viruses: Determining the Factor that Confers Extreme Resistance to Potato Virus X in Potato. UNA, La Molina, Perú. *S. Vega (M. Querci/ L. Salazar)*.

Program 4. Insect And Nematode Management

Collaborative

Developing Control Components for Integrated Management of False Root Knot Nematode in Puno, Peru. J. Arcos (INIAA), *J. Franco* (PROINPA), *R. Canuana* (INIAA).

Economic Consequences of the Potato Tuber Moth in the Tunisian Potato Economy. *K. Fuglie/M. Essamet* (INRAT).

Evaluation of Germplasm and Selection for Cyst Nematode Resistance. *R. Eguiguren* (INIAP, Ecuador)/ *O. Hidalgo*.

Evaluation of Sweetpotato Germplasm for Resistance to Sweetpotato Weevil in Central America and the Caribbean. *National Scientists of the Region/ H. Kokubu, E. Carey, O. Malamud.*

Integrated Control of Andean Weevil in Venezuela. *F. Torres* (FONAIAP, Venezuela)/*L. Valencia.*

Integrated Control of Root-knot Nematode. *M. Goethals* (ISABU, Burundi)/ *D. Berrios.**

Integrated Control of Sweetpotato Insect Pests in Argentina. *H. Bimboni, D. Ruberti* (INTA, Argentina)/ *K.V. Raman.*

Integrated Management of Andean potato Weevil in Farmers Fields. *FUNDAGRO* (Ecuador,Colombia)/*Luis Valencia.*

Integrated Management of False Root-Knot Nematode of Potato. (Bolivia). *J. Franco/R. Montecinos/N. Ortuno* (PROINPA).*

Integrated Management of Sweetpotato Weevil (*Cylas formicarius*). *D. Amalin, E. Vásquez* (VISCA, Philippines)/ *P. Vander Zaag.*

Integrated Management of Tuber Moth in Burundi. *Z. Nzoyihera* (ISABU, Burundi)/*D. Berrios.**

Integrated Pest Management (IPM) in Potato. *G.P. Das, M.M. Rashid* (Tuber Crops Research Centre, BARI)/ *M.D. Upadhya.*

Integrated Pest Management (IPM) in Sweetpotato. *G.P. Das* (Tuber Crops Research Centre, BARI)/*K.V. Raman.*

Integrated Pest Management for Sweetpotato. *J. Sakubu* (ISABU, Burundi)/ *D. Berrios.**

IPM for Potato Pests in Kenya. *C. Ngaah-Taracha* (KARI, Kenya)/ *N. Smit.*

IPM for Sweetpotato Pest in Kenya. *O. Magenya, C. Ngaah-Taracha* (KARI, Kenya)/*N. Smit.*

Management of the Andean Weevil. *A. López* (ICA, Colombia)/*L. Valencia.*

Population Dynamics of the Potato Tuber Moth, Optimizing IPM Strategy in Field and Storage. *H. Ben Salah, R. Ben Amor, K. Lebdi* (INRAT, Tunisia)/*O. Roux.*

Production of Sweetpotato Planting Materials and Management of Sweetpotato Insect Pests. (Paraguay) Bilateral Italian. *T. Mayeregger* (IAN), *M. Cardozo* (SEAG)/*A. Strohmenger* (IAO), *K.V. Raman, P. Accatino.*

The Design and Execution of an Integrated Control Program for Andean Potato Weevil in Huatata, Chincheros, Peru. *M. Pacheco* (INIAA, Peru)/*J. Alcázar.*

The Integrated Control of the Potato Tuber Moth in Tunisia: Farmers Fields and Storage. *H. Ben Salah, K. Lebdi* (INRAT,Tunisia)/*O. Roux.*

Contracts

Breeding and Screening for Resistance to PCN. *R. Egúsquiza, M. Canto-Sáenz.* UNA, Peru.

Consultancy on Biological and Selective Chemical Control of Potatoes and Sweetpotatoes Insects Pest. *J. Sarmiento and colleagues.* UNA, Perú.

Development of Host-Plant Resistance to the Sweetpotato Weevil, *Cylas formicarius elegantulus. P. Thompson, J. C. Schneider.*

Use of Sex Pheromone and Entomopathogenic Nematodes for Control of Sweetpotato Weevil, *Cylas formicarius (Fabricius). R. Jansson.* University of Florida, IFAS, Florida, USA.

Departmental

Breeding for Resistance to Insect Pests (Potato Tuber Moth, Leaf Miner Flies and Aphids) of Potato. *A. Golmirzaie/ K. V. Raman.*

Components of Integrated Root-Knot Nematode Management and Interrelationships of the Nematode with other Organisms in Potato. *P. Jatala.*

Components of Integrated Root-Knot Nematode Management and Interrelationships of the Nematodes with other Organisms in Sweetpotato. *P. Jatala.*

Development of IPM Strategies Against the Sweetpotato Weevil and Its Socioeconomical Implications. *H. Kokubu/ A. Swindale.*

Development of Mass Production Methods for *Beauveria* sp. Parasitic to the Andean Potato Weevil (APW) and the West India Sweetpotato Weevil. *H. Torres.*

Development of Mass Production Methods for West Indian Sweetpotato Weevil (SPW). *H. Torres.*

Integrated Control of Potato Cyst Nematode. *M. Canto, J. Landeo.*

Management of Potato and Sweetpotato Insect Pests of Importance in Region I. *L. Valencia.*

Management of Potato Insect and Mite Pests of Global and Regional Importance. *K.V. Raman.*

Management of Sweetpotato Insect and Mite Pests of Global and Regional Importance. *K.V. Raman.*

Management of Sweetpotato Insect Pests of Importance in Region I. *L. Valencia.*

Screening for and Utilization of Resistance of Potato to Root-Knot Nematodes. *P. Jatala.*

Screening for and Utilization of Resistance of Sweet potatoes to Root-Knot Nematodes *Meloidogyne* Species. *P. Jatala.*

Special Projects

Special Project on PTM. *O. Roux.* Swiss Development Cooperative.

Theses

Evaluation of Potato Cyst Nematode Reproduction *Globodera pallida* (Stone Behrens 175 in the Pot Test). Universidad Nacional de Cajamarca, Cajamarca, Perú. *C. Posadas* (*M. Canto-Sáenz*).

Evaluation of Sweetpotato Resistance to *Euscepes postfasciatus* FAIRMAIRE. UNA, La Molina, Perú. *J.Sarmiento* (*K.V. Raman/M. Palacios*).

Reaction of 15 Plant Species to 15 American Populations of *Nacobbus aberrans*. Universidad San Antonio Abad, Cusco, Perú. *T. Boluarte* (*P. Jatala*).

Screening for Resistance to Sweetpotato Weevil. UNA, La Molina, Perú. *A. Decheco* (*K.V. Raman/J. Sarmiento*, UNA).

The Inheritance of Resistance to *Meloidogyne incognita* in Sweetpotato. *B. Huerta* (*P. Jatala*).

Program 5. Propagation, Crop Management

Collaborative

Adaptive Research on TPS Production. *J.S. Rojas* (INIA, Chile)/*J. Bryan.*

Agronomic Techniques for Potato Seed Production. *National Scientists/C. Carli.*

Basic Seed Production in Peru. *E. Franco* (INIAA, Perú).*

Client-oriented Seed Program. *E. Franco* (INIAA, Perú).*

Collaboration with National Programs in the Evaluation and Selection of TPS Progenies and Superior Clones. *National Breeders/ H.M. Kidane-Mariam.*

Developing Technology for the Use of Cuttings for Seed and Table Potato Production and for Sweetpotato Production in Southeast Asian Countries. *National Scientists/M. Potts.*

Development of a Propagation System for Potato in Cameroon and other Countries in the Region. *National Scientists/ C. Martin.*

Development of a Propagation System for Sweetpotato in Cameroon and Other Countries in the Region. *National Scientists* (Africa)/*C. Martin.*

Development of Basic Seed Production in Kenya. *I. Nyoroge* (KARI, Kenya)/ *C. Carli.*

Development of Improved TPS Progenies for Various Environments of China. *Z. Dongyu* (CAAS)/*National Scientists of China/Song Bofu.*

Development of Multiplication Methods on Sweetpotato. *National Scientists* (Kenya)/*C. Carli.*

Evaluation of Rapid Multiplication Techniques for Basic Seed Production in the Region. Region III. *National Scientists/ C. Carli.*

