
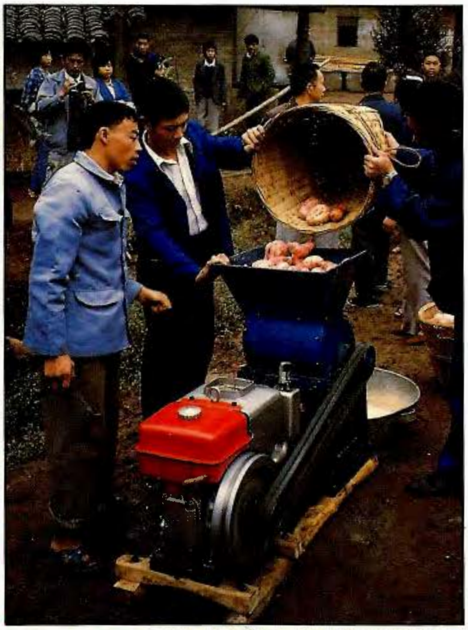


ANNUAL REPORT

CIP 1991

Worldwide Potato and Sweet Potato Improvement

RWANDA

CHINA

RWANDA

Cover photos:

Sweet potato, *Ipomoea batatas* L.(Lam.) plays a vital role in combating food shortages and malnutrition, especially in tropical countries with mounting population pressures and decreasing areas of arable land. The crop is used as fresh and processed food for humans, as well as for animal feed.

Sweet potato heads the list of developing world crops in terms of quantity of energy produced per hectare per day. Often grown under marginal conditions, sweet potato is now grown in more than 100 countries around the world, ranking seventh in terms of total global production and fifth on the list of developing countries most valuable food crops. On a per-hectare basis, average protein production per hectare is of the same order as cereals, beans, and chickpeas.

International Potato Center

Annual Report 1991

Worldwide Potato and Sweet Potato Improvement

International Potato Center
Apartado 5969, Lima, Peru

1991

The **International Potato Center (CIP)** is a nonprofit, 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 sweet potato as basic foods in the developing world. CIP is one of 13 nonprofit 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 1990, through the CGIAR, CIP received funding from the following donors: the governments of Australia, Austria, Belgium, Brazil, Finland, France, Germany, India, Italy, Japan, Netherlands, Norway, People's Republic of China, the Philippnes, Spain, and Switzerland; the Canadian Intertional Development Agency (CIDA); the Canadian International Development Research Centre (IDRC); the Danish International Development Agency (DANIDA); the Chemical and Miner Society (CHILE); the European Economic Community (EEC); the German Agency for Technical Cooperation (GTZ); the Inter-American Development Bank (IDB); the International Fund for Agricultural Development (IFAD); the Rockefeller Foundation; the Swedish Agency for Research Cooperation with Developing Countries (SAREC); the United Kingdom Overseas Development Administration (UKODA); the United States Agency for International Development (USAID); the United Nations Development Programme; the World Bank (IBRD).

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Foreword

During this past year, we have seen many changes at CIP and throughout the world. Here at CIP, we are in the final stages of the development of a new strategic plan leading into the future, and a new director general is already in place. The host country for CIP's headquarters has a new government and president, and the economic and social instability with which we have had to live and work in recent years is being curtailed: there is hope for better times on the horizon. This past year, there has been a major confrontation in the world as many countries rapidly joined forces to halt aggression. Important potato-producing countries in eastern Europe, with whom it has been difficult for CIP to cooperate until now, have opened their doors to the rest of the world for help and collaboration.

These are truly changing times, and the changes can be both good and bad depending on what we make of them. Many people fear change— the uncertainty, the unknown, the challenges of new situations. Visionaries, sometimes called dreamers, look on change as an opportunity to expand their horizons, test their ability to adjust, adapt, and challenge their intelligence and creative ability. We in agricultural research, we in the Consultative Group for International Agricultural Research (CGIAR) must, together with our national program partners, put our dreams to work in these changing times. Our work may be perceived as risky because there is no security that we can win our battle to develop the technology to produce adequate and sustainable foods for the populations of the near future, as well as to develop the technology to clean up the environment and maintain adequate levels of low cost energy for fuel and transportation. In the near future, good agricultural land will be needed to produce energy for fuel as well as food.

Without vision into the future and without strategic planning for the changes needed, this planet will run out of life; thus, we must increase the odds to favor the future of mankind. We must all be winners. Dreamers, visionaries, and chance-takers produced the green revolution and put us on the moon. Our dreams, visions, and scientific speculation can lead to success in solving the problems of food and environment that we face today.

The opportunities opening up in the world today can well be compared to the opportunities which Columbus presented to the world as he touched the American hemisphere, almost 500 years ago. A look at history shows that many of the opportunities he created were used up in the necessary struggles for freedom of religion and equality for all people, and in usually less necessary struggles over power and ownership of territories. Today we are blessed with communication capabilities that unite most of the world with up-to-date information, we are moving closer to an integrated approach to research, and most of the world has freedom of expression. But although human slavery has been abolished, for the most part, economic slavery is widespread across the developing and much of the developed world. Inadequate food and undernutrition hold over one half of the world in bondage. There is still much to be done although significant progress has been made during the past 500 years.

We at CIP are introducing changes that provide many valuable opportunities in today's world. These include increased collaboration with developing countries and among developed and developing countries, increased linkages with the private sector for addressing priority problems, new break throughs in curtailing use of chemicals through biotechnology, and even stronger emphasis on environmental issues related to agricultural research.

To take advantage of these opportunities, institutions such as CIP have to be programmed for change. Such programming requires flexible scientists who have breadth as well as depth in their training and experience. At CIP, the ongoing international planning conferences, the recent self-study, and the external reviews have all been a part of the process of programming CIP for change. The new strategic plan developed with our national partners is also a part of the process, and I feel confident that CIP will be taking advantage of the opportunities created by change.

CIP has a new chairman of the board of trustees who brings with him experience from other international institutions and other crops which can be very useful to CIP and its program of changes. He is supported by a very active group of trustees, from both developed and developing countries, who are anxious to help CIP move in the right direction to face changing needs. In my opinion, CIP management is very fortunate to have the mix of personalities and capabilities presently on the board, to help with policies and to overview programs leading into the future. Thus, as I move on to new challenges, I am able to write my last foreword for a CIP Annual Report with confidence in what the future will bring for CIP and the progress CIP will make in serving world agriculture.

I am proud to have been given the opportunity to found CIP and lead its progress over the past 20 years. Now it is appropriate that along with other changes, a new director general lead CIP into the future, keeping its mission abreast of the changing priority objectives for tuber and root crop production and utilization.

Richard L. Sawyer

Richard L. Sawyer
Director General

Coping with Change:

Charting a Course for Tomorrow's Research Careers

Dr. R. L. Sawyer helped launch CIP in 1971 and has served as Director General for the past 20 years. On his retirement, we asked that he write this article as a guide to young scientists now beginning their careers in international agricultural development.

Scientists who are now setting their course towards careers in research require talents and training that are different from what used to be required many years — or even a decade — ago. But the landmarks and guide lights leading them towards scientific accomplishment are much the same as before and promise to remain so tomorrow.

When I finished my Ph.D. in the 1950s, the status areas for research were haploids, wide crosses, growth regulators, and the peaceful use of atomic energy. The buzz words of today include sustainability, biotechnology, and perhaps strategic planning and modelling. These buzz words reflect a wider, faster-moving stream of science that will demand strong navigational skills in keeping careers on a straight course. The winds of change stem from population pressures on plants, land, food, water, and air.

William Ernest Henley in his famous poem "Invictus" proclaims: "I am the master of my fate, I am the captain of my soul," a philosophy that serves well in guiding careers. Strategic career planning recognizes that it is we ourselves who set our own course: not our superiors, nor our facilities, nor our equipment, nor our teachers. The "Guidelines" suggested here are intended for use by young scientists, as well as by their mentors.

Early Learning — The Yeoman Years

Successful research careers are goal-driven, but also require planning and the setting of objectives within time frames to meet specific needs. Ideally, we should know our career choice at the start of our undergraduate training. Unfortunately, most of us chart our path as we develop our skills. We do not always begin with the knowledge of our final port of call. But we should always at least try to have a clear idea of the direction in which we are heading. Some basic points of the career compass include the development of:

- a missionary zeal for accomplishment;
- an active mind, open and thirsty for knowledge, and hands willing to work;
- a willingness to persist in the process of learning and doing, no matter what obstacles and storm winds we encounter.

Exploring and learning are continuing processes for the successful research scientist of today or tomorrow. During the early years of formal training, students who expect to become scientists should "hang loose," training across many fronts, and keeping their options open. Tunnel-vision training of the recent past cannot produce flexible scientists capable of adjusting to the changing research needs and changing job responsibilities that are required for 21st-century science. For a productive research career:

Do not hurry the training and make sure there is an adequate balance between depth of training along lines of particular interest and capability, and breadth of training across many fronts to prepare you for the political, social, and economic changes rapidly taking place across the world.

In recent years, science has been knocked from its pedestal, and research is now both a service and a product that must be sold to the many audiences on which it depends for funding. During the lifetime of today's young scientists, the world of research will become an integrated community spreading throughout the developed and developing world to include national and international programs in both the public and private sectors. Good scientists must make sure they acquire good communications skills in their training, so that they can adequately explain the value of what they are doing to the general public. Many institutions today expect their scientists to be able to attract the funding for their research and their salaries. This means scientists have to be able to sell research as a product or service.

First Jobs

Years one and two on the first job require many critical adjustments. For many young scientists who have spent several years concentrating on very specific thesis projects, the move to new research projects can be difficult. In fact, many scientists stay with their thesis work for the rest of their careers.

Quickly chart a well-balanced work program that considers the priority problems of your institution, your community, and your country.

The thesis is important and demonstrates an ability to do creative research. However, the thesis research should open your mind and help set your course towards other challenges.

For young scientists who have gone abroad for training, the return home can be traumatic. Many of you expect to come back to the country you left. But both you and the country will have changed tremendously; thus the social, political, and economic adjustments required of you come at a time when you need to be establishing scientific credibility in your first research job. The sophisticated research equipment on which you depended for your thesis may not be available at the institution to which you have returned. (This could well be a blessing in disguise, because it could help cut the cord on thesis research dependency.)

International scientists going to a new country for their first research job expect to face new situations and may find the adjustment easier than those who are returning home from abroad. There are, however, many family adjustments — to school systems, languages, cultures, social structure—that occur at the same time you are mapping the first stop on your research career. While sharing in the adjustment process of your family, you must persist in your research efforts.

Balance of work

As a beginning scientist, quick visibility to management and clients is essential to the quality of your research, your caliber as a scientist, and your dependability as a person. You need to start a research process that will lead to a steady flow of research papers to be published in scientific journals and provide recognition among your peers througout the research world. You also will want to start the research that could possibly lead to a major scientific breakthrough that will ensure job opportunities for a major portion of your research career. Such breakthroughs are rare, but lead to golden opportunities and many career alternatives.

The research process needs to be attended to as soon as possible during your early years, along with any other assignments such as teaching, advising, or consulting.

Ideally, I suggest the following balance for research time:

Type of research	% research time
Progress-report	33%
Refereed journal	33%
Breakthrough	33%

Progress-report research will give you fast visibility as a scientist and produce quick results about which you can talk to managers and clients. It gives your administration results that can be used in their annual publications and provides extension workers with material for use in discussions with growers. Progress-report research includes variety trials, herbicide testing, screening of new potential varieties for resistance to pests and diseases, fertilizer trials leading to recommendations for farmers, and screening of chemicals for a variety of agricultural uses.

The research reported in ***refereed journals*** usually requires 3 to 5 years to obtain results sufficient for acceptance. This research may require multilocational verification in the testing as well as the accumulation of knowledge on seasonal or climatic variation. The emergence of a new variety, a new control measure for a disease or insect, the finding and verification of a new plant species, or the development of a better screening technique, are examples of research accomplishments that need to be shared with your peers in scientific journals and can lead to visibility in the national and international scientific communities. Excellent examples of such research are found in CIP Thrust reports.

For most scientists, the time available for ***breakthrough*** research is limited during the early years. Most initial research will probably be associated with their customary research responsibilities, usually in well explored areas. Breakthrough research may not be listed among the priority objectives of your parent institution, but it should come within the framework of the institution's mandate. It will challenge your thinking, keep you abreast of current research literature, and start an interchange of ideas with your peers through correspondence and discussions at scientific meetings. The true-seed (TPS) research with potatoes and the development of the potato for the warm tropics are good examples of breakthrough research at CIP. This research impacts directly on global agriculture and people of the developing world. You should phase into breakthrough research gradually over the early years: however, many scientists may never advance to this type of research in their career. Their capabilities will direct them to other research or proposal opportunities.

Seasoned Scientists

By the time you have been on your first job for 5 to 7 years, your research should be reflected in a steady flow of papers published in refereed journals. These should lead to queries as to your availability for vacancies in other institutions. A scientist should take these queries seriously, since periodic changes are very important for advancing research careers. Most scientists will find that at least two or three changes in institutions during their first 15 years will be beneficial to their career. Sometimes such changes occur in a single institution through a change of job responsibility.

Career positions in advanced research institutions such as CIP are maintained for scientists who have moved into breakthrough research and have developed a good national and international image during their first 10 years in research. If you have not demonstrated such ability within this time frame, you should seriously consider moving on, before the institution starts nudging you along. By the age of 45, scientists should find themselves on a correct course for the years that should be the most productive of their careers.

Many of you who have achieved the most visibility as scientists will be challenged by the possibility of going into management and some of the job offers you receive will be for management positions. Before making this change, make sure you have the personality and flexibility to became a good manager. I strongly urge scientists to take a good course in management early in their research career.

Take a management course early in your career to identify your natural inclinations, capabilities, and limitations, and thus strengthen them through study and carefully selected experience.

Even though you may never choose to enter a management position, such training will help you to better manage your research career and your life.

Many scientists throw away their most productive research years by moving into management positions for which they are not suited. Some of the questions you should ask yourself before making such a change are: Do you take criticism readily and give criticism gracefully? Do you like people? Do you settle personality problems without getting emotionally involved? How stable are you emotionally? Do you want to go into management, because you feel it is more important than research? Would you feel productive in a situation where you no longer had a flow of research papers? The markers for success in management are very different from those in research. They are more indirect and depend on the institution and staff being well managed.

No matter the stage of your career, you should periodically check your course setting, and ask yourself questions about the past and present and what you expect for the future. Do you have a good balance of work among your present research projects? Are you sufficiently productive in present research to deserve some freedom of choice for a portion of your research time? Have you taken the time to train technicians to approach your research as you would? Do you feel locked into a situation where you are no longer "the master of your fate?"

The answers to these kinds of questions will indicate the career track that you should be considering, the training you should be getting or giving, and the kinds of discussions you should be having with management and your family in order to make the most of your research career.

In the first twenty years of CIP, a research environment has been developed and maintained wherein the greatest contributing factors to scientists' careers are their individual capabilities — not bench space, research equipment, attendance at scientific meetings, or their supervisors or management. The mandate and priority research objectives of the institution have served as the guiding principles for all of CIP's activities with concern for each individual career as well as for the institution as a whole.

The duty of all parent institutions and their management is to provide a sound vessel for their scientific careers. Whatever journey you may choose in your career; smooth sailing to each of you.

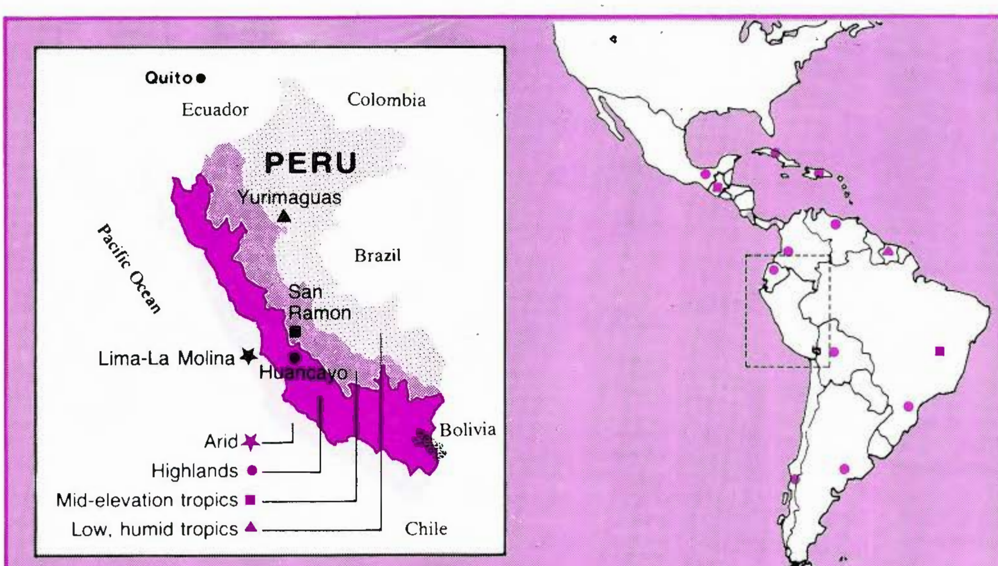
Richard L. Sawyer
Director General

Agroecological Zones and Related Thrust Research in 8 CIP Regions

CIP has four experiment stations in Peru, one in each of the major agroecological regions of the country. A fifth station has now been added at Quito, Ecuador. Our headquarters is located at a coastal desert site near Lima (240 m altitude), where facilities include general research and administrative offices, as well as laboratories, greenhouses, refrigerated and diffused-light stores, growth chambers, and experiment fields. A second station, in the cool Andean highlands near Huancayo (3,260 m), is the home of CIP's World Potato Collection. The remaining two stations are in the Amazon region: on in the mid-elevation jungle of San Ramon on the eastern slopes of the Andes (800 m), and the other in the hot, low jungle of Yurimaguas (180 m).

CIP research sites in Peru and the potato-growing seasons, with meteorological data for 1990 crop year.

Site:	✶ Lima-La Molina		● Huancayo	■ San Ramon		▲ Yurimaguas	● Quito
Latitude:	12°05'S		12°07'S	11°08'S		5°41'S	00°22'S
Altitude:	240 m		3280 m	800 m		180 m	3058 m
Growing season	Jan-Mar 90	May-Nov 90	7 year average	Nov-Mar 89-90	May-Aug 90	May-Aug 90	Oct-Apr 89-90
Air max (°C)	24.25	17.67	20.58	32.60	30.74	32.08	18.4
Air min (°C)	16.76	12.87	6.41	19.59	17.64	21.90	5.9
Evaporation (total mm)	515.00	588.00	1109.60	666.90	416.60	203.50	1361.0
Rainfall (total mm)	0.1	11.3	668.31	822.70	825.70	442.60	1140.5
Solar radiation (daily MJ/m^2)	16.90	12.10	20.22	29.91	23.28	33.20	n.a



CIP's international staff includes nearly 100 scientists, administrators, and other experts from over 20 countries. Many of our international staff members are stationed at CIP regional headquarters located throughout the developing world (next page), where they collaborate directly with the national programs. In Lima, Center operations are supported by more than 500 supporting scientists, technicians, administrative personnel, secretarial and clerical support staff, and specialized workers.

CIP's six research departments-Breeding and Genetics, Genetic Resources, Nematology and Entomology, and Social Sciences-are staffed and headed by international experts from developed and developing countries.

Our interdisciplinary research is concentrated within ten "Thrusts," which combine the work of specialists from several disciplines to improve potato and sweet potato production and use

CIP's Thrusts

I	Collection, Maintenance, and Utilization of Unexploited Genetic Resources
II	Production and Distribution of Advanced Breeding Material
III	Control of Bacterial and Fungal Diseases
IV	Control of Virus and Virus-Like Diseases
V	Integrated Pest Management
VI	Warm-Climate Potato and Sweet Potato Production
VII	Cool-Climate Potato and Sweet Potato Production
VIII	Postharvest Technology
IX	Seed Technology
X	Potato and Sweet Potato in Food Systems

PRACIPA	Programa Andino Cooperativo de Investigación en Papa	Bolivia, Colombia, Ecuador, Peru, Venezuela
PRAPAC	Programme Régional d'Amélioration de la Culture de Pomme de Terre en Afrique Centrale	Burundi, Rwanda, Uganda, Zaire
PRECODEPA	Programa Regional Cooperativo de Papa	Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama
PROCIPA	Programa Cooperativo de Investigaciones en Papa	Argentina, Brazil, Chile, Uruguay, Paraguay
SAPPRAD	Southeast Asian Program for Potato Research and Development	Indonesia, Papua New Guinea, Philippines, Sri Lanka, Thailand, Malaysia
UPWARD	Users Perspective with Agricultural R-Esearch and Development	Indonesia, Nepal, the Philippines, Sri Lanka, Thailand, Vietnam

CIP Collaborative Regional Bridges

CIP manages its global research and development program within a regional network through which CIP and national program scientists systematically evaluate technologies under a range of local conditions. This approach takes into account the farmer, consumer, and agribusiness community at all research levels, from the moment a problem is identified, through experiment station and on-farm testing and adaptation, until an effective solution is accepted by local potato and sweet potato producers.

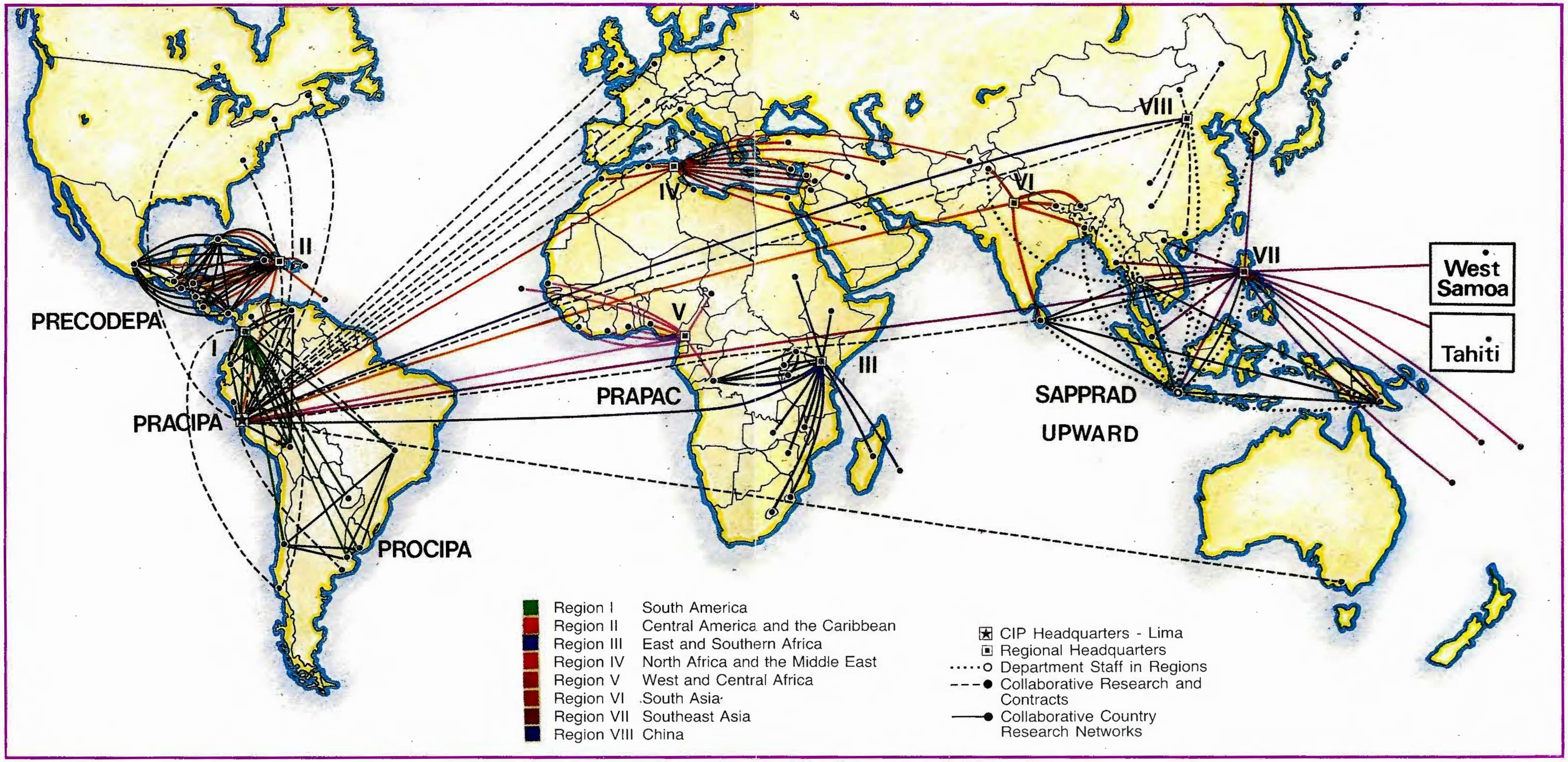
Rapid and continuing feedback from this evaluation plays a key role in guiding CIP's overall research program at headquarters in Lima, Peru.

CIP's capabilities are enhanced by numerous research and consultancy contracts that take advantage of the expertise and facilities available at other institutions, often in collaborative research in developed countries. Through contracts with developing-country institutions, we share specialized human and physical resources to focus on high priority local research.

Country Networks

CIP had helped to develop six unique collaborative research networks. In these networks, several countries in a geographical area pool their resources to solve common production problems. Once priorities have been assessed, each country undertakes the projects for which it has a comparative advantage, sharing its results with the others. CIP participates in the networks as an equal partner, providing technical assistance in its areas of expertise, as well as administrative guidance. The distribution of efforts allows CIP and the member countries to utilize their resources efficiently.

This system of shared responsibility and active interchange differs fundamentally from other agricultural networks that are designed primarily to aid in germplasm distribution. The members benefit from a wide range of research results, and at the same time their interests are consolidated and their self-reliance is strengthened.



PRECODEPA

Programa Regional Cooperativo de Papa (1978)
Costa Rica, Cuba,
Dominican Republic, El Salvador,
Guatemala, Haiti, Honduras, Mexico,
Nicaragua, and Panama.

This collaborative research network links potato research efforts of Mexico, Central America and Caribbean countries. The Research Program of PRECODEPA includes 10 projects aimed at solving the major constraints to potato production and utilization in the Region. Late blight is considered the most important pathological problem for PRECODEPA countries. The late blight project is led by Mexico and Costa Rica, with participation of all other members. Tuber moth also is an important constraint to potato production, as it causes severe damage to tubers in the field or in storage. The project's objectives are to reduce damage and to cut excessive use of pesticides. To combat this pest, an integrated control program is under way which includes the use of pheromones, biological control, and cultural practices. Bacterial wilt continues to cause yield losses in many countries of PRECODEPA although remarkable progress in the control of this disease has been reported in Costa Rica. An intensive program to promote potato consumption in the Region is being carried out under the leadership of the network's coordinator. Selected communication media are being used to reach wide audiences.

This network is continuing its workplan according to the program established in the five-year plan. The annual meeting of PRECODEPA was held in Costa Rica, where representatives from the 10 member countries presented their annual reports and discussed a program for research, training, and technical assistance for the coming year. The executive committee composed of three members met on three occasions during the year to closely monitor project development and other issues relevant to regional potato production.

CIP supported research, training, and technical assistance activities of PRECODEPA in 1990 through the coordination of its Regional Office in Santo Domingo. Germplasm contribution to PRECODEPA in 1990 amounts to 679 clones, cultivars, and progenies which were sent in the form of tubers, in vitro plants or botanical seed. Training with full or partial sponsorship from CIP was given in 6 courses and several individual training activities. CIP scientists participated in project reviews and provided technical assistance to several countries during the year.

PRACIPA

Programa Andino Cooperativo de Investigación en Papa (1982)
Bolivia, Colombia,
Ecuador, Peru, Venezuela.

PRACIPA research activities now form the potato research wing of a more extensive network in the Andean Region (PROCIANDINO), which covers five major crops of the region. PRACIPA still retains its autonomy and its own Directors Committee. Future plans call for the full incorporation of all administrative aspects under PROCIANDINO. A special bulletin covering the results activities, production and commercialization was published, and a planning meeting was organized in Cali, Colombia. Participants included research, extension and producer representatives. Clear objectives and activities were needed by PRACIPA to propose a follow-up to Phase III of the present network. The new activites include the following:

- Germplasm tolerant to frost.
- Germplasm resistant to late blight and virus.
- Early maturing varieties.
- Control of andean potato weevil.
- Integrated management of potato tuber moth.
- Limiting factors for potato production at farm level.

All of these activities, particularly 1 to 5, are included in CIP's own research priorities, thus there will be a close link between national research and CIP activities. Activity 6 will include specific research within each national program, but the overall program may be divided into components that by individual countries on behalf of the group.

PROCIPA

Programa Cooperativo de Investigaciones en Papa (1982)
Argentina, Brazil, Chile, Paraguay, Uruguay.

The members of this network continued to exchange genetic materials in 1990. Parental materials as well as segregating progenies in vitro and in true seed (botanical) form were thus made available to national programs. The germplasm was exchanged for purposes of breeding and germplasm enhancement.

Likewise, advanced potato clones selected for adaptation, resistance to pests, and consumer quality were distributed among the countries. Funding for these activities was provided by each national institution involved. CIP contributed to the total potato development effort through collaborative research and contract projects.

To enable PROCIPA to expand its current activities, especially its inter-regional projects, a proposal for external assistance has been prepared and submitted.

SAPPRAD

Southeast Asian Program for Potato Research and Development (1982)
Indonesia, Malaysia, Papua New Guinea, the Philippines, Sri Lanka, Thailand.

In 1990, member countries continued to conduct potato research projects assigned by SAPPRAD using national funds except in the Philippines which had funding support from SAPPRAD. The projects included: lowland potato breeding (the Philippines); mid-elevation potato agronomy (Indonesia); true potato seed (Sri Lanka); practical seed production (Papua New Guinea); small-farm mechanization (Malaysia); and postharvest and utilization (Thailand). In addition, each country continued to implement SAPPRAD-funded technology transfer projects aimed at bringing research results to farmers' fields. Indonesia, the Philippines, and Thailand conducted sweet potato evaluation trials to select 10 outstanding cultivars that were sent to the Plant Research Institute in Australia for pathogen clean-up and eventual distribution to member countries. Indonesia and the Philippines, which have the biggest sweet potato hectarages, began users'-perspective research in collaboration with UPWARD.

Regional workshops on consumer potato storage and sweet potato germplasm management were conducted in collaboration with CIP; production training courses were also held in each country.

A joint technical and coordinating committee meeting was held in Yogyakarta, Indonesia to share results, review progress of work and approve workplans for 1991.

SAPPRAD is funded externally by the Australian International Development Assistance Bureau (AIDAB) with appropriate counterpart funds from member countries. In 1990, the Australian Center for International Agricultural Research (ACIAR) provided funds to enable the Plant Research Institute (PRI) in Burnley, Australia to clean up outstanding potato cultivars from member countries.

As in the past, CIP support consisted of donation of germplasm, technical advice and fund administration. As SAPPRAD neared the end of Phase II, AIDAB and CIP commissioned an external team to review the program. Noting the network's practical accomplishments and recent addition of sweet potato to its mandate, the review team has recommended the extension of SAPPRAD into Phase III for another five years.

PRAPAC

Programme Régional d'Amélioration de la Culture de Pomme de Terre en Afrique Centrale (1982)

Burundi, Rwanda, Uganda, Zaïre.

The "Programme Regional d'Amélioration de la Culture de la Pomme de Terre" (PRAPAC) was established in 1982 to include Burundi, Rwanda, and Zaïre. In 1987, Uganda became a member of the network.

The Agency for International Development of the United States of America (USAID) provides the financial backing for PRAPAC, by supporting research activities through bilateral grants and also the PRAPAC Coordinator position. During 1990, this network was strengthened by the allocation of USAID bilateral funds in Zaïre and Burundi.

In Burundi, an integrated approach was launched for bacterial wilt control in the production of basic seed tubers. This approach has reduced the bacterial wilt infection from 60% to less than 1%, using a seed tuber production scheme based on an in vitro method of propagation combined with improved cultural practices. The method had proved to be practical and acceptable to resource-poor farmers.

The area planted to the variety "Lupita," selected in 1989 for resistance to late blight, is rapidly increasing. In Rwanda, several advanced clones with resistance to late blight were identified and are ready to be named as new varieties. The National Potato Program (PNAP) has started in vitro multiplication to enable the rural development projects to multiply and distribute good quality seed to farmers.

The construction of a training center for PRAPAC, located at Ruhengeri, Rwanda was completed and hosted three production and postharvest courses. In Uganda, a new seed program was established using varieties from Rwanda and local cultivars. Over 100 tons of quality basic seed potato were supplied to farmer-multipliers. Preliminary results of research on potato production from true potato seed (TPS) demonstrated great potential for utilization by vegetable farmers. A researcher from Zaïre has developed an appropriate method for the production of dehydrated potatoes as partial requirements for advance degree studies. This thesis work was supported through PRAPAC.

UPWARD

Users Perspective with Agricultural Research and Development (1989)
Indonesia, Nepal, the Philippines, Sri Lanka, Thailand, and Vietnam.

UPWARD completed its second year of operation in projects which include consolidation and expansion of research activities. Projects on sweet potato including research on postharvest, marketing, consumption, and nutrition are under way at national and local levels in all network countries.

Information exchange throughout Asia and the South Pacific on sweet potato and research methodological issues was facilitated by UPWARDS's inaugural workshop ("Why Users Matter in Agricultural Research") which was held in the Philippines in April and attended by 33 participants from all over Asia. An in-country training workshop on "Household Diagnostic Skills" was held in the Philippines including training on agricultural systems characterization, gender analysis, and food-habit interpretation. An Asian "Training of Trainers" course was also held in the Philippines, and was attended by Asian researchers.

Current research is strongest in the Philippines, and for the immediate future, priority will be given to expanding research in other countries of Asia, while consolidating and strengthening the Philippine research. Support also will be given to in-country training efforts that build on the international training courses now conducted directly by UPWARD.

UPWARD is funded by the Dutch Government and additional support was received from UNDP for some training activities during the year. Human resource support is received from several National Programs within Asia, as well as from universities and research institutes. CIP provides funding for the network coordinator and supports the headquarters administrative organization. UPWARD began in mid-1989, and was initially funded for three years. It is expected that an external review in early 1992 will evaluate the possibility of an extension to the project.

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Science and Technology:

Let the sky rain potatoes

CIP/Smithsonian Symposium

CIP and the Smithsonian Institute collaborated in a Quincentenary Symposium in Washington D.C., U.S.A. in October 1990, which was devoted to "The Potato: The Development Food". The presentations, summarized in this article from The Economist, represented the global scientific community now joined in development of the potato and other root and tuber crops.

The Symposium was "to commemorate the 500th Anniversary of Columbus' landing in the New World." The Smithsonian Institution's National Museum of Natural History will open a major exhibition, "Seeds of Change", on Columbus Day 1991.

IF ONLY FALSTAFF could have his wish. By the turn of the century, only a decade away, the world will have 7 billion mouths to feed, and the numbers will keep rising for at least 30 years after that. Good farmland is unlikely to increase. Though the "green revolution" of the 1960s—based on fertilizers and new strains of rice, wheat and maize—has done much to close the hunger gap in poor countries, it cannot satisfy the appetites of the next few generations. Will potatoes come to the rescue?

One group of believers is the International Potato Center (CIP), a research and agricultural training organization with headquarters in Peru, which earlier this month sponsored a conference in Washington on the potential of the spud. Greater reliance on potatoes has already begun in some places where hungry mouths are growing fastest. China has quadrupled the tonnage of its crop in the past 30 years and is outranked only by the Soviet Union (where a bumper crop is rotting in the fields). India is not far behind China. Other countries where the crop is becoming a mainstay for poor families include some in Africa, as well as Sri Lanka, Vietnam and the Philippines.

This spread may seem unlikely for a vegetable usually thought of as a cool-weather crop. That undeserved reputation is a historical accident: it just so happened that the Spaniards first found potatoes under cultivation high in the Peruvian Andes, from where they were introduced into Europe in about 1538. Had the *conquistadores* bothered to take a closer look at the whole Incan empire they would have found potatoes being grown in the lowlands too.

Not only will potatoes grow almost anywhere—even deserts, provided temperatures drop at night—they also yield more food per acre than grains do. An acre of potatoes, for example, produces twice as much protein as an acre of wheat. Potatoes can also withstand some conditions that grains cannot; as a root crop with its edible parts below ground the potato is practically storm-proof. And although it typically takes at least 150 days for potatoes to mature

From The Economist, October 13, 1990.

in temperate climates, in lower latitudes they are ready to harvest in as little as 40-90 days after planting. This enables farmers to sandwich crops of potatoes between slower growing cereals like wheat, rice, and corn, making arable land that much more productive.

Potatoes are exceptionally nutritious: they are rich in potassium, iron, magnesium, vitamins B and C, and complex carbohydrates, have a better quality protein than soybean and are 99.9% fat-free. The idea that they are fattening is a myth. Some historians have argued that there would have been no industrial revolution in Europe had low-paid workers not been able to feed themselves and their families on potatoes. But the history of the potato has some warnings too. The Irish famine of 1845-51 is often held up as evidence of the potato's vulnerability to diseases. The famine saw a third of the local population starve and another third or more emigrate.

Nothing like that famine has been seen since, but the fact that 80% of American and Canadian potato acreage is planted with just six of the thousands of varieties available is a grim reminder that it could happen again. If the potatoes in nineteenth-century Ireland had not been genetically uniform, the chances are that the famine would have been less severe. The Incas implicitly recognized the importance of genetic diversity, and CIP's scientists are determined to conserve it. They have collected 6,500 Latin American varieties for their breeding program, but do not rely on them alone. To counter the bacterial diseases of potatoes, for instance, they and their colleagues at Louisiana State University in Baton Rouge are experimenting with genes that cause silk moths to produce antibiotics. They want to put the genes into potatoes, where it is hoped they will do the same.

They are also hoping to fit potatoes with genes synthesized in the laboratory, so as to prevent viruses from multiplying in their cells. Antibiotics do not work against viruses; although some varieties of potato have genes that produce a natural resistance to some viruses, no variety has natural wide-ranging resistance. Since fungi also infect potatoes—indeed they contributed to the Irish famine—attempts are also under way to isolate and duplicate substances made by certain bacteria which act as antidotes for fungi. Once the genes that govern the manufacture of these antidotes are found, it may be possible to transfer them from bacteria to potatoes, yielding strains that will produce the antidote.

Potato engineers are also looking into the possibility of incorporating in potatoes those genes from bacteria which carry the instructions for making natural insecticides. One such insecticide works by attacking the skeleton and gut of several insects that prey on potatoes, and it spares both farmers and the environment the costs of commercial pesticides. Potatoes are exceptionally good candidates for genetic manipulation, because many species carry their genes on four sets of chromosomes in each cell, rather than on the two that are characteristic of animals and most plants.

Although none of these developments is ready for widespread application yet, others are. For example, potato plants with the best traits for various growing conditions can be propagated in test-tubes while still in the embryonic stage, provided they are maintained first in simple nutrient solutions and then in cheap screened outdoor enclosures, where they multiply even more rapidly. This so-called tissue-culture method, adopted in nearly 30 poor countries, has been especially successful in Vietnam. Peasant farmers there start the fledgling plants in their bedrooms, use part of the output for their own fields and have enough left over to sell to other farmers for cash. So popular has the technique become in Vietnam that potatoes are now the second-biggest crop (by weight) after rice.

CIP has also revived the ancient Peruvian practice of growing potatoes from seed as well as from the more conventional tubers. Using this approach, a mere handful of seed replaces tons of tubers, which are costlier and harder to transport. Tubers themselves can then be consumed rather than cut up and planted. The seeds are also less likely to transmit disease and are available throughout the year. Nearly 40 developing countries are adapting the seed method to their needs and some are already using it commercially.

Meanwhile, if the future of the white potato looks good, so too does that of its fellow root crop, the sweet potato. Recognizing that it will often grown on land too poor for the white potato, CIP has recently turned its attention to improving the nutritious yellow tuber as well.

A brief history of spuds

Why are potatoes called spuds? Rumour has it that a Society for the Prevention of an Unwholesome Diet has something to do with it. The early English word for a small digging implement-which just happens to be "spud" -may be a better bet, but potatoes were, indeed, thought to be poisonous (as were their relatives, tomatoes and green peppers) when they first came to Europe from the new world.

As it happens, all three vegetables belong to the same plant family as deadly nightshade and another noxious weed, tobacco. Petunias, too, are members of this family, and since potato blooms look a great deal like petunias, Marie Antoinette had them grown at Versailles to wear in her hair.

Fortunately for humanity, Antoinette Auguste Parmentier, a French pharmacist of the time, knew better. He persuaded Louis XVI to let him plant a field of the tubers and to station royal guards around it by day but leave it unguarded at night. As the canny Parmentier expected, peasants slipped in and raided the plot under cover of darkness. Soon potatoes were being eaten all over the realm.

Meanwhile, the Scots had overcome their original aversion to potatoes-it was not only that they were poisonous, but that they were not mentioned in the Bible. When Scotch-Irish immigrants began to settle in Maine in 1791 they brought them along into what was to become one of the United States.

It was, however, Thomas Jefferson who returned from Paris to introduce ***pommes frites*** to his fellow citizens, who have called them french fires ever since. Now as American as apple pie, they are being promoted as "American fries" at McDonald's and similar fooderies in places such as Tokyo and Hongkong.

Profitable as this is proving for fast-food entrepreneur and American processed-potato exporters, the cynical are displeased. Fries are promoted primarily in the family-restaurant trade, the idea being to hook children early and make them customers for life. But many new devotees of American fries do not know what most American consumers do! that preparing fries in the fast-food manner soaks the nutritious, low-calorie potato with lots of unwholesome fat. Fries for starters, cancer and heart disease for dessert.

Summary of Research Programs

As CIP develops its new Strategic Plan, we are taking stock of our achievements and lessons learned throughout the Center's first two decades of experience. In this summary, we tie current and past research work to four emerging management principles that are at the heart of CIP's research strategy. Examples from this year's Thrust reports are used to show relationships between current operations and the new strategic approach.

Focus - Integration - Balance - Impact

As in the past, our Thrust findings document substantial scientific advances and the building of strong research collaboration throughout the developed and developing world (see Thrust profiles for a quick overview). Now we must ensure that these efforts are translated efficiently for fast, productive impact in farmers' fields.

Within our new four-pronged approach, key strategic operations will be consolidated to (1) focus on projects with high potential for immediate impact, (2) integrate our global research, information, and training activities, (3) balance long-term goals with operations to quickly adapt and relay research findings to farmers, and (4) develop a strongly impact-oriented institutional culture at CIP, in which practical impact is our basic driving force.

Our first aim is to focus on fewer activities. We are selecting research, information, and training projects based on both their scientific value and promise for rapid and sustainable use by farmers. Activities will be integrated within each project to achieve maximum synergism and impact. In countries that already have substantial national research capabilities, we will emphasize research collaboration. In countries where NARS capabilities need to be strengthened for long-term sustainable development, we will emphasize training and information activities, thus paving the way for later collaboration in research.

As we more clearly identify the intensive focus areas, we will balance short-term practical benefits in the field with longer-term development benefits to partner institutions and NARS. Specific aims are to continually assess our partners needs, develop and adapt the appropriate technologies, and fully share and evaluate the results within the global agricultural community.

Further decentralization of CIP's activities within the global regional framework will help catalyze the four-part plan. In moving closer to our partners, we can collaborate more effectively with national agricultural research systems

(NARS) and the private sectors of both developed and developing countries. Using this approach, we will continue to develop novel research methodologies such as biotechnology to complement conventional approaches, with strong emphasis on environmental issues related to agricultural research.