Evaluation of TPS Progenies and Production of Hybrid Seed. *A. Azirin Asandhi* (LEHRI, Indonesia)/*National Scientists/ M. Potts.*

In-vitro and Rapid Multiplication for Basic Potato Seed Production. *J.S. Rojas* (INIA, Chile)/*J. Bryan.*

On-farm Potato Seed Production. *C. Muvira* (ISABU, Burundi)/*D. Berrios.**

Physiological Studies on True Potato Seed. *National Scientists* (India)/ *M. Upadhya.*

Potato Basic Seed Production in Burundi. *A. Sinduhije* (ISABU, Burundi)/ *D. Berrios.**

Potato Production from True Potato Seed. *N. Farag* (Ministry of Agriculture, Egypt)/*R. El-Bedewy.*

Potato Production from True Potato Seed in Tunisia. *M. Fahem* (CDRA, Tunisia)/*R. Cortbaoui.*

Potato Production from True Seed in Cameroon and Other Countries in the Region. *National Researchers* (West African Countries)/*C. Martin, C. Ntonifor.*

Potato Production from True Seed in Morocco. *A. Hilali* (IAV, Morocco)/ *R. Cortbaoui.*

Production and Evaluation of TPS Families for Subtropical Areas. (A) Breeding for TPS Parental Lines. (India) *K.C. Thakur, M.D. Upadhya.*

Production of Basic Potato Seed in Colombia. *A. Gonzales, P. Corzo* (ICA, Colombia)/*O. Hidalgo.*

Production of Hybrid True Potato Seed. *National Scientists* (India)/*K.C. Takur.*

Production of Seed Tubers from TPS. *E. Ortega* (FONAIAP, Venezuela)/ *O. Hidalgo.*

Production of Seed Tubers from True Potato Seed. *E. Ortega* (FONAIAP, Venezuela)/*O. Hidalgo, P. Malagamba.*

Screening of True Potato Seed Families as Transplants and Planting Tubers as Seedling Materials. *National Scientists* (India)/*M. Upadhya.*

Seed Potato Production in Paraguay. *A. Strohmenger* (IAN, Paraguay)/ *M. Mayerreger.*

Seed Production Systems Using True Potato Seed in Philippines and Vietnam. *National Scientists* (Philippines and Vietnam)/*M. Potts.*

Studies on Potato Hybridization, Pollen Management and Outcrossing Rates. *J. Kalazich* (INIA, Chile)/*P. Malagamba.*

Studies on TPS Production in Bangladesh. *H. Rashid, A. Quasem* (TCRC, Bangladesh)/*M.D. Upadhya.*

Survey and Virus Loss Estimates on Sweetpotato in Argentina. Socioeconomic Importance. *S. Nome* (Instituto de Fitovirología)/*L. Salazar.*

The Potato and the Utilization of Seed Tubers Derived from True Potato Seed in Paraguay. *T. Mayerreger* (IAN, Paraguay)/*A. Strohmenger.*

True Potato Seed Hybrid Families in Different Agroecology Zones of India. *National Scientists/M. Upadhya* (CPRI, India)/*P. Malagamba/K.C. Thakur.*

True Potato Seed, On-Farm Trials in India. *National Scientists/M. Upadhya* (CPRI, India)/*M.S. Kadian/P. Malagamba.*

Tuber Seed Production and Storage for Warm Climates in Asia. *National Scientists/M. Upadhya* (CPRI, India).

Tuber Seed Production through Rapid Propagation Method. Bilateral Italy.

M. Mayeregger(IAN, Paraguay)/*A. López* (SEAG, Paraguay)/*A. Strohmenger, P. Accatino.*

Use of TPS for Potato Production in Monserrat, Dominica, St. Kitts and Jamaica. *R. Fletcher* (CARDI, Jamaica)/*O. Malamud.*

Use of TPS for Potato Production in Nicaragua and Haiti. *F. Torres* (Nicaragua), *M. Bastiat* (Haiti)/ *O. Malamud.*

Contracts

An Investigation to Determine Optimum Environmental and Cultivation Requirements for Maximum Flowering, Seed and Storage-Root Production in Argentina, 1988 to 1991. *A. Boyl J. Ploper/H. Beaufort-Murphy.* INTA, Argentina.

Identification of Suitable Locations for Germplasm Multiplication. AARI, Turkey.

Production of Pathogen-tested Potato Germplasm for Southeast Asian and Pacific Countries. *P. Smith.* Victoria Department of Agriculture, Australia.

TPS Production in Turkey for the Needs of the Middle East and North Africa. AARI, Turkey.

Training and Consultancy Research in Effects of Soil Management and Fertilization on Flowering, Fruit Setting and Seed Quality of the Potato and Sweetpotato. *S. Villagarcía. UNA, Peru.*

Instituto de Investigaciones Agropecuarias, Chile. True Potato Seed Production in Chile. *J.S. Rojas, A. Cubillos.*

Departmental

Agronomic Technology for Growing Potatoes from TPS. *P. Malagamba/ J. Bryan/R. Cabello.*

Breeding, Selection and Distribution of Appropriate TPS Progenies and/or Parental Lines in the East and Southern Africa. *H.M. Kidane-Mariam.*

Development of True Potato Seed (TPS) Parental Lines and Progenies for Agronomical and Reproductive Characters. *A. Golmirzaie.*

Different Breeding Approaches for Hybrids TPS Production. *A. Golmirzaie/ P. Malagamba.*

Investigation of Environmental Conditions During the Development of Sexual Reproductive Organs of *Ipomoea batatas* and other *Ipomoea* Species. *H. Beaufort-Murphy.*

Maintenance and Multiplication of Pathogen Free Potato Seed; Production of Low Virus Seed. *J. Bryan.*

Maintenance and Multiplication of Sweetpotato Pathogen-Free Materials. *J. Bryan.*

Physiological Studies on True Potato Seed (TPS) Quality, Storage and Handling. *N. Pallais.*

Sweetpotato Propagation. *H. Beaufort-Murphy.*

TPS Production in Warm Climates. *P. Malagamba.*

Special Projects

Supporting Seed Production and Research to Improve Productivity of Potatoes in Peru. *E. Franco.* Swiss Development Cooperation, SEINPA.

Consultancy on Potato Improvement in Central Africa. *L. Sikka.* USAID Mission, Kampala, Uganda.

Strengthening of Potato Prebasic Seed Research and Production in Bolivia. *A. Devaux.* Swiss Development Cooperation, PROINPA.

Pilot Project for Potato Seed Production Under Rustic Greenhouses in Puno. *E. Franco.* Swiss Development Cooperation, SEINPA.

Sweetpotato Program in ISABU. *D. Niyongabo/D. Berrios.* Ministry des Affaires Entrangers, Belgium.

Theses

An Investigation of the Flowering Responses of *Ipomoea purpurea* in Lima, from Accessions Collected in Peru, Ecuador, Venezuela, Colombia and Bolivia. UNA, La Molina, Perú. *A. Reyes (H. Beaufort-Murphy).*

Evaluation of Different Types of Progenies for TPS Production. UNA, La Molina, Perú. *S. Buendía (A. Golmirzale).*

Influence of Various Potassium Levels and sources on the Colour of Chips Obtained from Potatoes, cv. Chasqa. (SQM Project). UNA, La Molina, Lima, Perú. *L. Linares García/ P. Malagamba, S. Villagarcía, J. Roca.*

Morphological and Physiological Behavior of Three Potato Clones Subject to Water Stress Due to Drought. PROINPA-IBTA, Bolivia. *P. Mamani (P. Malagamba, J. Roca).*

Promotion of Flower and TPS Production Via Growth Regulators. UNA, La Molina, Perú. *R. García (P. Malagamba).*

Program 6. Postharvest Management, Marketing

Collaborative

Assessment of Promising Potato Clones Under Seed and Ware Storage Conditions. *J. Kabira* (Min. Agriculture, Kenya)/*H. Kidane-Mariam.*

Evaluation of Potato Clones for Food Processing and Cooking Quality. SAPPRAD (Thailand). *K. Tantidham/ S. Wiersema.*

Evaluation of Sweetpotato Clones for Food Processing and Cooking Quality. SAPPRAD (Thailand). *K. Tantidham/ S. Wiersema.*

Improved Sweetpotato Processing in China. *Z.F. Tang/Song Bofu.*

Improvement of Potato Storage Techniques in Burundi. *Z. Nzoyihera* (ISABU, Burundi)/*D. Berrios.*