The Strategy in Action: Examples from our 1991 Thrust Reports

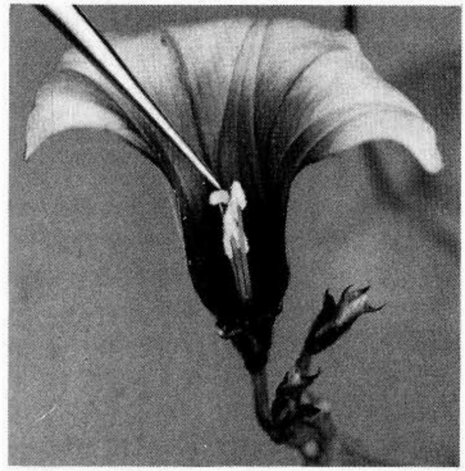
Our germplasm and breeding work reflects substantial achievements, particularly in the creation of improved potato materials that provide combinations of resistances and tolerances to biotic and abiotic stresses. We also have helped facilitate use of potato materials from selected sources, other than the Center's breeding program. As in previous years, we made steady progress in selecting potatoes with farmer-approved agricultural traits. For example, we have selected progenitors with high general combin ng ability, all with good tuber characteristics and adaptation to warm-climate conditions. Some of these potato populations also segregate for resistance to some of the most important diseases and stresses, including resistance to early blight, late blight, bacterial wilt, PLRV, and the immunity to PVY and PVX, and heat tolerance. Such broad-based potato populations are extremely valuable for the long haul, as we try to match production to meet growing demand. Our goal is to achieve optimal sustainable production at the lowest possible costs — both financial and environmental — to benefit low-income producers and consumers.

The challenge now facing CIP is to intensively exploit these populations in creating materials with specific combinations of traits for specific agroecologies. Thus, we will continue to strengthen the role of breeders in regional locations, who will work closely with NARS partners in blending the materials with locally adapted materials or in direct selection of promising varieties. Farmers will be more closely involved in the evaluation and selection as improved clones are redistributed to the various eco-regions for testing.

One of our most intensive, successful areas of research has been potato germplasm enhancement. This year, for example, we have clearly confirmed the enormous potential of haploids for facilitating evaluation of species germplasm. We have also advanced substantially in our work at the diploid level — and have then made crosses using a diploid-tetraploid crossing system. Such approaches have produced major scientific gains, and we now have a virtual treasure trove of enhanced genetic materials and information in this vital area. But we must reassess the balance between such long-term germplasm enhancement approaches and the short-term impact of making advanced materials available to national programs for their selection and use for practical impact in farmers' fields.

We envision that biotechnology will help accelerate our work in potato germplasm enhancement. Our report on the application of molecular methods reflects rapid advances in the use of genetic engineering. This includes introduction of anti-bacterial genes that have broad-spectrum activity against important plant pathogenic bacteria, such as *Pseudomonas solanacearum*, the causal agent of bacterial wilt disease. We have also developed a methodology for obtaining transgenic plants with antisense sequences for PSTVd. Our report also reflects advances in the use of genes that can help us combat various insect pests, including potato tuber moth, as well as in the use of anti-fungal genes as a potential control for late blight. Through such research, we plan to insert desirable genetic traits into advanced genotypes, thus avoiding the recombination problems associated with conventional breeding methodologies programs. Work on developing a more detailed RFLP linkage map of potato has progressed systematically this year and promises to serve us well in potato population development and identification of useful traits. These biotechnological approaches involve heavy collaboration with institutions in the developed world. As we assess comparative advantages, it seems likely that more biotechnological work will be done in collaboration with the private sector.

In sweet potato germplasm and breeding work, we continue to our focus on germplasm collection, characterization, and enhancement techniques, as opposed to breeding per se. Our sweet potato work takes into account the role of this crop as a source of food, feed, and industrial products. Germplasm and breeding research is oriented toward helping producers by increasing market demand for sweet portato. Selection for high dry-matter content is vital, because this characteristic is important for food, feed, and processing. Earliness, starch quality and quantity, vine production for animal feed, as well as non-sweetness and other taste factors are also being studied. Our research this year reflects rapid gains in such selection. Sixteen sweet potato clones at CIP, Lima have already entered into the pathogen cleanup program and will be ready for regional distribution in late 1991. These clones have high yield, good dry-matter content, and short growing seasons. Even though rapid progress is being made in this area through the use of conventional techniques, we expect that biotechnology will have a catalytic effect, as has happened in work on potato. Through our discovery that cytological techniques can be used to break the crossability barriers between wild and cultivated sweet potato germplasm, we are now tapping into a much wider genetic resorce. Our sweet potato breeding strategy involves immediate regionalization of activities to take advantage of locally-adapted clones, to develop advanced populations for use in specific agroecologies, and to provide for optimal control of pests and diseases. We anticipate heavy interaction with national programs and the private sector to define desirable characteristics.



We have continued to improve non-chemical control of diseases and pests. In potato virus work, we have emphasized economic control of virus through preventive techniques. Highly sensitive and precise virus detection techniques have been developed that are much less expensive than previously, thus permitting their widespread use by the NARS. This work has been especially effective in quick relay of scientific advances to partners, through CIP's global system of research, training, and information. We are now systematically assessing the impact of this work to document our collaborative achievements in providing clean planting materials to developing countries.

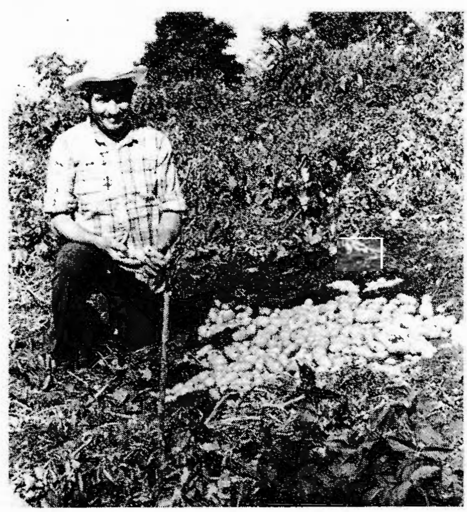
Our late-blight research approach is a good example of an appropriate balance between long-term and short-term priorities. The long-term priority is to produce breeding lines with general or field resistance to the late blight fungus. This year's findings show that major advances are being made with the aid of our well-established international testing scheme. And, for the near-term, we are also making good progress in combining field and race- specific resistance to be used immediately by national programs. Later on, such material can be replaced by field-resistant material identified by international testing. In the future, we will complement genetic resistance to late blight with other components of an integrated control strategy, such as biological control, agronomic practices, sanitation, and timely fungicide use, to prolong the longevity of host plant resistance.

On a global basis, bacterial wilt disease of potato is second only to late blight in terms of economic importance, and we have progressed rapidly in developing stable resistance to bacterial wilt disease. Over the long-term, such resistance will be the mainstay of wilt control in the highlands and in the warm tropical lowlands. For the present, shorter-term measures are being emphasized and other control tactics are being exploited much more extensively (e.g., use of healthy seed, and crop rotation). A key factor to future success in controlling wilt will be the success reported this year in the development of a detection kit for *Pseudomonas solanacearum.*

CIP's work in controlling the potato tuber moth, the major insect pest of potato, is perhaps the most obvious example of a major scientific advance which now needs to be translated into practical impact in farmers' fields. In the long run we expect that the genetic resistance, including that from glandular trichomes, will be a major component of our control strategy. To complement this long-term approach, however, we are now seeking shorter-term development of a combination of control measures, including use of biological control agents such as granulosis viruses and *Bacillus thuringiensis* (Bt). Most such development work will be achieved through collaboration with development-oriented institutions.

Nematode is a prime example of CIP's "hiving off" or stimulating the NARS, and projects such as PROINPA in Bolivia, in work where they have a comparative advantage. Such collaboration for mutual gains will be continued, to allow us to redirect some of our resources to more intensive work on other crucial research needs.

One such need is for control of sweet potato weevil, the major insect pest of sweet potatoes on a worldwide basis. Our report findings show that we are making rapid progress, both in terms of identifying genetic resistance to the sweet potato weevil and in investigating complementary control measures, such as use of parasitic fungi that can be exploited for the near-term using an integrated pest management approach.



As we catalyze the adaptation and adoption of new research products around the globe, we will increasingly emphasize the integration of coordinated training and communications in the process. In the examples of PTM and bacterial wilt research noted previously, the researchers, trainers, and communicators have already begun to develop specific technologies, media, and information services for specific geographical locations.

Our true potato seed (TPS) work is another prime example of scientific advances that must be rapidly translated into practical impact in farmers' fields. As in the past, our report again reflects excellent progress in physiological and breeding work on TPS. We are now increasing the emphasis on farmer adoption of TPS, and there is considerable potential for use in several Latin-American countries. Additional research will be devoted to determining potential adoption areas in other countries.

Development of practical and accurate testing procedures to determine seed-quality characteristics of selected TPS progenies is one of the scientific breakthroughs that can be of enormous value to strengthen TPS development work. Such work is essential to ensure that the users can assess the true capabilities of TPS.

In sweet potato propagation work, our findings indicate that rapid multiplication techniques can be adapted from the potato for use with sweet potato. This discovery is of enormous importance because lack of good-quality planting materials is one of the major global constraints in sweet potato agriculture.

In post-harvest management, processing, and marketing, we are focusing most of CIP's efforts on sweet potato. Specific training and communication activities will capitalize upon the scientific advances made in potato post-harvest research, such as development of diffused-light storage for seed potatoes and rustic storage methodologies for ware potato. The highest priorities in sweet potato post-harvest work include the development of better information about marketing, processing and storage in developing countries. Little information is available on these topics, and such studies will spur further work in this area.

In sweet potato post-harvest research, we are giving high priority to horizontal relay and transfer of selected processing practices among developing countries. This will involve very close collaboration between CIP scientists and NARS scientists, particularly in China and in the Philippines.

Most of last year's food systems research was on sweet potato, and results have helped us to identify the most important sweet-potato growing areas of the world. We have improved our conceptual framework for research planning through studies showing that there are three major food systems associated with the crop: extensive, intensive, and home garden systems, through which sweet potato is widely adapted to many different environments. The constraints studies highlight the need to develop alternative markets and uses for sweet potato, if these systems are to expand production. In the future, the food systems approach, will be used more extensively at CIP as an integral component of CIP's research philosophy, to help us in assessing major research and development opportunities.

Global Issues

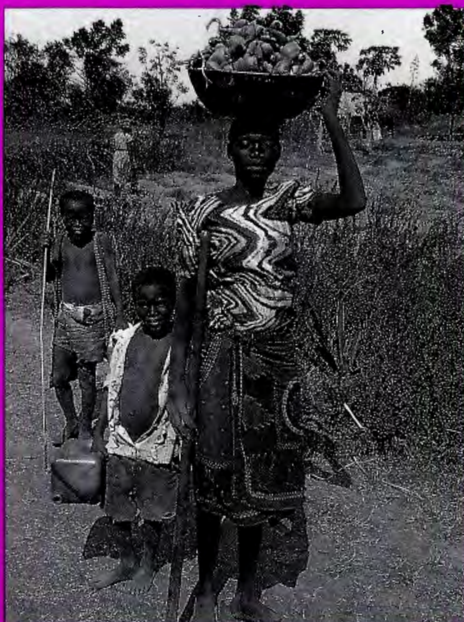
Within this overall approach, our research philosophy directly addresses larger agricultural development issues such as sustainability, protection of the environment, equity, and gender. Our Center-wide strategy is specifically designed to meet these challenges on a global basis.

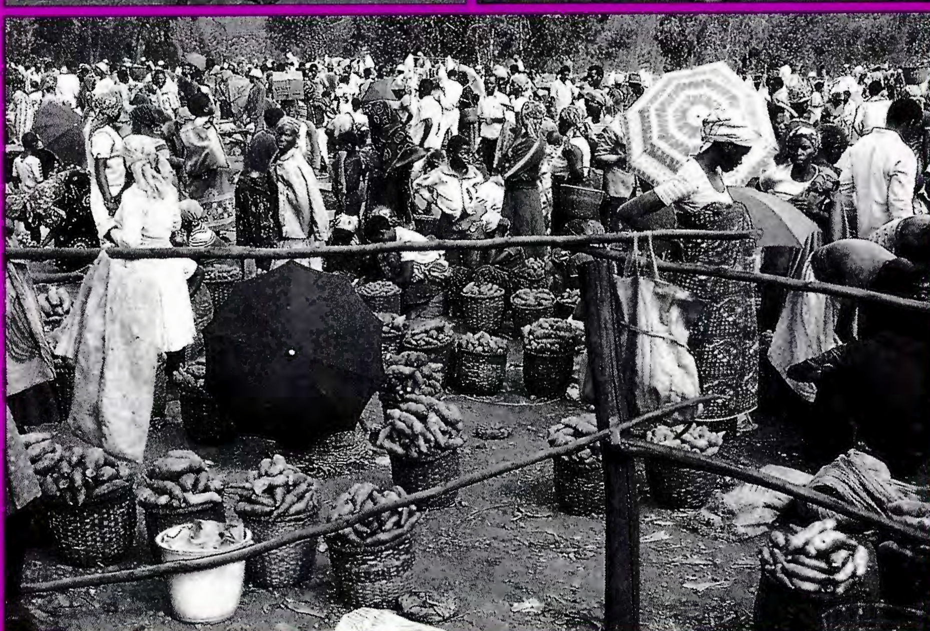
Our 1990 research has produced results that address the equity issue relating to the needs of poor farmers in marginal environments. These include frost- and drought-resistant potato clones and saline- and flood-resistant sweet potato cultivars. Our research on Andean root and tuber crops provide important information to accelerate conservation and development of these valuable high-altitude food crops. Our technology and training are targeted directly to help resource-poor farmers and consumers. The improved production techniques and marketing information help increase yields and farmer productivity, while lowering production costs and post-harvest costs and reducing use of chemical pest controls. In turn, the farmers expand their markets and increase their profits, the consumers improve their diets and enjoy lower food prices, and we simultaneously help protect our fragile environment.

CIP studies show that women do much of the cultivation and postharvest work in potato and sweet potato production and utilization throughout the world. Thus, we are identifying technologies especially useful for women in both field production and in the household. Women are encouraged to participate in all levels of research project planning and generation of technology, as well as in training (as trainees and trainers) and in related information and communications activities.

As this is written, we are completing a formal CIP Strategic Plan to address farm-level and global concerns of the 1990's. We are confident that our research will continue to play a vital role in improving the world's food supply for potato, sweet potato, and other root and tuber crops.

Thrust Reports





Flower structure of *Ipomoea* species.

Thrust I

Collection, Maintenance, and Utilization of Unexploited Genetic Resources

Thrust profile: 1991

Solanum serratoris was identified as a new potato diploid species from the series Tuberosa. This species was found in the province of Morona-Pastaza in Ecuador at 2500m in the hot and humid environment of the eastern slopes of the Andes.

Multiplication activities emphasized multiplication of wild potato species accessions that were underrepresented in the TPS collection. More than 200 accessions now have 1,000 to 4,000 seeds each. A total of 228 accessions of wild potato species were also tested for the seed-transmitted pathogens PVT and PSTV. Only 8 accessions were found to be infected with PVT and none showed PSTV infection.

The introduction of the potato germplasm collection to in vitro culture has been completed and only newly collected materials are being introduced this year. A complete duplicate set of the potato collection maintained in vitro is now available in Ecuador.

Six 2x hybrids of *S. berthaultii* were factorially mated as males to four cultivated 4x *tuberosum* clones. Twenty-three 4x x 2x families were evaluated along with the four 4x parents and seven 4x x 4x (inter-tuberosum) families, in three Wisconsin environments. Compared with the 4x parents and 4x x 4x families, the 4x x 2x families had greater yield, higher specific gravity, better general tuber appearance, but darker chip color. Superior 2x parents were identified for light chip color (P1006, P133-7, P100-1); good general tuber appearance (P94-1, P127-3); and early vine maturity (P100-6, P100-1, P133-7).

Resistance to potato tuber moth was confirmed by laboratory tests in 39 diploid genotypes derived from *S. sparsipilum*. From another 165 diploid genotypes involving *S. gourlayi* and *S. multidissectum* with resistance to RKN and/or PVY, 20 genotypes with resistance to PTM were selected using the storage test in San Ramon during the dry season. Of 13 diploid genotypes evaluated for resistance to bacterial wilt by inoculating isolate CIP 204 or race 3, two were selected as resistant and four as moderately resistant. In addition, high levels of resistance to aphid infection of PLRV were found in the accessions OCH 13823 and OCH 13824 of *S. acaule*.

Several infections of complete plants with *A. rhizogenes* and cocultivation of leaves and stems with *A. tumefaciens* were made in order to obtain transgenic plants containing antibacterial genes. Nearly 400 kanamycin-resistant GUS-positive plants were obtained using *A. rhizogenes*; approximately 50 such plants were obtained with *A. tumefaciens*. Plants containing cecropin or attacin genes coupled to CaMV or WI show a significant difference in resistance compared with the control plant. Similar approaches have been developed for obtaining transgenic plants with antisense sequences for PSTV.

In the case of sweet potato, eight collecting expeditions in Latin America obtained 343 accessions from 287 locations in Argentina, Paraguay, and Peru. A new *Ipomoea* species was described as *I. sawyeri* from among collections made in previous years. Collecting activities in Asia included two expeditions in China, where 64 accessions were obtained from West Yunnan and 100 accessions from Guizhou.

Sweet potato characterization of non-Peruvian cultivars was initiated in collaboration with NARS of Ecuador, the Dominican Republic, Jamaica, and St. Vincent. Sweet potato duplicates found in the Peruvian accessions on the basis of morphological comparisons were verified by electrophoretic analyses at CIP. The agreement of the morphological and electrophoretic groupings was almost 100%. In China, 52 sweet potato accessions were characterized by their patterns of peroxidase isoenzymes.

The sweet potato in vitro collection has been increased dramatically with the addition of new facilities at La Molina. At present, the collection consists of more than 2,300 accessions including 1,200 collected by CIP, more than 900 from the IITA collection, and about 200 from AVRDC. This in vitro collection has been partially duplicated in Venezuela, where it has been in storage for one year. Efforts to increase seed of accessions of wild *Ipomoea* species of section Batatas in the collection have also been initiated. Preliminary studies of storage root formation in progenies of 68 accessions of 6 wild species of section Batatas showed that some genotypes of *I. cordatotriloba*, *I. ramosissima*, and *I. tiliacea* produce thick storage roots.

In China, 2,451 evaluations were made for resistance to root rot, stem rot, black rot, bacterial wilt, stem nematode, sweet potato weevil, and for tolerance to drought and flooding. A total of 949 genotypes derived from crosses between 4x interspecific hybrids (H) and *I. trifida* (T) were evaluated in field trials at Cañete and San Ramón in Peru. In general, 4x H clones produced a higher frequency of high-yielding progenies than were produced by those with low yields. A second generation of 4x storage root initiators (HH) were obtained by intercrossing the highest yielding H clones. The HH clones exhibited a marked increase in pollen stainability, probably due to the elimination during meiosis of pairing problems between the *I. trifida* and *I. batatas* genomes in the H clones.

Through a new collaborative project with the Agricultural Genetics Company, a private company in the UK, cowpea trypsin genes will be inserted into sweet potato in an attempt to offer resistance to sweet potato weevil.

A GTZ-funded special project is concentrating on the conservation of other Andean root and tuber crops such as oca (*Oxalis tuberosa*), ulluco (*Ullucus tuberosus*), mashua (*Tropeolum*), and arracacha (*Arracacia xanthorrhiza*), that are in danger of extinction. There is evidence that local crop diversity has decreased over the last decades due to market demands for a limited number of cultivars with certain characteristics desired by urban consumers. At CIP there is an international in vitro germplasm collection of Andean tubers, with 148 accessions consisting of 61 olluco, 56 oca, and 31 mashua. Additionally, in cooperation with the Research Center of Andean crops (CICA) of the University of Cuzco in Peru, a collection of more than 700 accessions of Andean tubers from Southern Peru will be maintained and characterized. Field work was begun to obtain a better understanding of the folk taxonomy of olluco and oca in the Cuzco area. Interviews with farmers also revealed factors that apparently limit the production of Andean tubers, especially the long growing period (8-10 months) and the lack of external demand.

Collection, Maintenance, and Utilization of Unexploited Genetic Resources

One of the major contributions of Thrust I towards meeting CIP's mandate is to conserve the genetic resources of the potato, sweet potato, and other Andean root and tuber crops. Collecting these genetic resources either in their natural ecological niches or in farmers' fields in geographic areas with great genetic diversity, is the first step toward securing their ex situ conservation. The biosystematic studies made on the materials collected not only permit their taxonomic classification but also, with the discovery of new species, add new sources of variability.

Since all root and tuber crops conserved at CIP are vegetatively propagated, a sound strategy for their conservation is to identify and eliminate duplicates of the same cultivar, which are generally widespread over geographic areas. The consequent reduction in the number of accessions to be conserved increases the chances of maintaining a larger portion of the total genetic diversity present in a crop.

The evaluation of these genetic resources for traits that limit the productivity of these crops, and for factors that could be used to increase their present production capacity, is another component of the research activities in this Thrust. The use of these selected materials in germplasm enhancement programs facilitates their use in conventional breeding programs, which are generally slowed down when wild or primitive genes are introduced in their advanced populations. Modern molecular methods that could speed the transfer of desirable genes from wild or primitive species to advanced breeding lines or modern cultivars are also being studied.

Potato Genetic Resources

Biosystematic studies on potato

A new diploid species from the series Tuberosa was described in 1990 as *Solanum serratoris*. This species was found in the hot and humid environment of the eastern slopes of the Andes in the province of Morona-Pastaza (2500 m) in Ecuador.

Biosystematic studies within the species *Solanum chomatophilum* from the taxonomic series Conicibaccata revealed the existence of a new botanical form which was named *S. chomatophilum f. jircanense.*

The taxonomic position of 600 accessions of the living collection of wild potato species was reviewed during 1990. Although most of the accessions were confirmed in their taxonomic position, some accessions have been reclassified.

Potato Germplasm Collection

Maintenance. During 1990, a special effort was made to multiply those wild species accessions that were underrepresented in the TPS collection. More than 200 accessions now have between 1,000 and 4,000 seeds each.

A total of 228 accessions of wild potato species were tested for the seed-transmitted pathogens PVT and PSTV. Only eight accessions were found to be infected with PVT and none showed PSTV.

About 3,000 new TPS lots were obtained from Andean potato cultivars in the collection for storage at -15° C.

In vitro collection of potato germplasm. The introduction of the potato germplasm collection to in vitro culture has been completed and only newly collected materials are being introduced. A complete duplicate set of the potato collection maintained in vitro is now available in Ecuador. The storage period has been extended to two years because of the use of a new cold store in Quito.

The production of in vitro tuberlets is in progress to study their potential as an alternative to medium term storage, and to evaluate the genetic stability of tuber characters as compared with tubers produced in vitro.

Germplasm distribution. Demand for Andean cultivated germplasm is increasing as the number of pathogen-tested accessions in CIP's genebank increases. This year a total of 161 tuber samples, 148 in vitro plantlets, and 1300 seeds were distributed to 23 countries. Similarly, from the potato germplasm enhancement program, forty-five 4x x 2x and 2x x 2x TPS families were distributed to five countries. Most of these genetic materials have one or more desirable traits, thus, are used for research purposes or in breeding programs.

Potato Germplasm Enhancement

Evaluation of tuber traits of 2x (2 Endosperm Balance Number) wild species through haploid x wild species hybrids. The wild species of potato do not tuberize under long-day conditions, making evaluation of their tuber characteristics difficult. Seventy-eight haploid x wild species hybrid families involving *S. bukasovii, S. canasense, S. gourlayi, S. infundibuliforme, S. kurtzianum, S. multidissectum, S. sparsipilum, S. spegazzinii, S. vernei,* and *S. verrucosum* were evaluated in Wisconsin. The percentage of tuberization per family was greater than 50% in 72 of the families, indicating the potential of haploids to capture species germplasm for maintenance and evaluation. Thirty-eight percent of the hybrids that tuberized had eight or more tubers per hill. Dormancy ranged from 83 to 270 days postharvest.

Crossability of 4x potatoes (4EBN) with 4x (2EBN) species. Successful hybridization between 4x potatoes and *S. acaule* is obtained by counterfeit pollinations and embryo rescue. This technique was further improved by choosing the optimum stage for embryo rescue and optimal culture conditions. This modified technique also was extremely successful when applied to crosses between 4x potatoes and *S. stoloniferum*.

Performance and stability of 4x clones from 4x-2x crosses. Nine clones from 4x-2x crosses, derived from hybrids between haploid *tuberosum* and either *phureja* or *S. tarijense*, were evaluated with four cultivars in six Wisconsin environments. Three 4x clones from the 4x-2x crosses were more stable and had yields similar to cv. Atlantic; some also had superior specific gravity and chip color.

Use of 2x tuberosum haploid-wild species hybrids. Six 2x hybrids of *S. berthaultii* were factorially mated as males to four cultivated 4x *tuberosum* clones. Twenty-three 4x x 2x families were evaluated along with the four 4x parents and seven 4x x 4x (inter-*tuberosum*) families in three Wisconsin environments. Compared with the 4x parents and the 4x x 4x families, the 4x x 2x families had greater yield, higher specific gravity, better general tuber appearance, but darker chip color. Superior 2x parents were identified for light chip color (P100-6, P133-7, P100-1); good general tuber appearance (P94-1, P127-3); and early vine maturity (P100-6, P100-1, P133-7).

Yield and tuber characteristics of 4x progeny from 2x x 2x crosses. Unrelated, unselected 2x haploid-species hybrids that produce 2n eggs by second division restitution and 2n pollen by first division restitution, were intercrossed to generate 4x progenies. Nineteen 4x families were compared in Wisconsin with seven cultivars for tuber yield, tuber appearance, and tuber set. The mean yield of the 4x families was 30% higher than that of the cultivars. The best five 4x families outyielded the best five cultivars by 57% at one location and by 69% at another. Cultivars were superior for tuber appearance and tuber set. The high yields observed in 4x families are due to genetic diversity of the 2x parents and to the ability to transmit that diversity to the 4x progeny utilizing 2n gametes.

Inheritance of two mechanisms of 2n egg formation in 2x potatoes. The genetic control of two mechanisms of 2n egg formation was determined at the University of Wisconsin in 2x haploid-wild species hybrids of potato. Crossability data and cytological analyses of progenies generated for this purpose indicated single-locus control of each mechanism. Tests for allelism indicated that the two mutant genes are not allelic. The simple genetic control of 2n egg formation has significant implications in the evolution of polyploids and in the development of new breeding methods for potatoes.

Resistance to pests and diseases. Resistance to potato tuber moth was confirmed in 39 diploid genotypes derived from *S. sparsipilum*. From another 165 diploid genotypes involving *S. gourlayi* and *S. multidissectum* with resistance to RKN and/or PVY, 20 genotypes with resistance to PTM were selected, using the storage test in San Ramon during the dry season.

Diploid genotypes were evaluated for resistance to bacterial wilt by inoculating isolate CIP 204 of race 3. Of 13 genotypes tested, 2 were selected as resistant and 4 as moderately resistant. Fifty-two 4x x 2x families were produced from them to test their transmission of bacterial wilt resistance. Although most seedlings died six days after inoculation, some families had high survival rates. After re-inoculations to the surviving seedlings, four tetraploid genotypes were selected as highly resistant.

Very high levels of resistance to aphid infection of PLRV were found in the accessions OCH 13823 and OCH 13824 of *S. acaule*. More than 480,000 true seeds from 1004 combinations were obtained by intermating or selfing selected genotypes of *S. acaule* that were resistant to PLRV and/or PSTV.

Use of triploid-cultivated species. True seeds have been obtained from 3x x 2x crosses between 6 accessions of *S.* x *chaucha* and 1 of *S.* x *juzepczukii* with the diploid IvP 35. The seed will be used to study barriers to using triploid-cultivated species.

Chromosome doubling of useful 2x genotypes. Chromosome doubling of 30 diploid genotypes with genetic attributes such as PTM resistance was attempted, using in vitro techniques and colchicine treatments. The fact that only a few 4x genotypes were obtained was apparently due not only to the wild species in their pedigree but also to the inbreeding effect. It appears that there are some hereditary factors involved in the regeneration ability of the resulting tetraploids.

Application of Molecular Methods

Use of antibacterial genes. Potato transformation techniques with both *A. tumefaciens* (LB4404) and *A. rhizogenes* (R1000) were improved. These *Agrobacterium* strains were obtained through a collaborative project with Louisiana State University and contain a binary vector, pBI121, which has the Cauliflower mosaic virus promoter (CaMV) or a wound-inducible one (WI). In addition, the constructions contain two gene markers: the kanamycin and the B-glucuronidase genes (GUS). Antibacterial genes including cecropin, lysozyme, attacin, and shiva, of broad ·spectrum activity against plant pathogenic bacteria, were included in these constructs (Fig. 1-1).

Several infections of complete plants with *A. rhizogenes* and co-cultivation of leaves and stems with *A. tumefaciens* were made to obtain transgenic plants containing antibacterial genes. Nearly 400 kanamycin-resistant, GUS-positive plants were obtained using *A. rhizogenes*; approximately 50 plants were obtained with *A. tumefaciens*. They are being screened in the greenhouse against *Pseudomonas*. Plants containing cecropin or attacin genes coupled to the CaMV or WI showed a significant difference in resistance as compared with the control plant (Table 1-1). Pathologists consider a grade of susceptibility near 1.5, with respect to the control plant, as a good indication of increased *Pseudomonas* resistance. More inoculations are under way to further characterize these plants.

Similar approaches have been developed for obtaining transgenic plants with antisense sequences for PSTV. One hundred GUS-positive plants are being propagated and are ready to be infected with PSTV. *Agrobaterium* containing the coat protein gene of a PLRV Australian isolate is being tested with potato genotypes of good regeneration capacity and kanamycin-resistant plants have been obtained.

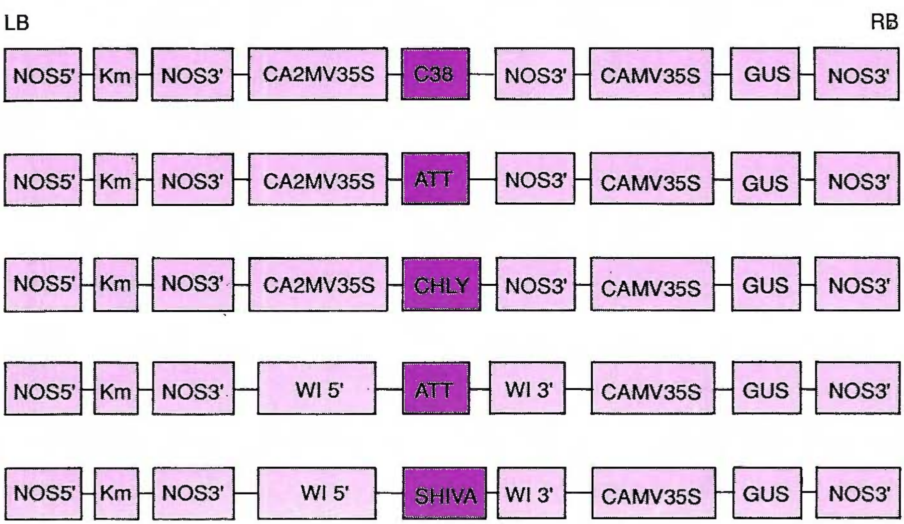


Figure 1-1. Antibacterial gene constructs included in *A. tumefaciens* and *A. rhizogenes*.

Table 1-1. Results of the first inoculation of transgenic potato plants containing antibacterial genes to *Pseudomonas* (Race 3, Biovar II).

Genotypes	Constructs used in genetic transformation	Grade of susceptibility
720088 x 375333.1	—	3.3985
"	R1000121WISHIVA	2.971
"	R1000121CA2C38	2.946
"	R1000121CA2C38	2.888
"	R1000121CA2ATT	2.737
"	R1000121WIATT	2.700
"	R1000121WIATT	2.621

Mean of 40 plants
Grade of susceptibility: 1: Healthy, 2: <25% wilt, 3: 25-50% wilt, 4: 50-75% wilt and 5: dead (control)

Use of Bacillus thuringiensis genes. Though a contract with ENEA, Italy, two sequences (280bp and 2100bp) were initially excised from their original plasmid pHUND using the restriction enzymes BamHI and SalI, subsequently inserted into a pGEM11Zf(-) plasmid vector (3223bp). Both the 5'-end and the 3'-end of the genes were sequenced, becoming identical in the ATG region and globally very similar to other known Bt sequences. No termination signal was found in the coding region.

The fragments were then excised from the pGEM plasmid using BamHI and SacI partial digestions and cloned in a PBI121.1 vector (11kb) in which the GUS region had been deleted. The PBI vectors containing the two Bt sequences have been transferred by triparental mating into *Agrobacterium* using disarmed *Agrobacterium* strain LBA4404 and the pRK2013 helper plasmid.

Potato leaf discs were prepared from young plants and transformed by *Agrobacterium* infection.

Use of attacin antifungal genes. Through a contract with the University of Tuscia, Italy, southern blots of DNA extracted from the GUS+ (*A. tumefaciens* 1) plantlets and digested with Hae III were hybridized with the attacin DNA sequence, isolated from plasmid pCa2Att (provided by Dr. Jesse Jaynes) and labeled, using the "multiprime" method (Amsterdam) and dCTP-32P. A clear hybridization signal appeared on DNA fragments of 1,250 bp of *A. tumefaciens* 1-transformed plantlets. Although this result indicates the presence of attacin-complementary DNA in the *A. tumefaciens* 1 plantlets, more study is necessary to ascertain if this type of DNA is of "foreign" (via *A. tumefaciens* 1 strain) origin.

Restriction fragment length polymorphism analyses (RFLP). The RFLP laboratory at CIP is almost fully operative. However, further development is needed in the efficient use of radioactive isotopes as well as safer labelling of probes by non-radioactive methods. Nearly one hundred DNA samples were prepared at CIP for collaborative work in the U.S.A., Germany, and Japan. A survey of RFLP polymorphism has been conducted on several 2x genotypes with virus resistances.

Sweet Potato Genetic Resources

Collecting Activities and Taxonomic Identification

Eight collecting expeditions carried out in Argentina (1), Paraguay (1), and Peru (6) produced 343 accessions in 287 locations (Table 1-2). The expedition in Argentina comprised the provinces near the border with Paraguay and was made in collaboration with INTA. The area explored is inhabited by the Guaranies, Tobas, and Matacos tribes. Plant characters and some socioeconomic data were obtained in these communities at the time of collection. Similar data were also recorded in Paraguay among the Chulupi and Chiripa tribes, in collaboration with SEAG.

A new *Ipomoea* species was described as *I. sawyeri* from materials collected in the Department of Puno in Peru.

Through a contract with the Xushou Sweet Potato Research Center (XSPRC), two collecting expeditions were made in China. In West Yunnan, where old local cultivars are still extensively grown, 64 accessions were collected in 20 localities of 4 prefectures (23°-25° N latitude). In Guizhou, where introduced cultivars such as Nancy Hall and Okinawa 100 are replacing local cultivars, 100 accessions were collected in 30 localities of 5 prefectures (25°-29° N latitude).

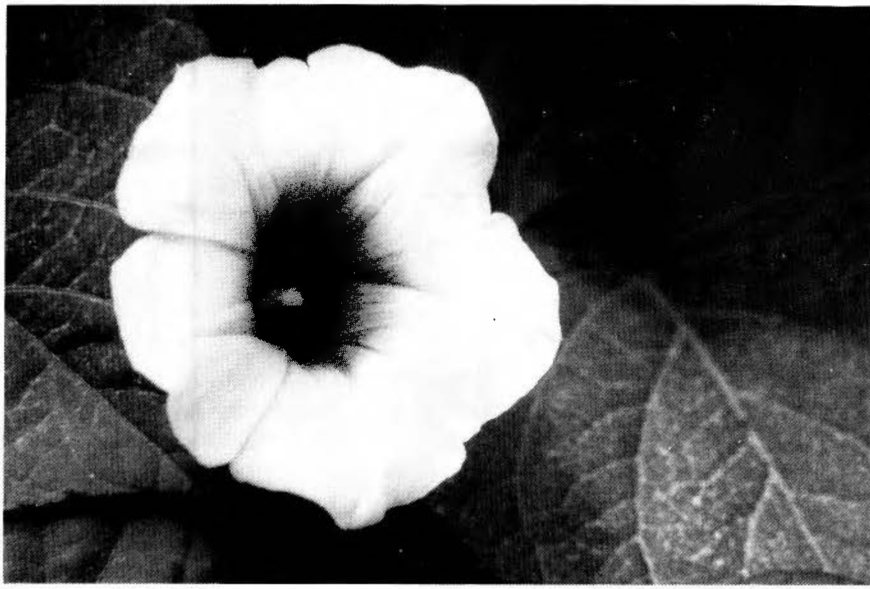
Table 1-2. Number of accessions of sweet potato genetic resources collected in 1990.

Country	Area explored, Department	Number of Localities	Type of material collected		
			I. batatas	Other spp.	Total
Argentina	4	183	136	47	183
Paraguay	9	69	33	69	102
Peru	6	35	16	42	58
Total	19	287	185	158	343

Sweet Potato Germplasm Collection

Maintenance. Sweet potato characterization of non-Peruvian cultivars has been initiated in collaboration with NARS of Ecuador, the Dominican Republic, Jamaica, and St. Vincent. Training in the use of key morphological descriptors for duplicate identification was provided to national scientists in these countries. Data were recorded for key morphological descriptors of vines and leaves. Storage root characters are to be recorded by the NARS at harvest. All data will be used to group similar accessions, which will be planted side by side for further comparisons.

An attempt was made to obtain true seeds from 928 sweet potato cultivars from countries other than Peru, that are maintained in the quarantine house at La Molina. Only a very few accessions flowered when grown in pots inside screenhouses during the summer at La Molina. Under natural environmental conditions



Ipomoea batatas **collected in Cuba. This popular sweet potato known as** ***boniato amarillo*** **is found in many typical Cuban dishes.**

only 24 cultivars produced a very few flowers. Of 173 cultivars from Colombia that were grown under short-days conditions (9 hours) for 30 days, 54 flowered, producing about 2000 seeds by cross pollinations. Only 9 out of these 54 Colombian cultivars set seeds by self-pollination.

CIP has begun to increase seed of accessions of wild *Ipomoea* species in the sweet potato germplasm collection. Seed increase of several accessions of *I. cordato-triloba*, *I. cynanchifolia*, *I. grandifolia*, *I.* x *leucantha*, *I. ramosissima*, *I. trifida*, *I. triloba*, and *I. umbraticola* of section *Batatas* has been successful in phytotrons at North Carolina State University. Under these artificial conditions, flower induction in *I. peruviana* was more difficult and so far, it has been unsuccessful in *I. tiliacea*. The recommended environmental conditions were tested at La Molina using 6 accessions of *I. triloba*. Seeds were obtained by hand pollination as selfs or crosses between genotypes of the same accessions.

Open-pollinated seeds of 77 accessions of all these species have been obtained in plants growing in the field at several sites in Peru. However, *I. peruviana* and *I. tiliacea* did not flower profusely in the field.

In China, a sweet potato collection of about 2,000 accessions is maintained in the field and in in vitro culture. The germplasm from North and Central China is maintained at Xuzhou, while that from South China is maintained at Guangdong.

In India, 14 accessions of local cultivars were collected in 4 sweet potato-growing areas.

In vitro germplasm collection. CIP's involvement with the conservation of sweet potato germplasm has required the construction of additional storage space for in vitro cultures at La Molina. To prevent quarantine problems, the transfer of sweet potato germplasm from other sister centers could only be made in the form of in vitro cultures. At present, the collection consists of more than 2,300 accessions including 1,200 accessions collected by CIP, more than 900 from the IITA collection, and about 200 received from AVRDC.

A slight substitution in the osmotical manitol by sorbitol has increased the time between subcultures of sweet potatoes in vitro to a maximum of 18 months.

The in vitro sweet potato collection has been partially duplicated in Venezuela, where it has completed one year in storage. A complete duplicate set of the in vitro collection is being prepared for shipment.

In China, 850 accessions are maintained in vitro under long-term storage conditions at the Beijing National Plant Genebank.

Duplicate identification. A large percentage of accessions of sweet potato cultivars has been collected or received as donations from many institutions in Peru. Emphasis on the identification of duplicates from these cultivars has been continued. Sweet potato duplicates, found in the Peruvian accessions by using morphological comparisons, were verified at CIP using the electrophoretic procedure developed at the Institute for Biochemistry, Braunschweig, Germany. A total of 604 accessions comprising 97 groups of 2 to 43 accessions each were compared by discontinuous polyacrylamide electrophoresis. The agreement of the morphological and electrophoretic groupings was almost 100%. Single differences in the pigmentation of the vine, petiole, or leaf veins in the lower surface produced differences in one or more protein bands.

In China, 52 sweet potato accessions were characterized by their patterns of peroxidase isoenzymes. The patterns obtained included from 3 to 11 bands, and all accessions could be differentiated on the basis of the number, distribution, intensity, and width of the bands.

Preliminary morphologic studies made on 14 local sweet potato accessions collected in India showed that they could comprise 6 different cultivars: Ganwa-red, Ganwa-white, Kali-Satha, Mungia, Nagichara, and Bagafa.

Germplasm evaluation. Yield trials using Peruvian cultivars were conducted at three coastal sites in Peru. Plants were harvested 6 months after planting. Of 862 accessions compared at the San Antonio Experiment Station in Cañete, accessions ARB 223, ARB 413, ARB 545, DLP 939, DLP 942, DLP 2697, and RCB IN-251 yielded from 1.7 to 3.4 kg per plant. At the La Agronomica Experiment Station in Tacna, 525 accessions were compared. Yields ranged from 2.7 to 4.2 kg per plant for accessions ARB 127, DLP 116, DLP 339, DLP 2223, DLP 2437, DLP 3059, RCB IN-77, RCB IN-103, and RCB IN-139. In another set of 153 accessions, comparisons were made under drought conditions at the Los Cedros Experiment Station in Tumbes. Yields were generally low and the promising accessions were ARB 646, DLP 153, DLP 900, DLP 1966, DLP 1994, DLP 2409, and EEY2 with yields ranging from 0.6 kg to 1.2 kg per plant.

The reaction of the sweet potato weevil *Euscepes postfasciatus* was not found to be correlated to nutritive components of the storage roots such as dry matter, fiber, beta carotene, sugar, and protein content, nor were correlations found between weevil reaction and plant characters such as storage root skin and flesh color, and diameter of the vines.

In China, 2,451 evaluations were made for resistance to root rot, stem rot, black rot, bacterial wilt, stem nematode, and sweet potato weevil, and tolerance to drought and flooding. These evaluations were made using accessions from the Chinese collection by institutes located at Beijing, Xushou, Guangdong, Sichuan, Nanjing, and Fujian. Several accessions with resistance or tolerance to the traits evaluated were identified and will undergo further testing (Table 1-3).

Germplasm Distribution. Distribution of *Ipomoea* materials for evaluation or utilization at CIP included 6,214 stem cuttings of 847 accessions; 3,951 storage roots of 1,037 accessions; and 2,055 seeds of 343 accessions.

Training in germplasm activities. Training in electrophoretic techniques applied to sweet potato germplasm was provided to nine scientists from Peru, Jamaica, and Colombia. This course was organized in collaboration with the University of Concepcion, Chile and the Institute for Biochemistry, Braunschweig, Germany.