Rustic Store for Ware and Seed Potato and Village Level Processing of Potatoes. *S. Mehra/J. Singh/V.S. Khatana/ S.K. Roy* (IARI)/*R. Nave.*

Storage of Ware and Seed Potatoes. *S. Doss* (Min. Agriculture, Egypt)/ *R. El-Bedewy.*

Studies on Potato Storage and Processing. *J. Lekunze* (IRA, Cameroon)/*C. Martin.*

Studies on Sweetpotato Storage and Processing. *J. Lekunze* (IRA, Cameroon)/ *C. Martin.*

Studies on Sweetpotato (*I. batatas*) as an Alternative Component of Cropping Systems on the Lowlands of Ecuador. *F. Hinostroza, R. Carillo* (INIAP, Ecuador)/*J. Korva, O. Hidalgo, G. Scott.*

Sweetpotato Germplasm Evaluation, Selection and Use of Suitable Materials when Processing for Food. (Colombia) *A. Alvarez, J. de la Torre, A. López* (ICA)/*O. Hidalgo, G. Scott.*

Sweetpotato Storage (Post Maturity Technology). *A. Abubaker* (Min. Agriculture, Kenya)/*S. Nganga.*

Thai Food Habits and Potential Processing of Sweetpotato. CIP/UPWARD. *P. Duluyapach/S. Wiersema/G. Prain.*

Use of Sweetpotato Starch and Flour in Food Processing. *S. Maneepun* (Kasetsart University, Thailand)/*S. Wiersema.*

Contracts

Breeding Yielding, Early and Disease Resistant Sweetpotatoes with Enhanced Food Quality and Nutritional Value. *W.W. Collins.* North Carolina State University, USA.

Case Study of Village-Level Processing in Vietnam. *Q. Nghiem.* UNDP Human Resource Development.

Development of Simple Processing Technologies for Sweetpotato/Potato Based Products for Low-Income Groups as Target Consumers. SAPPRAD. *T. Van Den.* The Philippine Root Crop Research and Training Center, Philippines.

Screening for Natural Sprout Inhibitors of Potato Tubers Using Plants of the Labiatae Family. *E.G. Quintana, O.K. Bautista.* University of the Philippines, Los Baños, Philippines.

Sweetpotato Marketing in Argentina: A Study Based on Data from the Central Market of Buenos Aires. *C. Maggi.* Instituto de Economía y Sociología Rural, Instituto Nacional de Tecnología Agropecuaria Argentina.

The Nutritional and Chipping Evaluation of Selected Parental Clones in Peru, The Philippines and Canada. *T.R.Tarn.* Agriculture Canada.

Departmental

Low-Cost Storage of Consumer Potatoes. SAPPRAD. *S. Wiersema.*

Marketing and Demand for Potatoes. *G. Scott.*

Marketing and Demand for Sweetpotatoes. *G. Scott.*

Potato and Sweetpotato Breeding for Processing in Tropical Countries. *H. Mendoza.*

Socio-Economics of Potato Processing. *G. Scott.*

Socioeconomics of Sweetpotato Processing. *G. Scott.*

Theses

Chemical and Nutritional Evaluation of Some Sweetpotato (*Ipomoea batatas*) Cultivars with Low Sugar Content for its Possible Use in Bakery. UNA, La Molina, Perú. *H. Cárdenas* (*Z. Huamán/N. Fong*).

Consumer Demand for Sweetpotato Bread in Lima, Peru. University of Wageningen, The Netherlands. *H. Denen.**

Effect of Growing Conditions and Postharvest Management on Quality of Potatoes for Processing and Fresh Consumption. Chiang Mai University Wiwat. *W. Panuampai* (*S. Wiersema*).

Fruit-flavored Sweetpotato Fresh Roots-based Appetizer Juice by Augmented/Enzymic Means. UPLB, The Philippines. *Wang Shengwu/ S. Wiersema.*

Processing Potentials of Sweetpotato UNDP. UPLB, The Philippines. *H. Qindara/S. Wiersema.*

Production of L-glutamic Acid Using Corynebacterium glutamicin and Glucose Derived from Sweetpotato Tubers. UNDP. UPLB, Philippines. *Phung Huu Hao/S. Wiersema.*

Relative Prices and the Feasibility of Producing Sweetpotato Bread in Lima, Peru. University of Wageningen, The Netherlands. *A. Overbeek (G. Scott).**

Trypsin Inhibitor Activity in Sweetpotato. Contract Project 68. North Carolina State University, USA. *Mr. Dapeng (W. Collins).*

Staff in 1991, listed by Department or Region

* Staff who left during the year.

+ Staff funded by special projects (see note page 46).

Directors

Richard L. Sawyer, Ph.D., Director General (until April, 1991)

Hubert Zandstra, Ph.D., Director General (as of April, 1991)

José Valle-Riestra, Ph.D., Deputy Director General

Peter Gregory, Ph.D., Director of Research

Kenneth J. Brown, Ph.D., Director of Regional Programs

Office of the Director General

William A. Hamann, B.S., Assistant to the Director General

Edward Sulzberger, M.S., Assistant to the Director General (Public Awareness)

Rosa Rodríguez, Head of Visitor's Office

Office of the Director of Research

Pons Batugal, Ph.D., Assistant to the Director of Research

José Luis Rueda, Ph.D., Assistant to the Director of Research

Research Programs Leaders

Production Systems

G. Prain (until April, 1991)
T. Walker (as of April, 1991)

Germplasm Management and Enhancement

J. Dodds

Disease Management

E. French

Insect and Nematode Management

K.V. Raman

Propagation, Crop Management

P. Malagamba

Postharvest Management, Marketing

G. Scott

Research Departments

Breeding and Genetics

Humberto Mendoza, Ph.D., Geneticist, Head of Department

Ali Golmirzaie, Ph.D., Geneticist (sabbatical, Oct. 1990 - Sept. 1991)

Edward Carey, Ph.D., Sweetpotato Breeder

Juan Landeo, Ph.D., Breeder

Enrique Chujoy, Ph.D., Geneticist (the Philippines)

T.R. Dayal, Ph.D., Sweetpotato Breeder (India)

Haile M. Kidane-Mariam, Ph.D., Breeder (Kenya)

Il Gin Mok, Ph. D., Sweetpotato Breeder (Indonesia)

Genetic Resources

John Dodds, Ph.D., Tissue Culture Specialist, Head of Department

Peter Schmiediche, Ph.D., Geneticist (sabbatical, Oct. 1990-1991)

Fermín de la Puente, Ph.D., Germplasm Collector

Zósimo Huamán, Ph.D., Germplasm Curator

Kazuo Watanabe, Ph.D., Cytogeneticist

Michael Hermann, Ph.D., Andean Crop Specialist, (Ecuador)+

Bodo Trognitz, Ph.D., Geneticist

Norio Sato, Ph.D., Tissue Culture Associate Scientist+*

Carlos Ochoa, M.S., Consultant

Carlos Arbizu, Ph.D., Special Consultant on Andean Root and Tuber Crops+

Nematology and Entomology

Parviz Jatala, Ph.D., Nematologist, Head of Department (sabbatical, July 1990 - Aug. 1991)

K.V. Raman, Ph.D., Entomologist (Acting Head, July 1990 - Aug. 1991)

Rolf Aalbu, Ph.D., Entomologist (Tunisia)*

Hirotaka Kokubu, Ph.D., Entomologist (Dominican Republic)

Luis Valencia, Ph.D., Entomologist (Colombia)

Olivier Roux, Ir., Associate Entomologist Breeder (Tunisia)+

Nicole Smit, M.S., Associate Entomologist (Tunisia)+

Pathology

Edward R. French, Ph.D., Pathologist, Head of Department

Luis Salazar, Ph.D., Virologist

Hossien El-Nashaar, Ph.D., Bacteriologist

Enrique Fernández-Northcote, Ph.D., Virologist

Gregory A. Forbes, Ph.D., Mycologist (Ecuador, as of November 1990)

Upali Jayasinghe, Ph.D., Virologist

John Elphinstone, Ph.D., Bacteriologist*

Maddalena Querci, Dot. Biol., Associate Scientist+

Linnea G. Skoglund, Ph.D., Mycologist (Kenya)

L.J. Turkensteen, Ph.D., Adjunct Scientist (The Netherlands)+

Massaki Nakano, B.S., Virologist, Visiting Scientist+

Jari Valkonen, M.S., Virologist, Visiting Scientist+*

Physiology

Patricio Malagamba, Ph.D., Physiologist, Head of Department

Helen Beaufort-Murphy, Ph.D., Physiologist

Noel Pallais, Ph.D., Physiologist

Frederick Payton, Ph.D., Agronomist (Dominican Republic)

Michael Potts, Ph.D., Agronomist (Indonesia)

Siert Wiersema, Ph.D., Physiologist (Indonesia)

Andreas Oswald, M.S., Physiologist+

Jukka Korva, M.S., Agronomist (Ecuador)+

Carlo Carli, Ing. Agr., Seed Physiologist (Kenya)+

Social Science

Thomas Walker, Ph.D., Economist, Head of Department (as of April)

Gordon Prain, Ph.D., Anthropologist (Acting Head of Department, Dec 1990-April, UPWARD Coordinator, the Philippines, as of Aug. 1991)

Charles Crissman, Ph.D., Economist (Ecuador)

Peter Ewell, Ph.D., Economist (Kenya)

Keith Fuglie, Ph.D., Economist (Tunisia)+

Robert Rhoades, Ph.D., Anthropologist (Philippines, until April)+

Gregory Scott, Ph.D., Economist

Anne Swindale, Ph.D., Agric. Economics (Dominican Republic)+

Adhiambo Odaga, Ph.D., Geographer (Cameroon)+

Alwyn Chilver, M.S., Economist (Indonesia)+

Research Support

Fausto Cisneros, Ph.D., Entomologist, Head of Department

Mario Pozo, Ing. Agr., Field and Greenhouse Superintendent (Lima)

Lombardo Cetraro, Biologist, Field & Greenhouse Supervisor (San Ramón)

Víctor Otazú, Ph.D., Superintendent (San Ramón)

José Luis Marca, M.S., Supervisor, Seed Production

Francisco Muñoz, ph.D., Superintendent (Ecuador)

Hugo Goyas, Ing.Agr., Supervisor (Yurimaguas)

Miguel Quevedo, Ing. Agr., Off-station Field Supervisor (Cajamarca & Cañete)

Lauro Gómez, Acting Supervisor (Huancayo)

Regional Research

The regional designations used here are those used during the year 1991.

Headquarters

James E. Bryan, M.S., Senior Seed Specialist

Region I - South America

Oscar Hidalgo, Ph.D., Regional Representative

- **Semilla e Investigación en Papa, (SEINPA) Peru**

Efraín Franco, M.S., Economist, Team Leader+

Juan Aguilar, Ing. Agr., Seed Production+

Jorge Recharte, Ph.D., Anthropologist+

Ricardo Wissar, M.S., Agronomist+

- **Project for the Investigation of the Potato, (PROINPA) Bolivia**

André Devaux, Ph.D., Seed Specialist, Team Leader+

Greta Watson, Ph.D., Human Ecologist+

Nicole Bezençon, I.R., Associate Expert+

Nelson Estrada, Ph.D., Breeder+

Javier Franco, Ph.D., Nematologist+

Joanne Parker, Ph.D., Fungi Mycologist+

- **Southern Cone (Chile)**

Primo Accatino, Ph.D., Breeder

Region II - Central America and the Carribean

Oscar Malamud, Ph.D., Regional Representative

Region III - East and Southern Africa

Sylvester Nganga, Ph.D., Regional Representative

Donald Berrios, Agronomist (Burundi)+

Lyle Sikka, M.S., Consultant on Seed Technology (Uganda Special Project)+*

- **Programa Regional d'Amelioration de la Culture de la Pomme de Terre en Afrique Centrale et de L'Est, (PRAPAC) Rwanda**

Marco Soto, Ph.D., Coordinator+

Region IV - North Africa, Near & Middle East

Roger Cortbaoui, Ph.D., Regional Representative

Ramzy El-Bedewy, Ph.D., Scientific Associate (Egypt)

Region V - West and Central Africa

Carlos Martin, Ph.D., Regional Representative

Thomas Gass, Eng., Associate Scientist+ (until May 1991)

Region VI - South Asia

Mahesh Upadhya, Ph.D., Regional Representative

M.S. Kadian, Ph.D., Agronomist

M.S. Jairth, Ph.D., Socioeconomist

K.C. Thakur, Ph.D., Breeder

V.S. Khatana, Ph.D., Socioeconomist

Region VII - South East Asia and the Pacific

Michael Potts, Ph.D., Regional Representative

- **User's Perspective with Agricultural Research and Development (UPWARD), The Philippines**

Virginia N. Sandoval, Ph.D., Anthropology, Asst. Coordinator

Inge Verdonk, Ir., Nutritionist (Philippines)+

Cherry Bangalanon, M.S., Family Res. Mgmt.

Region VIII - China

Song Bofu, Ph.D., Regional Representative

Training Department

Fernando Ezeta, Ph.D. Head of Department

George Hunt, Agr. Eng., Training Officer (Region III)*

Margarita Villagarcía, M.S., Training Assistant

Information Sciences Department

Carmen Siri, Ph.D., Head of Department

Hernán Rincón, Ph.D., Head Communications Unit

James Bemis, Ph.D., Senior English Writer/Editor

Alfredo García, M.S., Coordinator, Statistics Unit

Christine Graves, M.A., Writer/Editor

Carmen I. Podestá, M.S., Librarian/Information Officer

Marciano Morales-Bermúdez, M.S., Supervisor, Communication Unit

Fiorella Sala Cabrejos, M.S.T., Coordinator, User Services Manager, Information Unit

Administration

Controller's Office

Carlos Niño Neira, C.P.C., Internal Auditor (Acting Controller since January 1990)

Oscar Gil, C.P.A., Assistant Controller

José Belli, C.P.A.*

Vilma Escudero, B.S.

Jorge Bautista, B.S.

Alfredo González, C.P.A.*

Alberto Monteblanco, C.P.A.

- **Treasury Unit**

Lucy Correa, C.P.A., Accountant

- **Budget Unit**

Guillermo Romero, Chief Accountant*

Alberto Monteblanco, C.P.A., Accountant

- **Accounting Unit**

Miguel Saavedra, C.P.A., General Accountant

Edgardo de los Ríos, C.P.A., Accountant

Blanca Joo, C.P.A., Accountant

Eliana Bardales, C.P.A., Accountant

Office of the Executive Officer

César Vittorelli, Agr. Eng., Acting Executive Officer (as of Aug. 1991)

Adrián Fajardo, M.S., Exective Officer (sabbatical, as of Aug. 1991)

Maritza Benavides, Admin. Assistant

- **Logistics**

Lucas Reaño, C.P.C., Supervisor

Jorge Luque, M.B.A., Warehouse Officer

José Pizarro, Importations Officer

Arturo Alvarez, Local Purchasing Officer

Manuel Scollo, B.A., R.R.I.I., General Serv. Officer

- **Personnel and Labor Relations**

Guillermo Machado, Lic., Supervisor

Ana Dúmett, B.S. Soc. Assist., Social Worker*

Martha Piérola, B.S., Social Worker

Germán Rossani, M.D., Medical Officer

Lucero Schmidt, Nurse

- **Foreign Affairs Liaison**

Marcela Checa, Liaison Officer

- **Transportation**

Carlos Bohl, Supervisor

Jacques Vandernotte, Chief Pilot

Djordje Velickovich, Pilot*

Percy Zuzunaga, Co-Pilot

- **Equipment and Maintenance**

Gustavo Echecopar, Ing. Agr., Supervisor

- **Security**

Aldo Tang, Comdt., Security Supervisor

- **Travel and Telex**

Ana María Secada, Supervisor

- **Auxiliary services**

Nancy Oshiro, Supervisor

Scientific Associates

Teresa Ames Icochea, Ph.D., Micologist (Peru)

Adolfo Boy, Ph.D., Sweetpotato Agronomist (Argentina)

Manuel Canto, Ph.D., Nematologist (Peru)

Rómulo del Carpio, Ing. Agr., Taxonomist (Peru)

Ulises Moreno, Ph.D., Physiologist (Peru)
Francisco Vilaró, Ph.D., Sweetpotato Breeder (Uruguay)
Sven Villagarcía, Ph.D., Soil Scientist (Peru)

Scientific and other Assistants

Breeding and Genetics

Raúl Anguiz, M.S., Biol.
Walter Amorós, M.S., Ing. Agr.
Miguel Ato, Ing. Ind. Alimentarias
Luis Calúa, M.S., Ing. Agr.
Luis Díaz M.S., Ing. Agr.
Jorge Espinoza, M.S., Ing. Agr.
Rosario Gálvez, M.S.
Manuel Gastelo, M.S., Ing. Agr.
Luis Manrique, Ing. Agr.
Elisa Mihovilovich, M.S.
Daniel Reynoso, M.S., Ing. Agr.
Felix Serquén, M.S., Ing. Agr.*
Jorge Tenorio, B.S., Biol.