Table 1-3. Evaluations for biotic and aboitic stresses made in the Sweet Potato Collection maintained in China.

Trait	No. Acces. evaluated	Cultivars with resistance or tolerance
Resistance to:		
Root rot (*Fusarium solani*)	206	Huangzimen, Jiayushu Puerdabai, Xushu 18, AIS 25-2, I444
Stemrot (*Fusarium oxysporum* *f. batatas*)	247	Xingchenbendizhong, Mianhuazhong and Ribenshu
Black rot (*Ceratocystis fimbriata*)	528	22 accessions
Bacterial wilt (*Pseudomonas solanacearum*)	471	Shenglidabai, Heiguobaizi
Stem nematode (*Ditylenchus destructor*)	632	Dianpingshu, Laobaibai, Chaituobai, Hunanshao, Jingluoshu, Meiguohong, CI412-2.
Sweet potato weevil (*Cylas formicarius*)	247	Hongpishanyu, Nanjinhongpi, Tiedingfan
Tolerance to:		
Drought	60	Fengshoubai, Tiedingfan Yiwohong, Lu78066, Xushu 18 Liashu 224
Flooding	60	Fengshoubai, Nongdahong Fengshu 1, Xushu 18
Total	2451	

Sweet Potato Germplasm Enhancement

Anticipating that in the future there might be a need to exploit some valuable genes from wild *Ipomoea* species to solve specific problems, some basic research on interspecific hybridization is continuing. There are a number of problems to be overcome, such as crossability barriers, ploidy differences, fertility in the hybrids, and lack of storage root formation.

Yield evaluations of 4x interspecific hybrids and I. trifida. A total of 949 genotypes derived from crosses between 4x interspecific hybrids (H) and *I. trifida* (T) were evaluated in field trials at Cañete and San Ramon. In general, 4x H clones which yielded well (more than 300 g/plant) in these trials produced a higher frequency of high yielding (200 g) progenies, than did those H clones which did not yield well. In most cases, progenies of H clones which yielded well in San Ramon also yielded well in Cañete, indicating a desirable degree of environmental stability in the tester clones.

A second generation of 4x storage root initiators (HH) was obtained by intercrossing the highest yielding H clones. A total of 209 HH clones coming from 64 different cross combinations among 25 parents was obtained from 279 seeds and was evaluated in field trials in Cañete and San Ramon (Table 1-4). Genotypes such as the selection HH 38.4, which yielded over 1 kg/ plant at both locations and had a dry matter content of 36.4% at Cañete, may have potential as a variety. The dry matter content of the trial in Cañete ranged from 25.8% to 46.8%, with a mean of 38.3%.

At both La Molina and San Ramon, many H clones had low pollen viability. The HH clones exhibited a marked increase in pollen stainability, probably due to the elimination during meiosis of pairing problems between the *I. trifida* and *I. batatas* genomes in the H clones.

Fourteen HH clones of the 174 evaluated, produced 2n pollen at frequencies varying between 0.16% and 5.06%. The occurrence of 2n pollen in 4x individuals (4x (2n)) will allow the production of 6x genotypes from 4x x 4x(2n) crosses.

Production of cultivated hybrid material with specific traits. Seeds have been obtained using 72 selected female parents in polycrosses for characters such as earliness, compact growth habit, vines with heavy pubescence and abundant latex and low sugar, high beta carotene content, and strong anthocyanin pigmentation in the storage root flesh.

Production of interspecific hybrids using wild species of section Batatas. A total of 29 interspecific hybrid combina-

Table 1-4. Yield distribution of *Ipomoea* progenies (HH) coming from the intermating of selected 4x inter-specific hybrids (H clones) at two locations.[a]

Location	Yield ranges in kg/plant 0-0.2	>0.2-0.6	>0.6-1.0	>1.0	Total (%)
	(percentages of totals number of clones at each location)				
Cañete	47.4	39.9	9.5	3.2	100
S.Ramon	47.0	35.0	9.8	8.2	100

[a] Total number of clones evaluated: Cañete, 158; San Ramon, 183.

tions are now available as seed families. These hybrids involve *I. cordato-triloba*, *I. cynanchifolia*, *I. ramosissima*, *I. grandifolia*, *I.* x *leucantha*, *I. tiliacea*, *I. trifida*, *I. triloba*, and *I. tenuissima*.

Studies of storage root formation in wild species of section Batatas. Preliminary studies were made to determine storage root formation in progenies of 68 accessions of 6 wild species of section Batatas. Although only a few genotypes per accession were included in the study, thick storage roots were observed in some genotypes of *I. cordatotriloba*, *I. ramosissima*, and *I. tiliacea*. In the other species, *I. leucantha*, *I. trifida*, and *I. triloba*, none of the genotypes produced roots of similar thickness.

Application of Molecular Techniques

To develop whole plant regeneration techniques from explants produced by molecular techniques, the regeneration potential of the cultivars Huachano, Ihuanco, Centennial, Morada INTA, Jewel, Maleno, Sunny, and Imby is being studied. In order to stimulate shoot organogenesis in internodes, leaves, roots, and petioles of these cultivars, several culture media which include auxins, citoquinines, gibberellins, putrescine, and adenine in different concentrations are being tested (Table 1-5). Through a new collaborative project with AGC, a private company in the UK, cowpea trypsin genes will be inserted into sweet potato in an attempt to incorporte resistance to sweet potato weevil.

Table 1-5. Composition of several culture media tested to stimulate shoot organogenesis in sweet potato.

	Growth regulators in mg/l						
Medium	IAA	KIN	BAP	ZEA	GA	Putrescine	Adenine
MR1	2	1					
MR2	2	1			1		
MR3	2	1			5		
MR4	2	1			10		
F1	1						
F2	0.2		1		10		
F3	0.2		1				
F4	0.5		1				
F5 [a]	0.5		1		10		
F6 [a]	0.2	1					
F7 [a]			0.2				
F8 [a]				2			
F9 [a]				0.2			
F10[a]				2		20	
F11[a]							20[b]

[a] Media now under study.
[b] Subculture medium used after preincubation in dark with the other media.

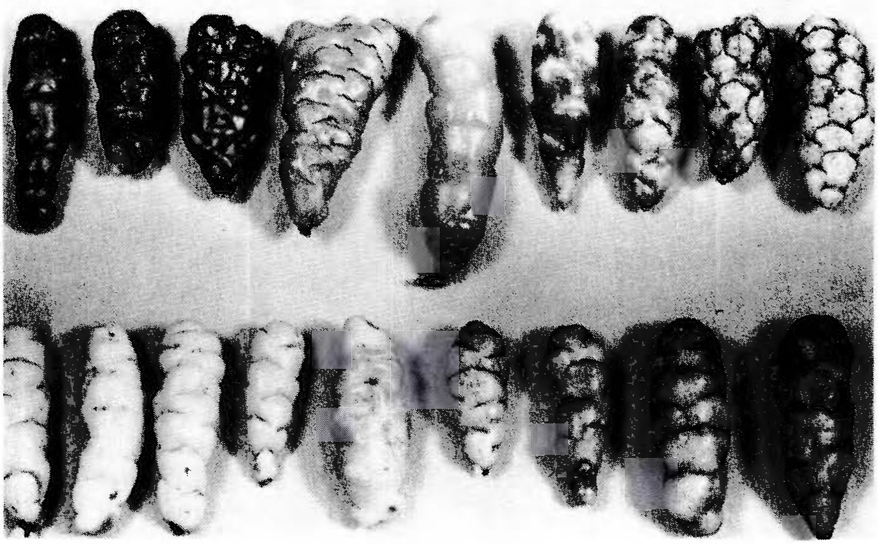
Genetic Resources of Other Andean Root and Tuber Crops

It is generally recognized that the genetic resources of Andean root and tuber crops such as oca (*Oxalis tuberosa*), olluco (*Ullucus tuberosus*), mashua (*Tropeolum*), and arracacha (*Arracacia xanthorrhiza*), among others, are in danger of extinction. Therefore, a joint effort for their conservation has been organized involving the NARS of Peru, Ecuador, and Bolivia, and IBPGR and CIP, with funding from GTZ.

Collecting activities. In cooperation with the Research Center of Andean crops (CICA) of the University of Cuzco in Peru, a collection of more than 700 accessions of Andean tubers from southern Peru will be maintained and characterized. Descriptors for oca and olluco were revised and improved during visits to CICA. A computerized germplasm catalogue has been created and efforts to retrieve missing passport data are under way.

The collection at CICA was increased with 38 new accessions of oca, olluco, and mashua, and 4 accessions of arracacha collected in the provinces of Pisac, Paruro, and Calca (Department of Cuzco). It is expected that this collection will be further enlarged with materials of these crops maintained by INIAA in Cajamarca, Huancayo, and Puno (over 2000 Peruvian accessions) and by INIAP in Ecuador (about 400 accessions).

In vitro collection. At present, CIP has an international in vitro germplasm collection of Andean tubers with 148 accessions (61 olluco, 56 oca, and 31 mashua). Most of this material was obtained from the University of Ayacucho in Peru and 38 accessions were collected during 1988 and 1989 in Colombia and Bolivia. A computerized database with passport data as



Oca has great morphological diversity in terms of tuber shape, pigmentation, eye number, and distribution.

well as isozyme data is available on this collection.

Folk studies related to olluco and oca. Field work was undertaken to arrive at an understanding of the folk taxonomy of olluco and oca in the Cuzco area. Preliminary isozyme results largely confirmed peasant classifications of olluco cultivars or groups of cultivars for which specific Quechua terms are widely used. Interviews with peasants also revealed factors which apparently limit the production of Andean tubers, i.e. the long growing period (8-10 months) and the lack of external demand. Elderly informants confirmed that crop diversity in Andean tubers has decreased locally over the last decades and attributed this to market demands for a limited number of cultivars with certain characteristics desired by urban consumers.

Isozyme analysis with starch gel electrophoresis. Isozyme analyses were used to find additional variation in genetic materials that are morphologically alike. The genetic diversity in some of the Andean root and tuber crops was found to be very small in comparison with that found in potatoes or sweet potatoes.

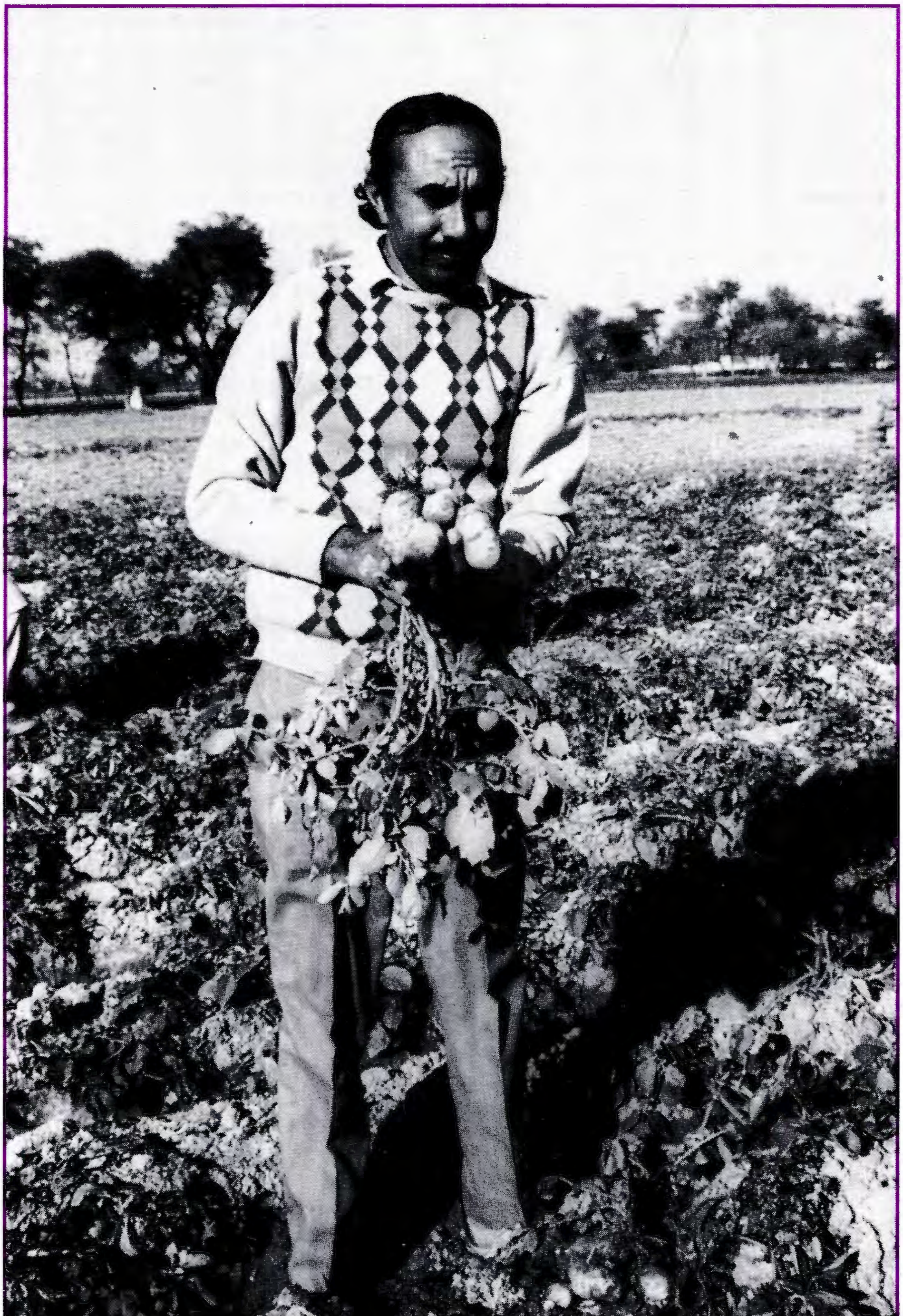
Of nine enzyme systems tested using tubers of olluco and oca, five were found to give polymorphic and sufficiently stained banding patterns in both species (histidine-citrate buffer, pH 5.7): MDH (malate dehydrogenase), PGM (phosphoglucomutase), PGI (phosphoglucoisomerase), 6-PGDH (phosphoglucodehydrogenase), and SDH (shikimic acid dehydrogenase). Three hundred accessions of Ecuadorian and Peruvian olluco, as well as 200 accessions of oca throughout the species range, have been examined for these enzymes.

Isozyme data of olluco largely confirmed the classification based on tuber morphology. By comparing isozyme data with tuber characters, minor but relevant differences in tuber morphology could be detected. Thus, existing descriptors for tuber characterization could be refined. Some genotypes were found to be highly duplicated (10-25) while others were represented by only one or a few accessions. The amount of duplication is approximately of 70%-80%, with a relatively small number of genotypes making up the bulk of the duplicated material.

Morphological and isozyme diversity of olluco in material from Peruvian collections appears to be lower than in the Ecuadorian collection. This finding, if it can be further supported by the analysis of Bolivian material, would contradict the general belief that most of this species' diversity is located in the central Andes (southern Peru and Bolivia).

Isozyme analysis in oca was more difficult because of the poor resolution of the banding patterns obtained. It appears that oca is genetically much more diverse than is generally recognized. Common isozyme patterns in the northern Andes are rare in the southern Andes. There is also preliminary evidence for isozyme clines both on altitudinal and latitudinal gradients, suggesting the existence of ecotypic differentiation. It is clear that such findings, if further confirmed, will be the basis for a rational exploration of the oca genepool.

Assessment of mucilage content in olluco. Mucilage is an undesirable constituent of olluco because it affects the eating quality. Highly variable mucilage content could thus be used to characterize olluco germplasm. An analytical method for accurately determining mucilage content would be extremely complex due to its compound nature. Therefore, a simple viscosimetric method was developed to detect mucilage levels.



Seed production trials in Pakistan.

Production and Distribution of Advanced Breeding Material

Thrust Profile: 1991

THE CLONES YY-7, duplex for PVY immunity, and 381064.8 were shown to be good combiners with high general combining ability (GCA) for yield, earliness, and good tuber attributes. They were selected as progenitors from a potato population of 79,000 seedlings.

The clone Y84.027 was confirmed as an outstanding progenitor for both yield and tuber uniformity, thus is now being cleaned of pathogens. Clone Y84.027 will be distributed for use as a progenitor for variety selection and TPS utilization. Two additional progenitors, NDD 277.2 and Maine 47, have now been freed of pathogens and are ready for distribution.

In a joint project with the National Institute for Agricultural Research (INRA) at Landerneau, France, 73 progenies were field-evaluated to select clones with long-day adaptation. At harvest, six sets of tuber families were prepared for distribution to Tunisia, Egypt, Turkey, and Peru for evaluation and selection. Two tuber family sets remained in France, one set for evaluation and the other for multiplication and further regional distribution. A new population also was created using French and other European clones and virus-resistant CIP materials as progenitors. This population is suited to the environmental conditions of North Africa and the Middle East.

In Bagladesh, a new potato variety, “Heera” (Diamond) CIP 379666.501, [(BR-63.65 x Katahdin).1 x M. Tropical] was released. This variety was selected from tuber families produced at CIP and introduced in Bangladesh about nine years ago. This new variety degenerates slowly, thus helping to maintain healthy seed stocks.

In the Philippines, CIP clones LT-7 and 378597.1 were consistently high yielders and clones LT-7, 7XY.1 and AVRDC 1287.19 were good TPS progenitors.

In Kenya, several clones with high yield, good levels of resistance to late blight, and good tuber characteristics were selected.

In Cornell University research contract studies, the clone L235-4 was identified as immune to PVY and PVX and showed a good level of resistance to the Colorado potato beetle. The clone E74-7, possessing high yield potential, immunity to PVY and PVX, and moderate resistance to PLRV, late blight, and cyst nematode, was selected.

In the University of Tacna Research Contract, several potato clones with tolerance to salinity have been identified and will undergo pathogen cleanup for regional distribution.

The North Carolina State University genetic studies on Erwinia soft rot indicated a heritability of $h^2 = .55$.

Sweet potato populations from several origins were tested under hot and humid conditions. Materials from Japan showed good adaptation in terms of yield and dry matter content.

Sixteen sweet potato clones bred at CIP-Lima were entered into the pathogen cleanup program and will be ready for regional distribution in late 1991. These clones have high yield, good dry matter content, and a growing period of 4 to 4 1/2 months.

Potato Population Development

Peru. During 1990, about 79,000 seedlings from 665 progenies were evaluated in 14 field experiments at San Ramon and La Molina, during the summer and winter seasons. This population segregated for resistance to some of the most important diseases and stresses, i.e., resistance to early blight, late blight, bacterial wilt, PLRV, immunity to PVY and PVX, and heat tolerance. The main objective of these evaluations was to select progenitors with high general combining ability (GCA),

Table 2-1. General Combining Ability (GCA) for yield, earliness, and tuber uniformity of some selected progenitors. San Ramon, summer 1990.

Progenitor	Yield/plant	Earliness	Tub.uniform.	Resistance
381064.8	**	**	**	BW
381064.9	*	*	*	BW
381065.3		**	*	BW
381077.1	**		*	BW
382302.3		**		BW
382306.1	*	**		BW
382309.1	**			BW
BW-002	**			BW
CUP-199	*		*	PLRV
I-1150	*		**	LB
MAINE 50		**	**	EB
LT-9				PVY,PVX
382305.1		**	*	BW
382309.3	**		*	BW
XY-20	*		**	PVX,PVY
YY-6	***	*		PVY
YY-9	*	**		PVY
YY-7	**	***	**	PVY
YY-10	**			PVY
YY-19		***		PVY
377964.5 (TESTER)	*	***	**	
575049 (TESTER)	*			LB

* medium GCA
** high GCA
*** very medium GCA

earliness, and good field and tuber characteristics; and to select progenies with good adaptation to warm conditions for further regional evaluation and utilization. Sixteen clones showed high GCA for at least one characteristic. The clones YY-7 and 381064.8 were good combiners for all three characteristics (Table 2-1). Progenies selected at San Ramon for high yield, early maturity, and heat tolerance are presented in Table 2-2. The clone Y84.027 was confirmed this year as being an outstanding progenitor for yield and tuber uniformity and is being cleaned up. This clone will be distributed to CIP regions and national programs to be utilized as a progenitor for variety selection and TPS utilization.

France. In a joint INRA-CIP project to select materials for long-day adaptation for use in North Africa and the Middle East, tuber families of 51 CIP and 22 INRA progenies were produced in the INRA

Table 2-2. Top-yielding and early maturing progenies selected at San Ramon, summer 1990.

Progeny	Yield g/plt	Tuber uniformity	Earliness	Selected clones
YY-12 x 377964.5	680	6.4	6.3	1
YY-10 x 377964.5	670	6.4	5.7	1
YY-7 x 377964.5	669	7.3	7.0	3
YY-9 x 377964.5	619	7.2	6.3	3
YY-11 x 377964.5	604	6.6	7.0	2
XY-20 x 377964.5	586	7.6	6.3	6
382309.3 x YY-6	873	6.0	4.0	0
381064.8 x YY-6	640	6.3	4.0	1
381064.8 x YY-9	607	6.4	5.0	1
381064.9 x XY-14	574	6.2	5.0	1
381065.1 x YY-6	572	6.0	4.0	1
381065.4 x YY-6	556	6.0	4.0	0
XY-20 x 377964.5	650	6.7	6.3	1
LT-7 x YY-9	635	6.9	5.0	2
MAINE 50 x XY-14	567	6.6	5.7	1
Y84.027 x LT-7	557	6.7	5.7	1
SERRANA x 377964.5	550	6.6	7.7	0
CUP-199 x YY-9	543	5.9	5.0	0
XY-17 x I-1035	533	6.4	7.0	2
XY-4 x AVRDC1287.19	531	6.1	5.0	1
YY-7 x LT-7	511	6.4	5.7	1
XY-20 x I-1035	506	6.9	5.0	0
MAINE 51 x XY-14	504	6.2	5.0	0
XY-17 x LT-7	504	6.2	5.0	1
YY-9 x LT-7	488	6.6	5.0	1
I-1035 x YY-9	487	6.7	5.0	3
B75-86.8 x XY-14	485	6.0	7.0	1
Y84.011 x XY-20	483	6.8	5.0	1
MAINE 51 x XY-20	476	6.6	3.7	1

Earliness: 1=late, 5=medium, 9=very early.
Tuber uniformity: 1=not uniform, 5=medium, 9=very uniform.

greenhouse at Landerneau. The CIP progenies were segregating for heat tolerance and virus resistance. The INRA progenies were hybrids between late blight resistant-CIP clones and French progenitors segregated for adaptation to long days and late blight resistance.