Genetic Resources

César Aguilar, Ing. Agr.
Jesús Amaya, Tech. Dipl.
Humberto Asmat, Biol.
Aníbal Baltazar, Ing. Agr.
Jorge Benavides, Biol.
Fausto Buitrón, Ing. Agr.
Alfonso Del Río, Biol.+
Jaime Díaz, M.S.
Walberto Eslava, Ing. Agr.
René Gómez, Ing. Agr.
María del Rosario Herrera, Biol.
Kurt Manrique, M.S.
Gisella Orjeda, M.S.
Matilde Orrillo, Biol.
Ana Panta, Biol.
Armando Quispe, Ing. Agr.
Alberto Salas, Ing. Agr.
Roxana Salinas, Ing. Agr.
Carmen Sigüeñas, Biol.
Judith Toledo, Bio.+
Fanny Vargas, Ing. Agr.
Sandra Vega, Biol.+
Víctor Zambrano, Biol.

Nematology and Entomology

Jesús Alcázar, M.S., Ing. Agr.
Tatiana Boluarte, Ing. Agr.
Verónica Cañedo, Biol.
Roberto Delgado de la Flor, Ing. Agr.
Oder Fabián, Ing. Agr.
Arelis Carmen Garzón, Biol.*
Lily Gavilano, Biol.
Alberto González, M.S.
Erwin Guevara, Ing. Agr.
Rossio Haddad, Biol.
Angela Matos, Ing. Agr.
Norma Mujica, Ing. Agr.
María Palacios, Biol.
Marina Zegarra, Biol.*
Víctor Zambrano, Biol.

Pathology

Pedro Aley, M.S., Ing. Agr.
Ciro Barrera, Ing. Agr.
Ida Bartolini, M.S., Biol.
Miguel Cervantes, Biol.
Carlos Chuquillanqui, B.S., Ing. Agr.
Christian Delgado, M.S., Biol.
Violeta Flores, Biol.
Segundo Fuentes, Biol.
Wilman Galíndez, Ing. Agr.
Josefa Gamboa, Biol.
Liliam G. Lindo, Ing. Agr.
Charlotte Lizárraga, B.S.

Josefina Nakashima, M.S.
Ursula Nydegger, Tech. Dipl.
Ricardo Orrego, Ing. Agr.
Hans Pinedo, Ing. Agr.
Judith Toledo, B.S.
Hebert Torres, M.S., Ing. Agr.
Ernesto Velit, Biol.

Physiology

Rolando Cabello, Ing. Agr.
Rosario Falcón, B.S., Biol.
Nelly Fong, M.S., Nutrition
Rolando Lizárraga, B.S.
Norma de Mazza, Q.F.
Jorge Roca, B.S., Biol.

Social Science

Mariscla Benavides, M.A., Pub. Admin., Sociol.
Miguel Daza, Lic. Sociol.
Hugo Fano, Economist
Cristina Fonseca, M.S., Agronomist
José Herrera, M.A., Economist
Víctor Suárez, B.S., Statistician

Information

- **Computer Unit**

Ana María Ponce, M.S., Eng., System & Database Manager
Roberto Castro, Ing. Electron., System Design & Development
Alberto Vélez, Eng., System Manager
Pia María Oliden, Computer Operations
Jorge Apaza, Ing. Econ., PC Management and Support
Jorge Palomino, Accountant, VAX and PC Support

- **Information Unit**

Ivan Bendezú, Ing. Agr., Database Assistant
Martha Crosby, B.A., Librarian
Griselda Lay, B.A., Information Assistant
Jorge Vallejo, Ing. Agr., Classification Assistant
Cecilia Ferreyra, Information Services

- **Communication Unit**

Jesús Chang, M.S., A.V. Section Coordinator
Emma Martínez, Lic., Supervisor of Processes
Jaime Machuca, Ing. Agr., A.V. Operations Section Coordinator
Felix Muñoz, B.C.E., Distribution Section Coordinator
Anselmo Morales, Art Section Coordinator
Rufino Failoo, Photomechanics Section Coordinator
Godofredo Lagos, Print Shop Section Coordinator
María del Carmen Prieto, Text Section Coordinator
Christy Zevallos, Lic., A.V. Specialist

- **Statistics Unit**

Beatriz Eldredge, B.S., Biometrician

Training

Iván Boluarte, Agr. Eng. Assistant*
Nelson Espinoza, Assistant, (leave of absence, Sept. 1990-1991)
Jorge Palacios, Dip., Language Teacher
Américo Valdez, M.S., Ing. Agr.

Research Support

Roberto Duarte, Agr. Eng.
Ana María Romero, Agr. Eng.*
Nelson Meléndez, Tech. Dep.*

Others

Roberto Duarte, Agr. Eng.
Luis Navarrete, Ing. Agr. (SEINPA, Puno, Peru)
Noemí Zuñiga, M.S. Ing. Agr. (SEINPA, Cajamarca, Peru)

Region I

Jorge Abad, Ing. Agr
Carlos Canizares , Ing. Agr.
Jorge Carillo, Ing. Agr.
Patricio Espinosa, M.S.
Diego Estrella, Ing. Agr.
Ivan Reinos, M.S.
Leonor Romero, Assistant
Luis Zapata, Ing. Agr.

Region II

C. Mejía, Tech. Assist.
R. Arbona, Tech. Assist.
P. Gómez, Tech. Assist.
Jorge Queiroz, Ing. Agr.

Region III

Stan Kasule, B.S., Assistant*
John Kimani, M.S., Technician
J. Mutuura, M.S. Research Associate

Region IV

A. El-Ashker, Technician
A. El-Oraby, Technician
M. Shahata, B.S.
M. Sharkoni, B.S.

Region V

C. Ntonifor, Tech. Asst.

Region VI

S.K. Mehra, M. S., Postharvest Assistant

Region VII

A. Demagante, M.S., Res. Asst.
V. Escobar, M.S., Res Asst.
B. Fernández, M.S., Res Asst.
C. Montierro, M.S., Res. Asst.
R. Muyco, Res. Asst.
F. Aquino, Res. Asst.
A. Pangelinan-Ona, Res. Asst.
M. Piniero, B.S. Human Ecol.
B. Susana, B.S., Res. Asst.
G. Opena, Res. Asst.
R. Demonteverde, Res. Aide

Region VIII

Gong Xifeng, Res. Asst.
Wang Gui Ling, Res. Asst.

+ Positions designated with an "+" are separately funded as Special Projects by the following donor agencies:

- Australian Development Assistance Agency
- Belgium, General Administration for Cooperation and Development (AGCD).
- Canada, International Development Research Centre (IDRC)
- Food and Agriculture Organization of the United Nations (FAO)
- Italy, Ministry of Foreign Affairs
- Japan, International Board for Plant Genetic Resource
- Netherlands, Ministry of Foreign Affairs
- Rockefeller Foundation
- Swiss Development Cooperation and Humanitarian Agency
- United Kingdom, Overseas Development Administration (ODA)
- United States, Agency for International Development (USAID)
- United States, Pepsico Food International
- United States, McDonald's Corporation
- World Bank/INIPA
- Food Industry Crusada Against Hunger (FICAH)

Moreno Patiño y Asociados
Sociedad Civil de
Responsabilidad Limitada
Firma Miembro de
Price Waterhouse

Las Begonias 441
Lima 27, Peru
Apartado 2869

Telfs 42-0567 - 42-0555
Telex 20008 Pnwalr
Fax 426522

Moreno Patiño

REPORT OF INDEPENDENT ACCOUNTANTS

February 26, 1992

To the Members of the Board of Trustees
International Potato Center - CIP

We have examined the statements of financial position of International Potato Center - CIP (a not-for-profit organization) as of December 31, 1991 and 1990, and the related statements of operations and changes in unexpended fund balances and changes in financial position for the years then ended. Our examinations were made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our report dated March 14, 1991, our opinion on the 1990 financial statements was qualified because it was not possible to determine with reasonable accuracy if the core contribution receivable from the Interamerican Development Bank would be collectible. As explained in Note 3, this donation was received during 1991 with no material effect on the afore-mentioned financial statements. Accordingly, our present opinion on the 1990 financial statements, as presented herein, is different from that expressed in our previous report.

Also noted in the afore-mentioned report, our opinion on the 1990 financial statements was qualified because the Center did not record depreciation on its property, plant and equipment. As explained in Note 6, the Center has restated the 1990 statement of financial position to record the accumulated depreciation at December 31, 1990 of US$7,698,091 and has recorded the depreciation for the year ended December 31, 1991 with charge to operating expenses in an amount of US$1,536,645. In accordance with generally accepted accounting principles, the Center should restate all the financial statements at December 31, 1990.

In our opinion, except for the effect in 1990 of the matter described in the preceding paragraph, the financial statements examined by us present fairly the financial position of International Potato Center - CIP as of December 31, 1991 and 1990 and its operations and changes in its unexpended fund balances and changes in its financial position for the years then ended, in conformity with generally accepted accounting principles consistently applied.

Moreno Patiño

Countersigned by

.....(partner)
Francisco J. Moreno
Peruvian Public Accountant
Registration No. 155

INTERNATIONAL POTATO CENTER - CIP

STATEMENT OF FINANCIAL POSITION (Notes 1 and 2)
as of December 31, 1991 and 1990
(Expressed in U.S. dollars)

	1991	1990
ASSETS		
CURRENT ASSETS		
Cash and short-term deposits	1,134,799	854,603
Accounts receivable:		
Donors (Note 3)	4,247,561	6,163,869
Advances and current portion of loans to executives and employees (Note 4)	318,787	260,308
Other	254,476	580,300
Inventories of laboratory and other supplies	761,232	832,771
Prepaid expenses (Note 5)	912,134	659,829
Total current assets	7,628,989	9,351,680
RESTRICTED FUNDS (Note 7)	218,399	207,767
LOANS TO EXECUTIVES AND EMPLOYEES - NON-CURRENT PORTION (Note 4)	35,755	49,582
FIXED ASSETS (Note 6)		
Cost	19,317,018	18,402,430
Accumulated depreciation	(9,123,886)	(7,698,091)
	10,193,132	10,704,339
LIABILITIES AND FUND BALANCES	18,076,275	20,313,368
CURRENT LIABILITIES		
Bank indebtedness (Note 7)	217,201	515,960
Accounts payable and other liabilities	596,006	884,238
Grants received in advance - donors	1,000,000	1,600,000
Other accounts payable and accrued expenses	564,162	958,699
Payable to donors	136,000	—
Total current liabilities	2,513,369	3,958,897
PROVISION FOR SEVERANCE INDEMNITIES net of advances of US$ 28,058 (US$31,599 in 1990)	1,288,423	553,204
FUND BALANCES		
Capital invested in fixed assets	10,193,132	10,704,339
Capital fund	1,536,645	—
Unexpended fund balances (Note 8)	2,544,706	5,096,928
	14,274,483	15,801,267
	18,076,275	20,313,368
GRANTS PLEDGED (Note 9)		

The accompanying notes are part of the financial statements.

INTERNATIONAL POTATO CENTER - CIP

STATEMENT OF OPERATIONS AND CHANGES
IN UNEXPENDED FUND BALANCES (Notes 1 and 2)
as of December 31, 1991 and 1990
(Expressed in U.S. dollars)

	1991	1990
REVENUE		
Operating grants:		
Unrestricted	13,857,384	13,402,659
Restricted	1,805,756	2,229,890
Other restricted core grants	527,176	1,131,085
	16,190,316	16,763,634
Special project grants	3,943,561	2,983,216
Grants for fixed asset additions	874,978	1,103,600
Grants for cooperative activities	521,627	200,331
Working fund grants	—	210,000
Other income, net	498,463	842,058
	22,028,945	22,102,839
EXPENSES		
Operating costs:		
Potato and sweetpotato research programs	5,601,140	5,483,698
Research services	1,944,079	1,743,836
Regional research program and training	3,279,023	4,018,637
Conferences and seminars	22,050	80,278
Information services and library	1,275,400	1,145,563
Administration costs	1,974,344	1,880,156
General operating costs	3,207,872	2,975,305
Depreciation	1,536,645	—
External program and management review	—	97,049
	18,840,553	17,424,522
Other restricted core expenditures	649,541	919,096
Special projects	3,632,681	3,104,683
Cooperative activities	434,725	190,055
	23,557,500	21,638,356
(Deficit) excess of revenue over expenses	(1,528,555)	464,483
Transferred to capital invested in fixed assets	(1,023,667)	(1,847,661)
Unexpended fund balance, beginning of year	5,096,928	6,480,106
UNEXPENDED FUND BALANCE, END OF YEAR	2,544,706	5,096,926

The accompanying notes are part of the financial statements.

INTERNATIONAL POTATO CENTER - CIP

STATEMENT OF CHANGES IN FINANCIAL POSITION
For the years ended December 31, 1991 and 1990
(Expressed in U.S. dollars)

	1991	1990
SOURCE OF FUNDS		
(Deficit) excess of revenues over expenses	(1,528,555)	464,483
Adjustment to reconcile to net cash provided by operations:		
Depreciation	1,536,645	—
Provision for severance indemnities	841,307	554,553
Cash provided by operations	849,397	1,019,036
Decrease in accounts receivable	2,183,653	—
Decrease in inventories	71,539	—
Decrease in loans to executives and employees-non-current portion	13,827	—
Increase in payable to donors	136,000	—
Increase in accounts payable and other liabilities	—	869,771
Increase in grants received in advance	—	1,542,400
Decrease in restricted funds	—	117,364
	3,254,416	3,548,571
APPLICATIONS OF FUNDS		
Purchase and replacement of fixed assets		
- Core acquisitions	905,604	1,847,661
- Net cost of replacement	118,063	—
Payment and advances of severance indemnities and exchange gain in the year	106,088	740,401
Increase in prepaid expenses	252,305	153,369
Increase in restricted funds	10,632	—
Decrease in accounts payable and other liabilities	981,528	—
Decrease in grants received in advance	600,000	—
Increase in loans to executives and employees-non-current portion	—	25,330
Increase in accounts receivable	—	2,311,118
Increase in inventories	—	12,424
	2,974,220	5,090,303
Increase (decrease) in cash and short-term deposits	280,196	(1,541,732)
Cash and short-term deposits, beginning of year	854,603	2,396,335
CASH AND SHORT-TERM DEPOSITS, END OF YEAR	1,134,799	854,603

The accompanying notes are part of the financial statements.

INTERNATIONAL POTATO CENTER - CIP

NOTES TO FINANCIAL STATEMENTS
as of December 31, 1991 and 1990
(Expressed in U.S. dollars)

1. Operations

The International Potato Center (CIP) is a nsot-for-profit organization located in Lima, Peru, with programs throughout Latin America, Central America, and the Carribbean, the Near and Middle East, Asia, and Africa. CIP's principal objective is to contribute to the development of the potato and other tuberous roots, through scientific research programs, preparation and training of scientists, dissemination of research results in publications, conferences, forums and seminars, and other activities, in accordance with its objectives.

CIP was established in 1972 in accordance with an Agreement for Scientific Cooperation with the Government of Peru signed in 1971 and expiring in 2000. The Center is a member of the group of International Agricultural Research Centers which is supported by the Consultative Group for International Agricultural Research.

In accordance with existing legislation and provisions of the Agreement described above, CIP is exempt from income tax and other taxes. If for any reason the Center's operations are terminated, all of its fixed assets are to be transferred to the Peruvian Ministry of Agriculture.

2. Summary of significant accounting policies

The principal accounting policies are as follows:

a) Foreign currency

The books and accounts are maintained in U.S. dollars. Transactions in other currencies are recorded at the rates of exchange ruling on the dates of transactions. Pledges in currencies other than U.S. dollar are recorded at exchange rates prevailing at the time of receipt, or if outstanding at December 31, at the rates of exchange in effect at year end. Monetary assets and liabilities in currencies other than U.S. dollars are translated at market rates of exchange at the end of the year.

b) Accruals

The financial statements of the Center are presented using the accrual basis of accounting, except for outstanding commitments (d, below).

c) Revenue

Grant transactions are recorded as revenue on the basis of donor commitments.