The 73 tuber families were planted in the field at Landerneau during the spring 1990 for field evaluation and selection. Vine-killing of the crop took place 100 days after planting (DAP). Despite the long days and the heat wave in France during July and August, the yield was generally high and some progenies yielded over 1.5 kg/plant. The best progenies in this trial were: from CIP, Serrana x LT-7, Serrana x 377888.8, BR63.15 x YY-1, B71.240.2 x YY-9, Maine 47 x Y84.015, LT-8 x XY.13, XY.4 x 377964.5, XY.7 x 378015.16, 377964.5 x YY-9; and from INRA, CGN-69.1 x 74.5.48, ARK-69.1 x 74.5.48, ARK-69.1 x 74.5.48, CFL-69.1 x 78.46.11, I-853 x 78.46.11, CFQ-69.1 x Korrigane, and CGN-69.1 x Korrigane. Six sets of tuber families were obtained at harvest, from which one set will be sent to Tunisia, Egypt, Turkey, and Peru for evaluation and selection. The remaining two sets stayed in France, one set for further evaluation and the other for multiplication and regional distribution.

Also at INRA-Landerneau, a new hybrid population was generated utilizing as progenitors French and other European cultivars and CIP materials. Approximately 300 hybrid combinations were obtained from this population and will be used to develop cultivars suitable for conditions in North Africa and the Middle East.

Kenya. Over 190 clones in different stages of selection were evaluated for late blight resistance and other agronomic characteristics. In comparison with local check varieties, there were several clones that showed good resistance to late blight and high tuber yield. The best clones from these trials were 378711.5, 381381.20, 382136.4, 381378.18, and 387792.1. Analysis of the data showed a high correlation between late blight resistance and yield. Since this disease is widespread in East Africa, materials with good late blight resistance could considerably contribute to crop sustainability.

Several tuber families were generated by crossing CIP-selected clones with locally adapted cultivars. These materials will be screened for late blight and bacterial wilt resistances, heat tolerance, and agronomic attributes.

Bangladesh. The Tuber Crops Research Center released the CIP clone 379666.501 as a new variety, "Heera" (Diamond). This is the first officially released potato variety of Bangladesh. Other advanced CIP clones will be released at regular intervals.

The Philippines. Several selected clones and segregating materials, either TPS progenies or tuber families, were evaluated in 1990 at the lowland environment at Canlubang. Cultivars Sequoia, Cosima, Katahdin, Atlantic, Red Pontiac, and CIP clones LT-7 and 378597.1 had consistently high yields. Clones LT-7, 7XY.1, and AVRDC 1287.19 were good TPS progenitors.

More than 1000 selected clones and cultivars in diffused light storage (DLS) were evaluated in 1987, and this resulted in the selection of 50 clones in 1989 that showed a good storability in DLS for a period of 7 to 9 months. Using these selected clones as progenitors, a population of 100 progenies was obtained and field-evaluated for yield during the summer season, 1990. Tuber families were obtained and are now being stored under DLS for 9 months to assess storability.

Table 2-3 summarizes the breeding activities during 1990.

Cornell University. Two clones illustrate the progress in two of the population improvement programs in this contract. L235-4 is seven generations removed from the wild diploid species *S. berthaultii.* Two of the backcrosses were made with *S. tuberosum* ssp. *tuberosum.* This clone has the "A" trichomes of the wild species but lacks the "B" trichome droplets. The clone, immune to PVY and PVX, when

Table 2-3. Summary of potato germplasm evaluation results in 1990.

Evaluation of germplasm	No. evaluated	Clones/families selected
Advanced clones/cultivars		
PRI-Australia	15	Red Pontiac, 379686.3
Canlubang	35	Kufri Lalima, Atlantic, Capiro, Ballenera, Conchita x K. Jyoti. 3, Katahdin, NY-81
Tuber Families Bulked	37	BR63.76 x I-1039, I-1039 x BR112-113, P-5 x 7XY.1, Serrana x 7XY.1, P-5 x LT-7, Amapola x 7XY.1, LT-7 x LBB
TF	68	P-5 x BR112-113, 381064.10 (OP), BR63.74 x I-1039, I-1035 x BWB, BR63.76 x I-1039, P-5 x Serrana, LT-7 x LBB
TPS Trials		
Heat tolerance/Virus res.	30	377964.5 x XY-13, Y84.027 x LT-7, XY-4 x 378015.16
Earliness, Erwinia, virus, BW resistance	29	XY-20 x AVRDC 1287.19 381064.9 x XY-13, XY-3 x AVRDC 1287.19
Heat tolerance, virus, LB resistance	27	CFQ-69.1 x XY-4, 381382.34 x XY-9, I-1039 x XY-9 I-853 x XY-16, Atzimba x XY-9
Inter TPS progeny test	24	Y84.027 x 377964.6, WNC-521.12 x LT-7, Atlantic x NDD 277.2, YY-9 x 575049, 377887.25 x 377964.5
Local crosses	62	384015.19 (OP), 385146.96 (OP), F77087 x BR63.5, I-1035 x 381064.10, 2377 x AVRDC 1287.19, I-1035 x LT-7, 378597.1 x 381064.7,
TPS families with good storability in DLS,	44	2.447 x 385137.52, 385145.1 x 385152.32, 385110.42 x TPS 13, 384515.9 x Bk, 385379.3 x TPS 67
Clones/Cultivars for Processing	9	Atlantic, 380584.3, LT-9
Qualities (Chips)		
Evaluation of Selected Clones, Cultivars, Tuber Families for Yield and Good Storability in DLS	544 cl/cv 283 TF/Bk progenies	Ongoing till Nov. 1990

subjected to Colorado potato beetle-exposure trials reduced the density of L3 and L4 larval stages by more than 50%. L235-4 produced 1.7 kg/plant and represents a major breakthrough in developing insect-resistant varieties.

The clone E74-7 is a neo-*tuberosum* clone obtained by seven generations of cyclic selection with andigena germplasm. It is highly resistant to PVY and PVX, moderately resistant to PLRV, late blight, and scab, and has high yield. In two yield trials it ranked first and second in marketable yield.

North Carolina State University. A sample of 80 long day-adapted clones were planted in a crossing block to generate seed for preservation of the population. These 80 clones have high specific gravity, good resistance to *Alternaria* and *Erwinia*, and may have some heat tolerance.

During the 1990 winter season all clones were evaluated for the presence or absence of PVX and PVY, and PLRV. No PVX was detected. PVY and PLRV were detected in many clones but some were free from all three viruses (as detected by ELISA). This may indicate that some virus resistance is present in the population. A graduate thesis project is continuing the incorporation of PVY and PLRV resistance into this population, which already has high specific gravity and resistances to *Alternaria* and *Erwinia* soft rot.

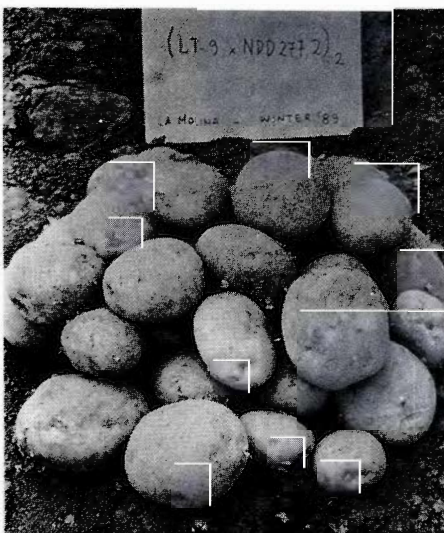
Preliminary studies showed heritability of resistance to *Erwinia* soft rot to be h^2=.55. Specific gravity was shown to have a very low genetic correlation to soft rot resistance, although the phenotypic correlation may be high. Clones with good resistance to soft rot were identified.

Universidad Nacional de Tacna. High tolerance to salt has been confirmed in potato clones that survived in extremely saline soils and restricted watering conditions. Susceptible checks growing under these conditions succumbed to salinity. The clones (Bzura x LT-7).13, (LT-8 x 378015.16).2, (Bzura x 575049).1, (Bzura x LT-7).2, and (Serrana x Y84.011).6, among others, were particularly well adapted to these conditions.

A sample of 20 advanced clones showing good levels of tolerance to salinity and restricted watering conditions were utilized as progenitors to generate, by bulk pollinations, a new population with enhanced adaptation to saline soils. The adaptation to these environments implies tolerance to salinity and boron toxicity as well as mineral stresses other than salinity, such as deficiency of N, P, and Zn.

True Potato Seed (TPS) Research

Introduction of resistance to PVY and PVX immunity into the TPS populations within the lowland tropic genetic materials was continued in 1990. In addition, PLRV sour-



Potato virus X and Y immune clones selected as potential varieties.

ces of resistance from the Polish-CIP research contract for virus resistance were utilized. The progenies were tested for agronomic and reproductive characters in different seasons at San Ramon and La Molina. Some families with good performance were identified and good yielding clones were selected (Tables 2-4 and 2-5).

Two excellent progenitors for TPS utilization, NDD 277.2 and Maine-47, have been freed from pathogens and will be distributed in the regions to be used in breeding. The hybrids Serrana x NDD 277.2 and Maine 47 x 378015.16 were found in previous TPS-progeny evaluations to be outstanding progenies for potato production from TPS.

Kenya. In CIP's Region III, 78 hybrid and 25 OP progenies were obtained from CIP's selected clones. Most of these progenies have adequate seeds to launch progeny evaluation trials at the regional headquarters in Kenya and in selected national programs. Currently, progeny evaluation trials as well as seedling tuber production are under way at Tigoni and Kabete near Nairobi. Samples of selected TPS progenies have also been distributed to national programs within Region III.

Table 2-4. Evaluation of a segregating TPS-virus resistant population. San Ramon, rainy season, 1990.

Pedigree	Weight of Tub/Plt (kg)	No. of tub/plt	Plants at harvest	Tuber color	Tuber shape	Tuber size	Flowering intensity	Flowering duration	Pollen product.
C.227LM86-B x XY13	0.508	14.46	26	9	6	6	6	7	2
C.227LM86-B x YY9	0.461	12.95	30	9	6	6	6	83	3
C.734LM86-B x YY9	0.456	11.91	23	9	6	7	5	7	3
C.227LM86-B x YY5	0.422	11.65	28	9	6	5	5	6	3
C.227LM86-B x XY14	0.422	9.67	27	9	6	6	7	8	2
C.13LM86-B x XY13	0.404	14.26	24	9	3	5	6	7	2
C.200LM86-B x XY14	0.379	10.51	28	9	4	6	6	7	2
C.212LM86-B x XY14	0.378	6.32	26	9	6	6	7	7	1
C.212LM86-B x XY13	0.372	12.89	25	9	4	6	8	8	2
C.581LM86-B x YY9	0.370	10.75	27	9	5	6	8	8	2

Table 2-5. Evaluation of a TPS-virus population. La Molina-90. La Molina, winter 1990.

Pedigree	Weight of tub/plt (kg)	No. of tub/plt	Tuber color	Tuber shape	Tuber size	Plants at harvest	Earliness	Flowering intensity
C.631LM86-BxDG8168	956	46.5	9	6	6	39	6	1
C.227LM86-BxBULKYYB	950	27.1	9	5	6	39	5	2
C.227LM86-BxDG8168	944	21.5	9	5	6	40	5	1
C.51LM86-BxDG8168	927	33.4	9	6	6	39	5	3
C.227LM86-BxBULKYYA	891	21.7	9	6	6	39	5	2
C.203LM86-BxBULKYYB	889	31.8	9	6	5	38	5	3
C.603LM86-BxDG8168	888	30.9	9	6	6	39	5	4
C.603LM86-BxBULKYYA	869	23.8	9	5	6	39	5	3
C.632LM86-BxBULKYYB	857	27.3	9	6	6	38	5	2
C.632LM86-BxHER22.2	803	27.4	9	6	6	38	5	2

Distribution of Potato Germplasm

Table 2-6 summarizes distribution of germplasm in 1990. Shipments of clones as tubers have increased while those of in vitro clones have decreased. This is due to the high demand for the clones used in the international late blight project, which are not available in vitro. The demand for tuber families decreased as more countries attained the capability to utilize TPS progenies, which have been increasingly in demand.

Sixty-five developing countries and 13 developed nations received CIP's germplasm in 1990.

Table 2-6. CIP germplasm distribution 1990.

Region	Clones Units	Clones Accs	In vitro Plantlets Units	In vitro Plantlets Accs.	Tuber Family Units	Tuber Family Accs.	TPS Units	TPS Accs.	TPS Progeny Units	TPS Progeny Accs.
-	368	152	556	153	0	0	40655	306	0	0
I	13790	1136	491	231	8558	81	90155	546	455700	
II	4646	514	448	137	203	9	2700	17	1328000	26
III	8533	1078	201	83	15371	335	256200	66	336010	68
IV	1389	228	158	79	6428	137	0	0	684800	138
V	3015	549	48	24	4133	106	0	0	367600	54
VI	186	33	207	84	1544	37	105000	7	194000	104
VII	530	30	158	68	2511	44	406400	190	2553800	66
VIII	0	0	102	50	0	0	57480	240	0	0
Total	32457	3720	2369	909	38748	749	958590	1372	10021210	514

Sweet Potato

Peru. A sample of 80 Peruvian germplasm accessions was evaluated in an observation trial on alluvial soil at Yurimaguas. At harvest, at 4 1/2 months, 72 clones produced little or no root yield and only eight clones, with a mean yield of 11.4 kg/ha (overall trial mean was 1.5 t/ha), were selected. The root dry matter content of these clones averaged 35.8%.

Hybrid clones from the germplasm collection were evaluated at Tacna, Cañete, and Yurimaguas to identify the best clones for further evaluation. Selected results of these trials are presented in Table 2-7. On the basis of yield and dry matter content, only two clones were selected across environments. The results of these trials reconfirm the low frequency of clones from the Peruvian germplasm collection that show adaptation to hot and very humid conditions. Tables 2-8 and 2-9 present means by country institution of origin and type of planting material (seedlings vs. cuttings) for dry matter content and fresh root yield obtained in several trials at Yurimaguas. The Japanese materials had high dry matter content and yield. These materials are also valuable because several progenies lack ß-amylase in their progenitors. The AVRDC/IITA seedling trials presented in Table 2-9 were conducted in very acidic soils during the rainy

Table 2-7. Yield and dry matter content of selected germplasm accessions (hybrids from the breeding program of R. del Carpio) at Cañete (C), Tacna (T), and Yurimaguas (Y)[a]. Harvested after 4 1/2 months.

	Yield (t/ha)			Root Dry Matter Content (%)			Selected[b]		
Clone	C	T	Y	C	T	Y	C	T	Y
Cñ SD144-79	-	-	6.3	-	-	35.6			+
RCB 103-IT	38.8	13.8	6.9	22.0	-	33.0	+		+
RCB 137-IT	25.8	57.9	1.7	35.1	24.8	34.0	+	+	+
RCB 2980-H	39.4	0.0	16.9	25.1	-	29.4	+		+
RCB 3449-H	22.5	22.5	17.4	17.3	17.2	17.5	+	+	+
X Selected	27.1	26.8	6.9	27.3	26.6	26.3			
n	100	70	44	100	70	44			
X Trial	16.6	9.3	1.4						
n	364	480	404						

[a]Trials were replicated. Single-row plots consisted of 10 cuttings per clone, planted 0.2 m within plot and 0.9 m between plots.
[b] Preliminary selections based on root appearance and yield.

season. Both the mean fresh root weight and the proportion of selected clones were relatively higher for the AVRDC material (15.7%), than for that of IITA (11.3%). These results show that foreign materials could provide good sources of adaptation to wet, tropical conditions.

Harvest of TPS trials at San Ramon.

Table 2-8. Root yield and root dry matter content in sweet potato seedling and clonal trials conducted at Yurimaguas[a].

Source Country	Trial	No. families[b] (individuals)	Fresh root yield means (range) (g/plant)	Dry matter content means (range) (%)
China	BST8902	22 (112)	143 (37 to 337)	36.0 (27.7 to 45.4)
	OT9005	22 (112)	319 (0 to 843)	30.8 (16.2 to 45.1)
	OT9006	22 (112)	244 (0 to 1050)	33.8 (15.6 to 50.5)
Japan	BST8902	20 (162)	30 (0 to 110)	37.8 (to 47.0)
	OT9005	20 (133)	295(0 to 1175)	33.5 (11.4 to 50.8)
	OT9006	20 (133)	212 (0 to 875)	35.7 (16.7 to 56.5)
Peru	BST8901	14 (467)		26.5 (to 34.6)
	OT9005	14 (67)	225 (0 to 592)	32.8 (24.3 to 54.6)
	OT9006	14 (67)	149 (0 to 610)	35.6 (15.0 to 49.6)
Puerto Rico	BST8902	2 (13)	14 (8 to 20)	35.8 (29.1 to 42.4)
	OT9005	2 (7)	284 (124 to 494)	28.2 (20.8 to 39.2)
	OT9006	2 (7)	224 (32 to 363)	33.2 (22.4 to 41.8)
USA	BST8902	11 (81)	74 (21 to 137)	30.5 (25.9 to 39.1)
	OT9005	11 (76)	275 (0 to 820)	28.0 (16.6 to 42.1)
	OT9006	11 (76)	193 (0 to 1870)	30.7 (14.1 to 46.5)
Vietnam	BST8902	3 (48)	78 (51 to 95)	33.2 (29.1 to 36.8)
	OT9005	3 (42)	321 (29 to 615)	28.9 (18.9 to 39.4)
	OT9006	3 (42)	216 (0 to 550)	31.4 (18.2 to 48.8)
Jewel	OT9005	40	232 (0 to 426)	25.5 (16.1 to 35.8)
(Check)	OT9006	38	224 (65 to 458)	28.0 (22.5 to 37.6)

[a]For Jewel, the number given is the number of times the check was replicated.
[b]Except for the Peruvian seedlings, the materials included in this table were evaluated in the same seedlings trial (BST8902), and all were evaluated in the same clonal trials which were conducted simultaneously on acid (OT9005) and alluvial (OT9006) soils.

A group of 16 sweet potato clones bred in Peru were submitted for pathogen clean-up before regional distribution (Table 2-10).

The Philippines. Research on sweet potatoes concentrated on characterizating the germplasm collection for shade and drought tolerances, yield, earliness, dry matter content, and resistance to weevil and root-knot nematodes. To evaluate for shade tolerance, two trials were conducted. Trial 1 contained 120 clones and trial 2, 183 clones. In trial 1 shade provided by corn plants varied from 25% to 63%, in trial 2, from 48% to 81%. A random sample from the trials was grown under full sunlight.

The best clones in trial 1, harvested 90 and 120 days after transplanting, are presented in Table 2-11. In trial 1, shade reduced yield by 60% and root size by 65%.

Table 2-9. Means and ranges of fresh root yields and root dry matter contents in seedling trials and clonal trials of sweet potatoes from two sources. Trials were conducted at Yurimaguas.

Source	Trial	No. families[a] (individuals)	Fresh Root Yield means (range) (g/plant)	Dry matter content means (range) (%)
AVRDC	BST9001	22 (187)	140 (41 to 221)	31.9 (24.3 to 38.1)
	OT9007	22 (187)	504 (0 to 3600)	31.8 (15.7 to 44.2)
	OT9008	22 (187)	498 (0 to 1675)	32.8 (16.7 to 46.3)
IITA	BST9001	8 (30)	37 (0 to 80)	23.6 (to 29.7)
	OT9007	8 (30)	846 (0 to 2417)	28.3 (20.8 to 41.3)
	OT9008	8 (30)	466 (0 to 1360)	30.8 (22.4 to 38.7)

[a]The materials included in this table were evaluated in the same seedling trial (BST9001), and all were evaluated in the same clonal trials (OT9007 and OT9008) which were conducted simultaneously on acid and alluvial soils, respectively.

Table 2-10. Selected sweet potato cultivars programmed for pathogen cleanup and regional distribution.

Clone	Pedigree of progenitor		Yield/ plant	Dry matter
ST87.006	RCB.057.IN	Chalaquito	1262	30.95
ST87.009	RCB.028.IN	Sanpedrano	2198	31.08
ST87.030	RCB.057.IN	Chalaquito	—	33.57
ST87.070	RCB.057.IT	Yorouba	950	30.29
SR88.029	RCB.033.IN	Bco. Coyungo #1	714	27.42
SR88.050	RCB.217.IN	Juan Sanchez	661	27.98
SR88.055	RCB.144.IN	Camote de Oxapampa	592	31.16
SR88.075	RCB.144.IN	Camote de Oxapampa	1070	22.37
LM88.002	RCB.017.IN	Torreblanca	1083	26.89
LM88.007	RCB.049.IN	Oreja Galgo Blanco	879	25.02
LM88.014	RCB.017.IN	Torreblanca	829	28.58
LM88.082	UNTAC-01	Morado de Magollo	538	24.66
LM88.113	RCB.144.IN	Camote de Oxapampa	787	26.58
LM88.114	RCB.211.IN	Pacaranero	746	27.25
LM87.009	UNTAC-01	Morado de Magollo	684	32.59
LM87.045	UNTAC-01	Morado de Magollo	1460	32.41

In trial 2, the shade effect was so strong that very few clones gave significant yields.