Core unrestricted grants and capital and working fund grants are pledged on an annual basis and as such are recognized as revenue in the year in which the grant is pledged, as long as they are deemed to be probable of

collection. If a pledge is cancelled in a subsequent financial period, it is written-off and charged against revenues in the year it is cancelled.

Restricted grants, which may be pledged for more than one year, are recognized as revenue only to the extent that related expenses have been incurred or budgeted.

Other income, net, such as interest on investments, proceeds from sales of fixes assets and supplies, and administrative fees on special projects are recognized as earned.

d) Expenditures

Firm orders for purchases of fixed assets and services are recorded in the year of their commitment. At December 31, 1991, the amount recorded under this practice totalled US$67,110.

Expenditures made by international programs are recorded on the basis of reports received. Expenses related to special projects and cooperative activities are applied, when incurred, against the respective income.

e) Investments

Short-term investments principally comprise certificates of deposit bearing interest at current bank rates and are valued at cost.

f) Inventories of laboratory and other supplies

Inventories of laboratory supplies and other materials are valued at estimated market value which approximates cost.

g) Fixed assets

Property, plant, and equipment are stated at cost. This includes the purchase price plus costs of freight, insurance, and handling charges. Grants used for the acquisition of new or replacement property, plant, and equipment are charged to the appropriate fund source as period expense and subsequently capitalized. In 1991, the Center has adopted the practice of recording depreciation on its property, plant, and equipment to be in conformity with generally accepted accounting principles. The statement of financial position at December 31, 1990, has been restated to reflect this situation (Note 6). Depreciation is computed using the straight-line method over the term of the useful lives of property, plant, and equipment.

The cost of property, plant, and equipment, net of accumulated depreciation, disposed of in a fiscal period are charged directly to the capital invested in fixed assets and the corresponding asset account is reduced by the same amount.

Maintenance and repairs are recorded as operating costs in the year incurred.

h) Vacations

Employees' vacation expenses are charged to operating expenses when they are taken.

i) Provision for severance indemnities

In 1991, new legislation for severance indemnities was established. According to the new legislation, the accumulated indemnity from inception up to December 31, 1990, will be deposited in a financial institution progres-

sively during a period which may not exceed 10 years and will be made within the first semester of each year. The new legislation has retroactive effects for the calculation of indemnities for employees engaged after July 11, 1962. Indemnities as of January 1, 1991, will be deposited in the months of May and November of each year comprising all the months worked in each semester.

CIP has elected to pay accumulated indemnities from inception up to December 31, 1990, over a 10-year period. CIP paid the first year deposit in May of 1991 in the amount of US$25,266. The retroactive effect for the calculation of indemnities for employees engaged since June, 1972, increased the liability in the amount of US$841,307. CIP has paid the current year deposit in the amount of US$173,581.

3. Accounts receivable from donors

The 1990 agreement with the Inter-American Development Bank for the dollar core contribution of US$1,444,000 at December 31, 1990, had not yet been signed at that date; therefore, there was uncertainty whether the contribution would be received. During 1991, the contribution was received with no material effect on the financial statements. The contribution was reduced to US$1,230,000, the balance was covered by the International Bank for Reconstruction and Development.

4. Advances and loans to executives and employees

The Center offers home and vehicle loans to some employees. These loans are funded with its own funds, and they are repayable in monthly installments.

Advances and loan balances with executives and employees at December 31, are as follows:

	1991	1990
Advances to personnel	274,836	150,765
Loans funded by CIP, repayable over a one-to-three year period, bearing interest (as from 1988) of 11.5% per annum and secured by employees' homes	79,706	159,125
	354,542	309,890
Less current portion	(318,787)	(260,308)
	35,755	49,582

5. Prepaid expenses

This balance is comprised of the following at December 31:

	1991	1990
Advances to organizations for research work	317,596	241,748
Travel advances	71,440	53,642
Advances to contractors	159,600	148,220
Other	363,498	216,219
	912,134	659,829

6. Property, plant, and equipment

For the year ending December 31, 1991, CIP has begun to record depreciation on property, plant, and equipment to be in accordance with generally accepted accounting principles. CIP has restated 1990 year end balances of this account to record accumulated depreciation from inception to December 31, 1990, in the amount of US$7,698,091 with credit to accumulated depreciation account and debit to capital invested in fixed assets account.

For the year ended December 31, CIP recorded depreciation expense in the amount of US$1,536,645.

At December 31, property, plant, and equipment are stated as follows:

	1991			1990	
	Cost US$	Accumulated depreciation US$	Net book value US$	Net book value US$	Depreciation rate years
Buildings	5,150,101	1,030,408	4,119,693	3,816,366	33
Research equipment	2,100,794	1,528,750	572,044	712,652	7
Vehicles	2,249,239	1,783,902	465,337	566,967	
Aircraft	3,019,486	981,319	2,038,167	2,340,116	4-10
Furniture and office equipment	941,978	719,639	222,339	226,695	7
Operating farm equipment	662,773	346,054	316,719	362,069	10
Installations	2,352,876	1,272,404	1,080,472	1,159,004	10
Site development	837,638	185,956	651,682	670,625	33
Computer equipment	1,315,151	795,608	519,543	593,933	
Communication equipment and other	686,982	479,846	207,136	255,912	7
	19,317,018	9,123,886	10,193,132	10,704,339	

Vehicles and other fixed assets replaced or retired are transferred from the property, plant, and equipment and related equity account to a memorandum account. Fixed assets sold or donated are eliminated from the memorandum account. The balance of the memorandum account at December 31, 1991, is US$1,313,172 (US$519,967 in 1990).

7. Bank indebtedness

The Center has various credit lines and loan arrangements with Citibank N.A., totalling US$530,000 at December 31, 1991 (US$ 250,000 in 1990), which bear interest at the New York prime rate plus 1.5%. The amounts are guaranteed by a deposit of US$218,400 (US$207,767 in 1990) in the afore-mentioned financial institution which earns interests at 3.35% per annum (6.6% in 1990).

8. Unexpended fund balances

This balance is comprised of the following at December 31:

	1991	1990
Operating funds - Unrestricted	(3,026,012)	(347,062)
- Restricted	947,836	1,070,201
Working funds	1,785,000	1,785,000
Capital funds	—	148,689
Special projects	2,533,074	2,222,194
Cooperatives activities	304,808	217,906
	2,544,706	5,096,928

9. Grants pledged

During 1991, the following donations were pledged to CIP for special projects in 1992 through 1994:

	1992	1993	1994
I. Special Projects			
International Development Research Center	99,700	—	—
Swiss Development Cooperation and Humanitarian Aid	2,264,733	1,902,781	577,230
United States Agency for International Development	317,400	—	—
Netherlands Government	120,000	—	—
Inter-American Development Bank	209,000	—	—
Belgian Government	694,125	527,900	—
German Government Agency for Technical Cooperation - GTZ	260,000	7,944	—
Finnish Government	64,100	—	—
OPEC Fund for International Development	21,000	—	—
	4,050,058	2,438,625	577,230
II. Cooperative activities			
Federal German Government Agency for Technical Cooperation - GTZ	24,860	3,270	—
Kellogg Foundation	10,000	—	—
Rockefeller Foundation	96,510	—	—
Scottish Crop Research Institute	10,897	15,787	1 925
United Kingdom Overseas Development Administration	190,876	128,294	—
	333,143	147,351	1,925

The above amounts are not reflected in the accompanying financial statements.

Abbreviations and Acronyms

Terminology

ABA	abscisic acid
ADG	*S. tuberosum* ssp. *Andigena*
ANOVA	analysis of variance
APW	Andean potato weevil
ARTC	Andean root and tuber crops
BW	bacterial wilt
Bt	*Bacillus thuringiensis*
Cd	Duration of season expressed as temperature sum
CEVd	citrus exocortis viroid
cfu	colony forming units
CGA	general combining ability
CLD	chlorotic leaf distortion
cm	centimeter
CPB	Colorado potato beetle
CPTI	cowpea trypsin inhibitor gene
cv	cultivar
d	day
DAP	days after planting
DLS	diffused-light store
DNA	deoxyribonucleic acid
EB	early blight
ELISA	enzyme-linked immunosorbent assay
FRKN	false root-knot nematode
g	gram
GA	gibberellic acid
ug	microgram, 10^{-6}
GCA	general combining ability
GPA	green peach aphid
GV	granulosis virus
h	hour
ha	hectare
HSVd	hop stunt viroid
IAA	indole 3-acetic acid
IPM	integrated pest management
LB	late blight
LMF	leafminer fly
m	meter
McAb	monoclonal antibodies

min	minute
mmho/cm	millimho per centimeter (a measure of electrical conductivity)
NASH	nucleic acid spot hybridization test
nm	nanometer, 10^{-9}
NCM	nitrocellulose membranes
ns	not significant
PBS	phosphate buffer solution
PC	produccion comercial
PCN	potato cyst nematode
PCR	polymerase chain reaction
pg	picogram, 10^{-12}
PLRV	potato leafroll virus
PSTVd	potato spindle tuber viroid
PTM	potato tuber moth
PVA	potato virus A
PVT	potato virus T
PVX	potato virus X
PVY	potato virus Y
ppm	parts per million
RCBD	randomized complete block design
RFLP	restriction fragment length polymorphism
RH	relative humidity
RKN	root-knot nematode
RSM	red spider mite
SMC	seed moisture content
SPCFV	sweetpotato chlorotic flecks virus
SPCV	sweetpotato caulimovirus
SPFMV	sweetpotato feathery mottle virus
SPLV	sweetpotato latent virus
SPMMV	sweetpotato mild mottle virus
SPW	sweetpotato weevil
t	metric ton
TGA	tuber glycoalkaloids
TIA	trypsin inhibitor activity
TPS	true potato seed
TSM	two-spotted mite
TSPS	true sweetpotato seed
VCG	vegetative compatibility group
ZT	Zeatin riboside

Organizations

AGRIS	International Information System for Agricultural Sciences and Technology (Italy)
ALAP	Latin American Potato Association
ARARI	Aegean Regional Research Institute (Turkey)
APA	African Potato Association
APA	Asian Potato Association
APS	American Phytopathlogical Society
AVRDC	Asian Vegetable Research and Development Center (Taiwan)
BARI	Bangladesh Agricultural Research Institute
BGRC	Braunschweig Genetic Resources Center (Germany)
BPI	Bureau of Plant Industries (Philippines)
CAAS	Chinese Academy for Agricultural Sciences
CABI	Commonwealth Agricultural Bureau International
CABO-DLO	Centre for Agrobiological Research (Netherlands)
CARDI	Caribbean Agricultural Research and Development Institute
CARI	Central Agricultural Research Institute (Sri Lanka)
CGIAR	Consultative Group on International Agricultural Research
CIAAB	Centro e Investigaciones Agricolas– A-Boerger (Uruguay)
CIAT	International Center for Tropical Agriculture (Colombia)
CICA	Centro de Investigación en Cultivos Andinos (Peru)
CICIU	Centro de Cria de Insectos Utiles
CIED	Centro de Investigaciones Educación y Desarrollo
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CNPH	Centro Nacional de Pesquisa de Hortalicas (Brazil)
CONAPAPA	Comite Nacional de Productos de Papa
COSCA	IITA/CIAT/Rockefeller Foundation Project financed by ESARRN
COTESU	Cooperación Técnica Suiza
CPRI	Central Potato Research Institute (India)
CRI	Crops Research Institute (Sichuan, China)
CRIFC	Central Research Institute for Food Crops (Indonesia)
CTCRI	Central Tuber Crops Research Institute (India)
EEA-INTA	Estación Experimental Agropecuaria-INTA (Argentina)
EMBRAPA	Empresa Brasileira e Pesquisa Agropecuaria (Brazil)
ENEA	Comitate Nazionale per la ricera e per lo sviluppo dell Energia Nucleare e delle Energie Alternative (Italy)
ESARRN	East and Southern African Root Crops Regional Network
FAO	Food and Agricultural Organization of the United Nations
FONAIAP	Fondo Nacional de Investigaciones Agropecuarias (Venezuela)
FORTIPAPA	Fortalecimiento de la Investigación y Producción de Papa (Ecuador)
FUNDAGRO	Fundación para el Desarrollo Agropecuario

GTZ	German Agency for Technical Cooperation
IAO	Instituto Agronomico per L'Oltremase (Italy)
IBPGR	International Board on Plant Genetic Resources
IBTA	Instituto Boliviano de Technologia Agropecuaria
ICA	Insituto Colombiano Agricola (Colombia)
ICAR	Indian Council for Agricultural Research
ICIPE	International Centre for Insect Physiology and Ecology
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
ICTA	Instituto de Ciencia y Technologia Agricolas (Guatemala)
IDB	Inter-American Development Bank
IDRC	International Development Research Centre (Canada)
IFPRI	International Food Policy Research Institute
IICA	Interamerican Institute for Cooperation on Agriculture
IITA	International Institute of Tropical Agriculture (Nigeria)
ILRAD	International Laboratory for Research on Animal Diseases (Kenya)
INIA	Instituto Nacional de Investigaciones Agropecuarias (Chile)
INIAA	Instituto Nacional de Investigación Agraria y Agroindustrial (Peru)
INIAP	Instituto Nacional de Investigaciones Agropecuarias (Ecuador)
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias (Mexico)
INIPA	Instituto Nacional de Investigacion y Promocion Agropecuaria (Peru)
INIVIT	National Institute for Research in Tropical Roots and Tubers (Cuba)
INPT	Institut National de Pomme de Terre (Togo)
INRA	Institut National de la Recherche Agronomique (Senegal)
INRAT	Institut National de la Recherche Agronomique de la Tunisie (Tunisia)
INTA	Instituto Nacional de Technologia Agropecuaria (Argentina)
IRRI	International Rice Research Institute
IPD	Intergenebank Potato Database
IPO	Research Institute for Plant Protection (Netherlands)
IRA-Bambui	Institute of Agronomic Research (Cameroon)
IR-I	Inter-Regional Potato Introduction Project (USA)
ISABU	Institut des Sciences Agronomiques du Burundi
ISNAR	International Service for National Agricultural Research
KARI	Kenyan Agricultural Research Institute
LEHRI	Lembang Horticultural Research Institute (Indonesia)
MSU	Michigan State University (USA)
NAL	National Agricultural Laboratories (Kenya)
NARS	national agricultural research systems
NASA	National Aeronautical and Space Administration (USA)
NCSU	North Carolina State University (USA)
NPRC	National Plant Research Center (Kenya)
NSAC	Nova Scotia Agricultural College

ODA	Overseas Development Agency
ORSTOM	Institut Francais de Recherche Scientifique pour le Developpement en Cooperation
PBI	Plant Breeding Institute (UK)
PCARRD	Philippine Council for Agriculture and Resources Research and Development
PGS	Plant Genetic Systems (Belgium)
PNAP	Programme National de l'Amelioration de la Pomme de Terre (Rwanda)
PRACIPA	Programa Andino Cooperativo de Investigación en Papa (CIP regional network)
PRAPAC	Programme Regional d'Amelioration de la Culture de la Pomme de Terre en Afrique Centrale et de l'Est
PRAPACE	Programme Régional d'Amélioration de la Culture de la Pomme de Terre et de la Patate Douce en Afrique Centrale et de l'Est (formerly PRAPAC)
PRECODEPA	Programa Regional Cooperativo de Papa (CIP regional network)
PROCIANDINO	Programa Cooperativo de Investigaciones en Papa (southeast South America)
PROCIPA	Programa Cooperativo de Investigaciones en Papa (CIP regional network)
PROINPA	Project for the Investigation of the Potato (Bolivia)
RICA	Red Interamericana de Comnicadores Agricolas
SAAS	Sichuan Academy of Agricultural Sciences
SAPHA	Servicios Agrarios, Puno (Bolivia)
SAPPRAD	Southeast Asian Program for Potato Research and Development (CIP regional network)
SCRI	Scottish Crops Research Institute
SEINPA	Semilla e Investigación en Papa (Peru)
SOTEC	Society for the Development of Appropriate Technology
UNALM	Universidad Nacional Agraria La Molina (Peru)
UNCP	Universidad Nacional del Centro del Peru
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNDP	United Nations Development Programmme
UPLB	University of the Philippines Los Baños (the Philippines)
UPWARD	User's Perspective with Agricultural Research and Development (CIP regional network)
USAID	United States Agency for International Development
ViSCA	Visayas State College of Agriculture (Philippines)
YNU	Yunnan Normal University (China)
YAU	Yunnan Agricultural University (China)