Yield, Earliness, and DM Content

A total of 271 clones were evaluated for these traits from December to April 1990. At 90 DAP, yield ranged from 7g to 755 g/plant, and at 120 DAP, from 25g to 1430 g/plant. As observed last year, clones that were high yielding at 90 DAP were also the highest yielders at 120 DAP. Clones selected for high yield and/or DM content,

Table 2-11. Effect of shade on sweet potato yield. The Philippines, 1990.

	Trial 1						Trial 2					
	Yield (g/plant)				Gain (+) or loss (-) (%)		Root size (g)				Gain (+) or loss (-) (%)	
	F		S				F		S			
Clone	90	120	90	120	90	120	90	120	90	120	90	120
VSP-5	612	683	166	203	-73	-70	175	137	46	74	-74-	46
VSP-6	510	1500	231	244	-35	-84	134	346	56	94	-58	-73
LO86	500	600	133	157	-73	-74	125	139	43	56	-66	-60
BPISP2	470	963	246	404	-48	-48	138	193	85	155	-38	-20
Kinabakab	483	750	165	285	-66	-52	207	150	62	118	-70	-21
LO91	260	450	127	150	-51	-67	81	113	46	63	-43	-44
LO36	300	450	102	125	-66	-72	92	75	39	63	-58	-16
Bureau	300	225	182	221	-39	- 2	171	90	86	81	-50	-10
Miracle	225	583	173	170	-77	-71	82	250	75	63	- 9	-75
TN-57	425	588	99	246	-77	-58	170	214	45	230	-74	+ 8
Mean of 15 clones	382	654	154	201	-60	-65	122	160	50	84	-59	-44

F = Full sunlight, S = with shade, % change = $\frac{S - F}{F} \times 100$

both at 90 and 120 DAP, include N002, N020, N003, N053, N052, N001, N060, L004, L060, N021, M011, N074, M014, N038, L066, L088, L082, DC-6, Bintung, L091, and N084.

A summary of the evaluation during the past three seasons indicates higher yields for lowland clones over highland clones across two seasons in 1989. There was a reduction in yield, root number per plant, and average root weight in the wet season, as compared with the dry season. The information gathered in these successive evaluations will serve as the basis for clone selection.

Resistance to Weevil (*Cylas formicarius*)

Two sets of clones were screened for resistance to the weevil. Following CIP procedure, a set of 114 clones was tested under laboratory conditions and 10 were classified as resistant. A total of 286 clones have been laboratory-screened since 1989 and 22 clones have been classified as resistant. These promising clones are being multiplied for further verification under field conditions. Of a field-tested set of 175 clones, 50 were classified as resistant. This field screening appears to be unreliable, thus results will be used to discard only the most susceptible clones.

Resistance to the Root-knot Nematode (*Meloidogyne incognita*)

The Philippines. In collaboration with the Department of Agriculture at Camarines Sur, 54 clones were screened for resistance to root-knot nematode. The plants were grown in three replicates in pots, and 20 day-old plants were inoculated with 10,000 eggs per pot at the base of the plants. As-

Heat-tolerant-early-maturing sweet potato clone.

sessment of the resistance was done after 60 days. Twenty-eight root samples per plant were used in determining resistance. Data recorded included number of nematodes, number of galls, and amount of eggmass per sample. A total of 10 clones were classified as resistant, which included Bangkas, DC-9, L052, and X-1. CM-3, D-3, DM-7, Clarin, L019, and M-1 were found to be moderately resistant. Another 74 clones are still being screened.

North Carolina State University. Seedlings from the 1989 polycross nurseries were evaluated for root-knot nematode reaction, food quality, earliness, and yield. Data are now being analyzed.

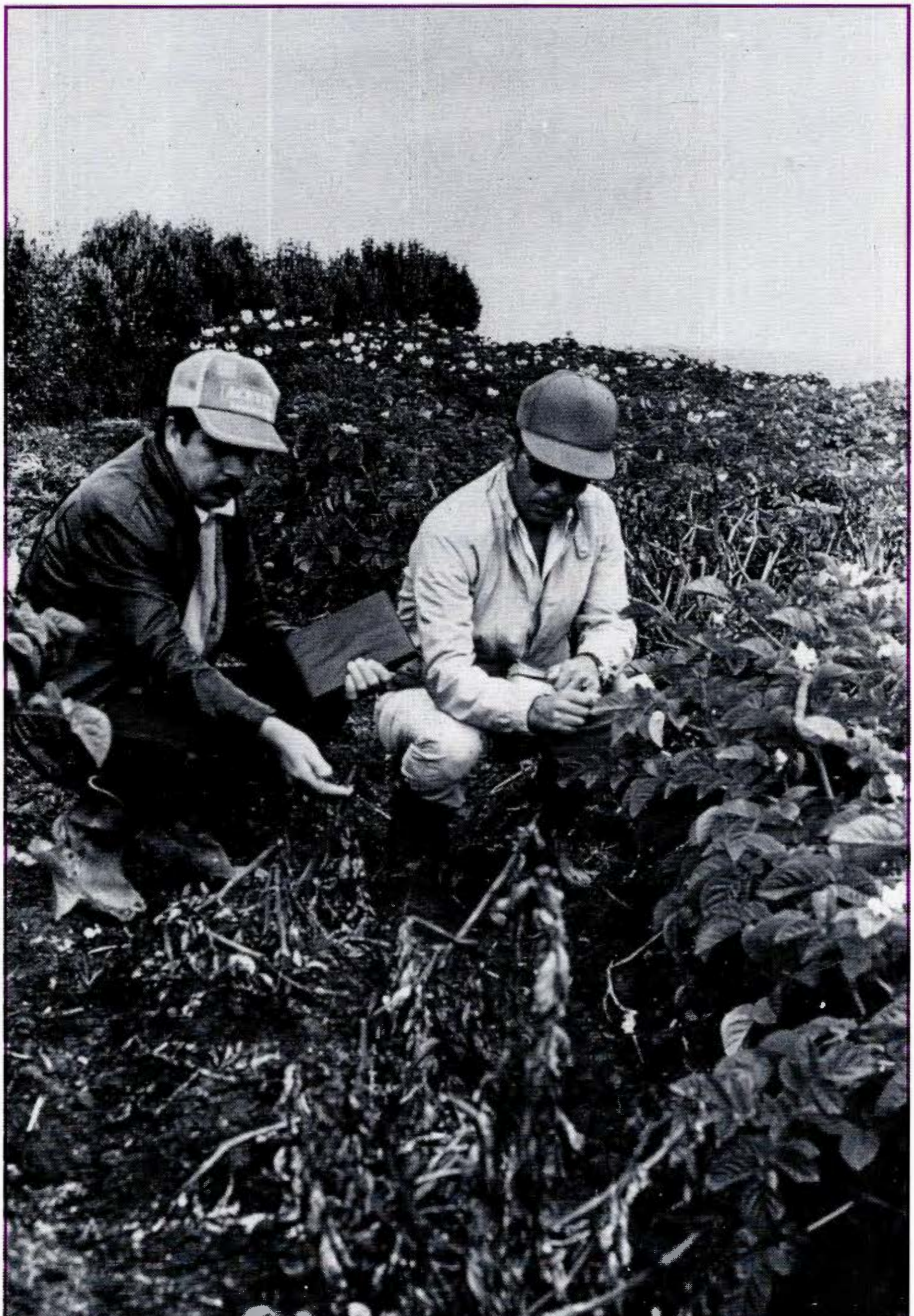
In 1989, a wide genetic-based population was begun. In 1990, 974 seedlings representing 18 families from a wide genetic background were planted in a crossing block with four replications to produce the second generation of this population. This trial has been harvested and seed is being extracted.

A sample of 450 offspring of 15 progenitors from 1989 crosses was evaluated under non-fertilized and fertilized conditions to determine heritability of dry matter, non-protein nitrogen, protein nitrogen, and total nitrogen, as well as the genetic correlations between these food-quality components. Plots were harvested last October and data are being analyzed.

Twenty-two clones were evaluated extensively for yield, cooking quality, and taste. These clones are now ready for distribution.

Universidad Nacional de Tacna. In this contract, several hybrid clones from various polycrosses have been screened for tolerance to salinity and drought.

As a result, four salt-tolerant clones have been selected and programmed for pathogen cleanup for future distribution to the regions and national programs.



Potato cultivar destroyed by late blight, flanked by resistant cultivars. Porcon, Cajamarca, Peru. INIAA program.

Thrust III

Control of Bacterial and Fungal Diseases

Thrust Profile: 1991

BACTERIAL AND FUNGAL DISEASES severely reduce potato and sweet potato productivity and use in developing countries. CIP collaborates with NARS and private industry to develop integrated control measures against these diseases, including the production of cultivars with durable resistance, derived from the screening for resistance in CIP's germplasm. In order of CIP's research priorities, the most important diseases are late blight, bacterial wilt, soft rot, blackleg, and early blight. Late blight is the most damaging disease of potatoes worldwide. New resistant populations have been improved by the inclusion of resistance to potato viruses X and Y. Selection for higher levels of field resistance has now begun at the Santa Catalina Experiment Station at Quito, Ecuador. Additional resistant cultivars have been selected in Bolivia, Burundi, China, Colombia, Mexico, The Philippines, Rwanda, and Uganda, as part of procedures for variety development. At Huanuco Experiment Station in Peru, variety INIAA-Canchan is the most recent of CIP's collaboratively developed or distributed cultivars to have been selected by INIAA staff.

Bacterial wilt is the most damaging disease in warmer climates. Resistant clones selected by national programs over the past four years include: BWH-87.66 and BWH-87.446 in Peru; 800935, 381064.8, 377852.2, 377319.7, and 10A-1 in China; and 800212, 800224, and 720118 in Uganda. These are being used as components of integrated control programs.

To produce bacterium-free tuber seed, it is necessary to have the diagnostic ability to detect the causal agent, *Pseudomonas solanacearum*. Biotechnological research at Wisconsin has produced a DNA probe suitable for such diagnostic purposes, and a detection kit for *Pseudomonas solanacearum* is being developed.

Recent improvements in the procedures to screen for resistance to *Erwinia* soft rot and blackleg include the use of a more aggressive bacterial strain, an evaluation scale that compensates for escapes, and the construction of a larger anaerobic incubation chamber that permits the testing of tubers of more uniform physiological age and turgor. Hybrids derived from *Solanum brevidens*, a new and promising non-strain-specific source of resistance, were found to be resistant to different strains of *Erwinia* in Peru and Scotland.

Monoclonal antibodies for *P. solanacearum* and *Erwinia carotovora* subspecies *atroseptica* and *carotovora* were developed in China for use in detection of latent infections in tubers and plants.

Clones with combined resistance to early blight (*Alternaria solani*) and viruses X and Y have been selected in Brazil and Uruguay, in areas where these problems are the most serious limiting factors. Similar combined resistances also have been identified in clones selected at San Ramon, Peru. Some of these selected cultivars showed improved qualities of yield, earlinesss, and heat tolerance.

A control method with minimal use of fungicide was developed in Ecuador for common rust of potato, which is a severe limiting factor in the high-elevation major producing region. In Peru, the national program selected a variety resistant to powdery scab, which is a damaging disease in the cold highlands, for recommendation to growers. Screening for resistance to several soilborne pathogens in Bolivia has shown encouraging preliminary results.

Surveys and research in Peru identified two previously unrecorded sweet potato storage root rots caused by *Aspergillus* sp. in the Department of Lambayeque, and *Pythium* sp. in the Department of Junin. Screening for resistance to soft rot (*Rhizopus stolonifer*) in San Ramon resulted in the selection of 12 cultivars with slight resistances. In Guangdong, China, screening for resistance to bacterial wilt allowed selection of two clones showing no disease, whereas the resistant check had a 5% rate of infection and the susceptible check, 100%.

A pilot program in Kenya provided preliminary data for a computerized databank based on surveys of sweet potato diseases in developing countries. Newly diagnosed diseases are being investigated. A survey begun in Argentina has revealed substantial losses to diseases in plant beds. Tests initiated to control the seedborne *Fusarium lateritium* that causes chlorotic leaf distortion have been inconclusive, and the apparent systemic infection of this fungus seems limited to the true seed.

Potato Diseases

Potato diseases are among the most important biotic factors limiting production. Of these, late blight is the most severe, greatly reducing yields, even when fungicides are applied. In cool regions, where seed programs are ineffective, bacterial wilt is a serious problem and can limit the production and expansion of the potato crop in the lowlands. The *Erwinias* cause soft rot in field and store, and blackleg in the growing crop; thus they account for considerable losses under some environmental conditions. Losses due to early blight are increasing in importance where late blight is controlled with specific fungicides, and in some environments relatively new for potato production in the warmer tropics.

Late Blight

Peru. At La Molina the breeding research continued with Population A, containing R-genes. A population of 30,000 seedlings was obtained from 100 families that were being screened under quarantine conditions in Lima against the most complex race ("C") of *Phytophthora infestans* (race 1, 2, 3, 4, 5, 6, 7, 10, 11). Approximately 10% of these seedlings were transplanted to pots and allowed to grow to maturity. Of these transplants, 1,800 seedlings from 75 families that included one parent with immunity to PVX and PVY were screened against both viruses. Immunity was confirmed by grafting, and the ELISA test provided information on immunity or escapes. Materials with the combined resistances will be used as parentals.

In early 1990, a variety named INIAA-Canchan was released by the Huanuco Experimental Station. CIP supplies Population A materials each year to this station; 120 new clones were tested in 10 hill-observation plots and 16 more advanced clones in replicated trials. High levels of resistance and high yields were reported, with three clones (85 LB 70.5, 380474.6, and 380474.18) yielding 1.9 kg per plant.

Agronomic testing of 590 selections at Cajamarca resulted in the selection of 300 clones, some of which were tested for processing quality. Another 99 clones from this group were tested in a simple lattice design, and results show that the yield potential of clones from this population is maintained even at low fertility levels and poor soil conditions (Table 3-1).

Table 3-1. Yield performance of the best 18 late blight-resistant clones tested in a simple lattice 10 x 10 design in Cajamarca, 1990.

Clone number	Yield kg/plant
85LB54.24	2.0
85LB54.9	1.4
85LB65.8	1.4
85LB4.11	1.4
85LB55.6	1.3
85LB15.19	1.3
85LB54.17	1.3
85LB53.12	1.3
85LB53.9	1.2
85LB65.7	1.2
85LB4.1	1.2
85LB51.4	1.2
Perricholi (check)	1.2
85LB75.3	1.2
85LB54.55	1.1
85LB51.15	1.1
Yungay (check)	1.1
85LB27.8	1.1
85LB4.38	1.1
85LB53.4	1.1
Tomasa Condemayta (check)	0.8
Mariva (check)	0.7
C.V.%	27.7
LSD (0.05) =	0.480

Plant density 33,333 plants /ha

Population A contains a broad range of variation of resistance, due primarily to horizontal resistance. This was demonstrated when fields where complex races of the fungus occur in Colombia and Rwanda (see Colombia and Rwanda reports below) were planted with samples of this population. An example of results at Rionegro, Colombia is shown in Figure 3-1.

To extract R-gene-free clones that have high levels of horizontal resistance from Population A, leaves detached from approximately 300 clones from Group VIII were inoculated simultaneously with races "0" and "C." Two drops of inoculum at a concentration of 4000 zoospores per ml were placed on each leaf of the same clone for each race and incubated in a petridish. Five days later, lesion expansion and sporulation were recorded. After repeating the test from three to five times, 26 clones were identified as free of R-genes. Four other such clones were identified in Groups I to VII. These clones are being intercrossed to produce the R-gene-free Population B. This work should permit a new strategy for late blight testing, as selection will be possible regardless of which race is present in a given location.

Two other sources of R-gene-free germplasm have been developed to complement that derived from Population A, of *Solanum demissum* ancestry. These two sources are from crosses among selected *S. tuberosum* subsp. *andigena* clones, which are in a third recombinant cycle, and from among selected *S. t. andigena* and *S. t. tuberosum* clones, which are in a second cycle. From each of these two sources (80 and 116 families, respectively), 30,000 seedlings will be screened in the field at

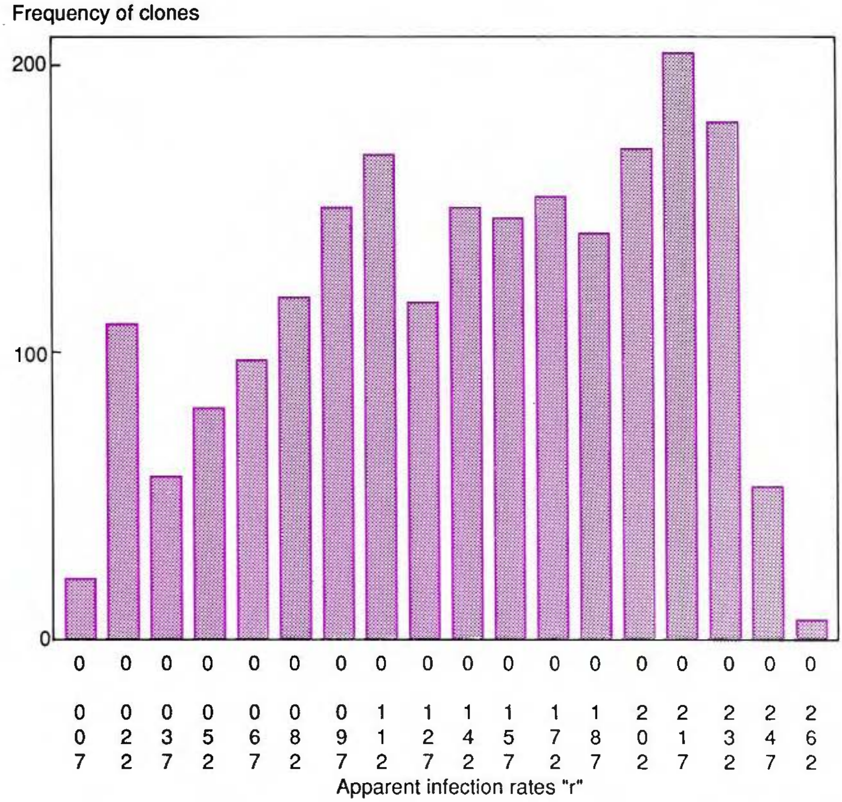


Figure 3-1. Distribution of values of apparent infection rates "r" of group IX clones tested in the field in Rionegro, Colombia.

CIP's new facilities in Quito, Ecuador, to select for higher levels of field resistance and superior agronomic characters.

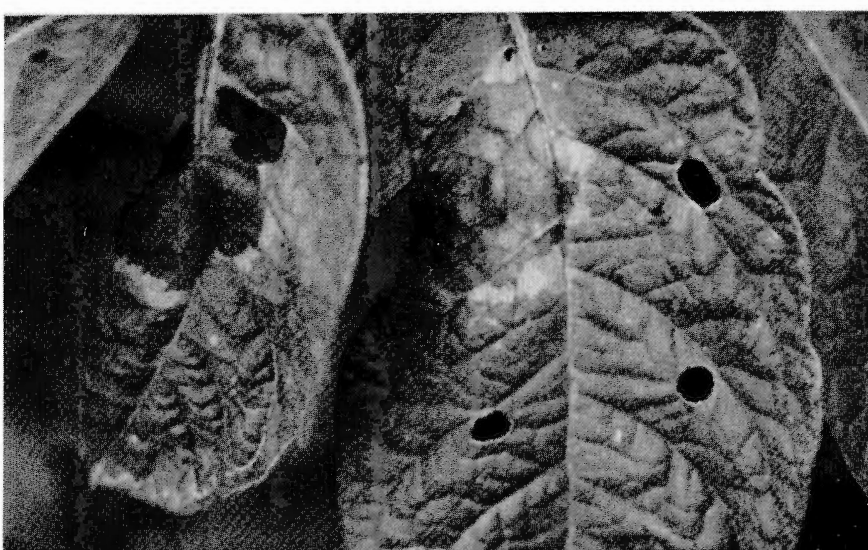
Bolivia. After several years of testing in CIP and Colombian trials, 261 clones were evaluated at Escalante, where late blight is prevalent. Fungicides were not applied in the tests, from which 74 clones were selected for future evaluations. These clones had average yields from 0.7 kg to 3.2 kg/plant and average late blight readings from 1.0 to 2.5, along with good agronomic characteristics. Cultivars Alpha (Dutch) and Huaycha Paceña (Bolivian) were shown to be susceptible, while Rosita, Puca Toralapa, and Chitagá (Monserrate) were resistant. No symptoms were found on the foliage of Runa Toralapa or Atzimba.

To select resistant cultivars with better adaptation to local conditions, 10,200 TPS were planted and 5,235 seedlings were inoculated in the greenhouse. These materials were from 102 families obtained from CIP and ICA-Colombia. After screening, 2,830 tolerant seedlings were selected and then grown in pots in the greenhouse. Approximately 1,200 plants were selected at harvest and are being further evaluated.

Burundi. Among materials received during 1990, 93 clones of 13 families performed well at the Gisozi station of ISABU. Of previously tested materials, 20 clones have been selected as superior. Advanced cultivar tests with five clones and four commonly grown varieties demonstrated that variety Uganda 11 outyielded the clones. In comparative trials at four locations with four selections, average yields of clones 381382.9 and 374080.5 were greater than those of Uganda 11, exceeding Uganda 11 by 3.6 t/ha and 4.1 t/ha, respectively. A third clone, BU-85058, whose average yield, was only 0.5 t/ha greater than Uganda 11 (because of greater susceptibility to late blight), will be tested in the dry season in marshland, or in other lowland areas where late blight is less prevalent.

China. On-farm, randomized complete block design trials in Yunnan Province have confirmed the results of 1987-1989 trials, demonstrating the yield superiority of CIP-distributed cultivars B-71-240.2 (720088), I-1085 (676089), and CFK 69.1 (720084). Cultivar B-71-240.2 (720088), was moderately resistant and of medium maturity, yielding 58.5 t/ha at Kunming and 43.9 t/ha at Xundian, as compared with yields of 29.5 t/ha and 23.8 t/ha for the check (Mira). The two other cultivars in these trials were highly resistant and yielded over 46 t/ha in Kunming.

Colombia. Continuing the ICA-CIP collaboration to test progenies generated in Peru, the IX annual test (Group IX) at La Selva, Rionegro was completed with 3,227 clones of 80 families (2,061 of these were also tested in Rwanda; see below). To provide a severe and uniform test, the most complex race isolated from the same field was used for inoculation. The objective was to select for horizontal resistance in the presence of unknown R-genes. A favorable environment for the fungus was



Late blight is the most damaging worldwide disease of potato.

assured by utilizing sprinkler irrigation to maintain a high relative humidity. After 120 days, 262 (8%) of the clones from 60 families were selected. Selections from previous years have been retested annually and progressively reduced in numbers, as a result of the appearance of new races and the use of stricter selection criteria in consecutively larger plots. The 145 clones from Groups I-VI remained resistant and have yielded well. After retesting of 22 Group VII selections, eight were chosen (Table 3-2). In a second test from 166 Group VIII clones that had been selected the previous year, all clones maintained their resistance; however, 105 were discarded because of undesirable agronomic characteristics. Another 94 clones from Group VIII, selected in Mexico, were also tested, and 43 were shown to be resistant. These 104 Group VIII clones are being multiplied under quarantine conditions in Lima for distribution to the regions and NARS. Selections from Groups I-IX will be retested next year.

Mexico. The INIFAP program at Toluca has made selections from CIP germplasm for late blight resistance, and

Table 3-2. Late blight performance of clones of Group VII during second semester of 1989. Int. Late blight trial. Data by Instituto Colombiano Agropecuario, Rionegro - Colombia. 1990.

CIP No.	Average yield kg/pl	Apparent infection rate (r)	Relative AUDPC[a]	Total AUDPC
386029-12	0.74	0.19	158.33	11082
386040-9	0.77	0.17	105.00	7333
385239-6	0.70	0.16	127.66	8948
386040-20[b]	0.77	0.16	113.00	7912
386030-4	0.62	0.16	156.66	10980
386087-12	0.54	0.12	52.66	3668
386011-7[b]	0.56	0.10	35.66	2508
386048-1	0.62	0.10	69.66	4898
386086-18	0.50	0.08	36.00	2508
386031-20[b]	0.45	0.08	26.00	1739
386083-7	0.73	0.07	24.00	1657
385176-20[b]	0.53	0.07	26.00	1817
386051-8[b]	0.44	0.07	19.66	1381
385180-25	0.56	0.06	14.33	992
386005-3	0.47	0.05	30.00	2241
386086-4	0.45	0.05	22.00	1505
386056-5	1.07	0.05	9.66	670
386073-7[b]	0.78	0.04	14.66	1015
386087-15	0.70	0.04	12.00	807
385199-28[b]	1.30	0.04	7.33	508
385183-2[b]	0.80	0.03	9.33	622
386054-5	0.22	0.03	7.66	544
C. V.		29.41	43.18	43.37

[a]AUDPC= Area under the disease progress curve.
[b]Selected.

has added 21 clones to its germplasm bank. Forty additional selections are in a third clonal generation and eight selections are in each of the yield trials (40 plants x 4 replications) and regional trials (20 plant plots). CIP Clones 382143.17, 380026.12, 382245.20, 381381.9, and 380018.21 have been selected in both trials, indicating considerable potential for variety development in the near future. Clone 380024.6 is now replicated in yield trials and is considered excellent by the INIFAP potato program.

The Philippines. At La Trinidad, Benguet (Table 3-3) five clones were selected by farmers and researchers from among 18 previously selected. These five clones showed good tuber characteristics in addition to late blight resistance, and yielded from 17.8 to 22.2 t/ha, compared with the susceptible and resistant check yields of 16.1 t/ha and 22.6 t/ha, respectively. In a third recurrent selection, 25 were selected from 96 clones. Table 3-4 shows the best 10 of these, which had 2 to 5 times greater yields than did the check, Cosima.

Rwanda. The Rwandan national program (PNAP) conducted a field resistance test with 2,061 clones of Group IX (simultaneously tested in Colombia) at the Kinigi Agricultural Research Station. Based on apparent infection rate (r-values), 80 clones performed better than did the resistant check variety, Cruza 148 (720118). In performance based on disease progress curves (AUDPCs), 72 clones were better than the check. Sixteen clones were superior to the check on both criteria. Clones within the families 384224 (38% selected) and 387233 (32% selected) were consistently better than the check. A total of 214 clones were selected for future testing.

As shown in Table 3-5, however, the more susceptible check, Sangema, bulked early and outyielded Cruza 148. Only 7 clones yielded more than did Sangema.

The addition of the Rwandan field-test site has permitted selection of CIP Popula-

Table 3-3. Tuber yields and late blight scores (LBS) 80 days after planting (DAP) of 5 selected clones out of 18 clones evaluated at La Trinidad, Benguet from December 1989 to March 1990.

CIP code	Pedigree	LBS 80DAP	Hills harvested (%)	Yield (t/ha)
384321.35	380479.15 x BK 3	2	86	22.2
384331.10	B-33 x Bk LB.79.80	3	95	22.0
384321.19	380479.15 x Bk 3	1	99	19.3
384298.63	380387.3 x Bk LAJ	1	79	18.3
384321.15	380479.15 x Bk 3	2	88	17.8
P-3 (resistant check)		4	95	22.6
Granola (susceptible check)		9	81	16.1
Mean		3.1	89.4	17.7
CV (%)		40.0	10.5	32.3
LSD (.05)		1.8	13.3	8.1

Table 3-4. Tuber yield and late blight scores of best 10 out of 96 clones evaluated in observation plts at La Trinidad, Benguet from November 1989 to April 1990.

Code	Pedigree	Late blight scores at 87 DAP	Avg. marketable Tubers/plant (no.)	Avg. marketable Yield/plant (kg)
2-21	(LBR1-3xBKLBR1 Phil).5	1	16	2.9
2-113	(LBR-1-1xLBR1-19).2	1	33	2.6
2-19	(LBR1-3xBKLBR1Phil).3	3	28	2.6
2-88	(LBR1-16xBKLBR1Phil).1	1	26	2.4
2-31	(LBR1-3xBKLBR1Phil).7	1	15	1.6
2-69	(LBR1-10xBKLBR1Phil).1	1	19	1.5
2-43	(LBR1-7xBKLBR1Phil).1	2	22	1.35
2-36	(LBR1-3xBKLBR1Phil).7	1	15	1.22
2-119	(LBR1-1xLBR1-19).1	2	17	1.18
2-11	(LBR1-1xBKLBR1Phil).1	3	12	1.12
Cosima	(susceptible check)	6	6	0.55

Table 3-5. Seven high-yielding resistant clones among 214 selected in a late blight test of 2061 clones planted at Kinigi Station, Rwanda. Checks listed are resistant varieties Sangema (Rwanda), Ndinamagara (Burundi), Perricholi (Peru), and Monserrate (Colombia). Data by PNAP-Rwanda.

Clone	Days after planting 40	47	61	68	75	AUDPC[a]	r-values[b]	Yield (gr)
387224.17	2	3	3	3	4	376	.04	650
387233.6	2	3	3	3	4	376	.04	950
387187.6	1	2	3	4	4	394	.09	650
387233.24	2	3	3	4	4	481	.05	800
387233.27	2	3	3	4	4	481	.05	1200
387244.5	2	3	3	4	4	482	.05	650
388791.14	2	3	3	4	4	481	.05	850
Sangema	2	4	6	9	9	2088	.20	625
Ndinamagara	2	3	5	6	6	1164	.12	500
Perricholi	2	4	5	6	7	1636	.13	350
Monserrate	2	9	9	9	9	3159	1.00	0

[a]AUDPC= Area under the disease progress curve.
[b]r-values= Apparent infection rate.

tion A under a heavier pressure of complex races in Africa, where there is a great need for resistant material.

Worldwide distribution. Late blight-resistant materials were distributed to 30 countries during the past year. Table 3-6 shows the distribution and selections made or materials grown for future testing.

Bacterial Wilt

Breeding and selection for resistance continue to be the methods emphasized to control bacterial wilt (BW), which is caused by the bacterium *Pseudomonas solanacearum*. Breeding and initial screening are done at CIP stations in Peru, followed by field screening at different sites in Peru, at

Table 3-6. Distribution of selected clones, clones in tuber families, and TPS in families, developed for resistance to late blight, by country, from October 1989 to October 1990.

Country	Number of selected clones	No. of clones/ tuber families	No. of botanical seed/families
Bolivia	70	1,832/50	6,000/30
Cameroon	128	2,685/57	
Congo	82		
Comores	18		
Colombia	143		6,000/30
Chile			2,400/17
China			13,500/60
Ecuador	112		
Ethiopia	158		
Egypt	27		
East Germany	129		
Ghana	30		
Guatemala	13		
Ivory Coast	16		
Indonesia		664/16	5,000/20
Kenya	162	337/17	4,000/20
Madagascar	60		1,927/20
Mexico	134		
Mozambique	56		
Nepal	27	494/19	
Nicaragua	36		
Nigeria	49	260/20	
Pakistan	173		
Peru	90		
Rwanda	95	2,481/96	
Tanzania	42	812/26	
Uganda	160	1,812/84	
Venezuela	30		3,000/40
Zaire	33		
Zimbabwe	47		
Cumulative totals	2,120	11,377/385	41,827/237

regional locations, and by collaborators in NARS. Because resistance alone does not always control the disease, resistance is normally used as a component of integrated control programs.

Peru. Segregating populations crossed for combined resistance to bacterial wilt and late blight were generated in Huancayo and selected for agronomic characteristics in La Molina. Advanced materials were tested in farmers' fields in collaboration with the Servicio de Investigación en Papa (SEINPA) in Huaraz for the fourth (final) time. Clone BWH-87.66 was selected as the most promising.

SEINPA continued to test materials in the Department of Cajamarca and previously selected clones BWH-87.174, BWH-87.176, BWH-87.177, BWH-87.178, BWH-87.180, and BWH-87.446, were multiplied for large-scale testing. Clone BWH-87.446 has shown high levels of field resistance to BW. In Chingues Bajo, a total of 6,636 clones, of which 1,007 were highly advanced and 5,629 were obtained from TPS (4,571 tetraploids and 1,058 diploids), were exposed to high infection pressure. From these, 3,806 clones were selected, and will be distributed throughout Cajamarca for further evaluation.

At the San Ramon experimental station, clones were tested for resistance to and freedom from latent infection. Plantings included 31 clones from series BWL-87, 172 from series BWL-88, and 212 from series BWL-89. In group BWL-87, only 2 clones were selected as apparently free of *P. solanacearum*; however, they showed latent infection. In group BWL-88, 19 clones were selected, and only 2 were found to be free from latent infection. In group BWL-89, 36 clones were selected, with 3 clones found to be bacteria free.

At CIP's Yurimaguas facility, a new field site was used for screening for resistance to BW. Evaluations are now being made of 274 genotypes selected over previous years for resistance to BW and to heat.

At La Molina, the technique for mass screening of potato genotypes to select for resistance to *P. solanacearum*, was further improved (see 1990 CIP Annual Report). Plants grown from cuttings, minitubers or true potato seeds (TPS) were transplanted into Jiffy-7 peat pellets and grown for four weeks or until a root system was developed. Established roots were submerged in an aqueous inoculum suspension for 10 seconds. Plants were evaluated after 4 days of greenhouse incubation at 27° C - 32° C and every 2-days thereafter for 14 days. Symptom development was strongly influenced by the concentration of inoculum ($5X10^5$ - $1X10^8$ bacteria/ml), reproduction methods for plants, and physiological age of cuttings. When roots were wounded and the highest concentration of inoculum ($1X10^8$) was used, none of the tested genotypes survived beyond 15 days. At the lowest concentration of ($5X10^5$), unwounded plants survived beyond 35 days. Advantages of this technique over the previously utilized mass screening in trays include 1) reduced variability due to avoidance of root-to-root contact; 2) easy reinoculation of surviving plants; and 3) rapid elimination of wilted plants. This technique can be used to screen plants grown from either TPS, minitubers (10mm - 30 mm diameter), or cuttings.

When disease ratings collected at 9, 11, 13, and 15 days after inoculation were considered as separate evaluations for the tested genotypes, the genotypes differed only slightly. Figure 3-2 shows evaluation data at 7, 9, 11, and 13 days after inoculation. When genotypes were evaluated only once with $5x10^7$ or $1x10^8$ bacteria/ml at 13 days (Fig. 3-2) and at 15 days (Fig. 3-3) after inoculation, most genotypes appeared to be susceptible. On the other hand, means calculated at separate evaluation dates differed substantially from means calculated over time (Fig. 3-3). Thus, frequent evaluation and calculation of the mean performance of genotypes over time is recommended for greenhouse screening, when conditions are very favorable for the pathogen. This procedure is to be used as a measure of tolerance for the genotypes, rather than for resistance. Subsequent field-testing should be used to evaluate resistance under natural conditions.

Brazil. Achat was again the best among 23 varieties evaluated for resistance to BW. This is convincing evidence, after

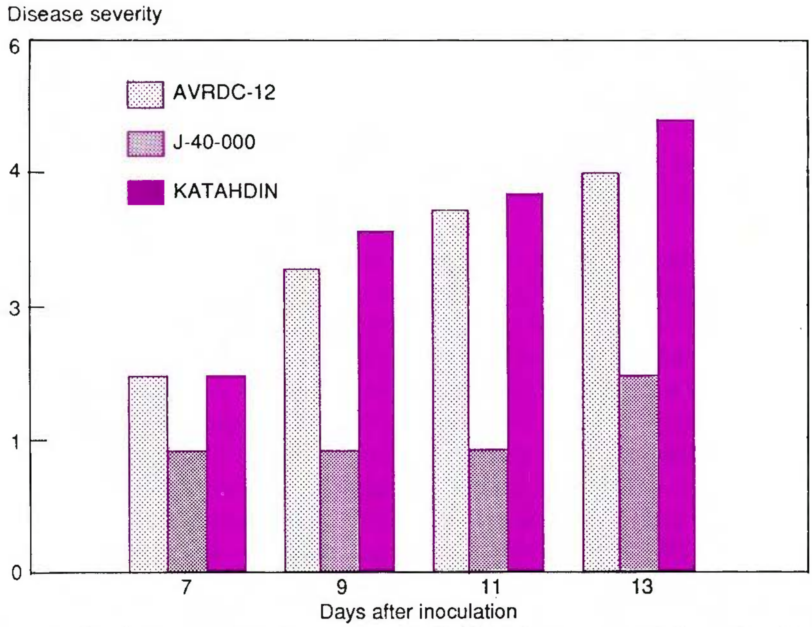


Figure 3-2. Disease ratings for bacterial wilt in three inoculated cultivars after 7, 9, 11, and 13 days. Bars represent means of disease ratings of 20 plants per cultivar after inoculation with 5 x 10^7 bateria/ml of a virulent strain of *Pseudomonas solanacearum.* Disease severity scale 1-5 (1 = no symptoms; 5 = plant dead).

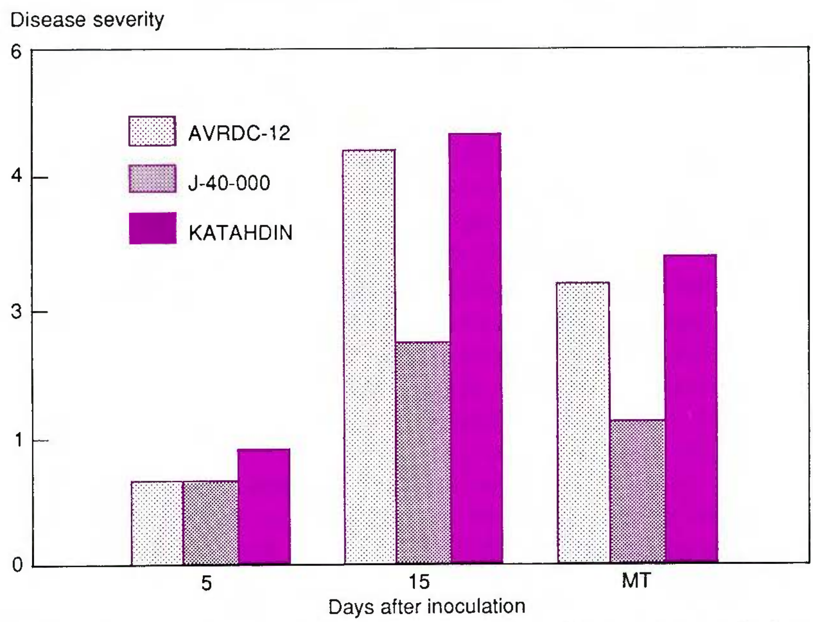


Figure 3-3. Disease ratings for bacterial wilt in three inoculated cultivars after 5 and 15 days, and the calculated mean overtime (MT). Bars represent means of disease ratings of 20 plants per cultivar after inoculation with 5 x 10^7 bateria/ml of a virulent strain of *Pseudomonas solanacearum.* Disease severity scale as in Figure 3-2.

years of testing CIP populations, that the BW strain found at the Brasilia site differs genetically from those for which resistance has been developed. Further support to this conclusion is given below in the report of research in the United States at Wisconsin.

China. At Penxian, Sichuan Province, 134 clones retained from the past year were evaluated in a BW-infested nursery and 44 were tested in a replicated trial. However, because of insufficient seed, only one plot could be planted of the remaining 90 clones. Of these clones, 31 were retained for further use, based on their resistance to BW and acceptable yield. Thirty TPS families also were evaluated at the same site, and 32 clones from 17 families were selected based on tuber shape, quantity, and weight.

At Enshi, Hubei Province, 828 clones and TPS families were evaluated in a BW-infested nursery. Clones 800935, 381064.8, 377852.2, 377319.7, and 10A-1 have proven consistently resistant to BW over four consecutive years. From TPS families, 334 plants were selected, representing 107 hybrid combinations. Of these, VIII-17, VIII-9, IX-54, IX-34, III x I, Tiger Head x III, and Mira x III were found to be highly resistant to both BW and LB and they also had high yield and excellent tuber quality.

At the Institute for Plant Protection, CAAS, the specificity of five monoclonal antibodies (McAb) was examined, using 36 strains of *P. solanacearum* isolated from 14 different hosts of diverse geographic origin. Of the five, McAb3 and McAb7 reacted strongly with all the strains. In a preliminary test using McAb3 in an immunofluorescent assay for detection of *P. solanacearum* associated with plant tissue, McAb3 was shown to have great potential for the detection of latent infection in plants showing no symptoms. The hybridoma cell lines were stable in secreting monoclonal antibodies against *P. solanacearum* after being stored in liquid nitrogen for about one year.

Indonesia. Studies were made of the frequency of infection of Granola variety with *P. solanacearum* and *Erwinia* spp. in 36 fields and in seed tubers in 20 stores in the main highland seed-producing areas of West Java. In 65-day-old plants, the mean percentage of infection with *P. solanacearum* was 26% (10%-75% range) and the mean with *Erwinia* spp. was 19% (10%-100% range). After 120 days in storage, tuber infection *P. solanacearum* averaged 65% and *Erwinia* spp., 60%. *Fusarium* spp. was also observed on 63% of the tubers with symptoms caused by *P. solanacearum.*

Imported seed considered free of *P. solanacearum* was grown in the highlands for seed production in 5 infested fields, and negative selection (removal of wilting plants) or positive selection (marking healthy plants distant from wilting ones), was applied. The percentage of infection of tubers after storing for 120 days averaged 3% for positive selection, 11% for negative selection, and 23% without selection pressure. These results suggest the potential of selection as part of an integrated disease control program in highland areas that would otherwise produce poor quality seed and spread diseases widely.

Kenya. At the National Agricultural Laboratory in Nairobi, 40 advanced clones and four local varieties (Desiree, Romano, B53, Kenya Baraka) were planted in a naturally infested field (race 3). At 7 weeks after planting, 74% of the clones and all local varieties had wilted and died. Of the 14 clones that survived after 7 weeks, 10 clones remained healthy at 10 weeks. These were clones 676103, 385261.8, 755020, 377852.2, 800947, 575049, 676028, 382150.16, 382196.2, and 374080.5.

Mauritius. In a program to select cultivars for lowland tropical conditions with resistance to *P. solanacearum*, CIP sent TPS to Mauritius in 1989 and 1990. Tuber families were produced and clonal selections and tuber families will be grown in 1991. The tuber families will be screened for adaptation, wilt, and late blight resistances.

The Philippines. At Mindanao, in collaboration with the Philippine Department of Agriculture, selections for resistance to BW were made in two trials in an infested nursery at Dalwangan (800 m). The resulting 86 selections were then tested for yield and susceptibility at Intavas (1200m) during the dry and wet seasons. At Dalwangan, clone (384015.24 x LT-7). 4, derived from a local cross, and clone 387585.3 were among the highest yielders, and were selected for their low susceptibility to BW. In the evaluations of 13 tuber families during the wet season and 31 tuber families in the dry season, the best tuber families were BR63.74 x I-1085, Amapola x 7XY.1, BR63.74 x 7XY.1, and BR63.74 x I-1039. They yielded well and showed a low incidence of bacterial wilt. Eleven additional clones were selected from 77 tuber families planted in the field, with families 388017 and 388020 providing the best clones.

The evaluations of TPS for resistance to BW and adaptability indicated that progeny of Serrana x LT-7 produced a full canopy, no incidence of BW, and yields of about 1 kg/m^2. Yields from CFK 69.1 x LT-7 and CFK 69.1 x DTO-28 were slightly lower, and CFK 69.1 x LT-7 had an emergence level of only 31%.

Uganda. Among the cultivars tested prior to 1989, the genotypes 800212, 800224, and 720118 showed relative resistance to local strains of *P. solanacearum*. Because of its dual resistance to late blight and bacterial wilt, clone 720118 recorded the highest yield in 2 on-station trials and 4 on-farm trials. In a local breeding and selection program, 13 selected clones and 307 tuber progenies from 11 families bred for dual resistance to BW and late blight were multiplied for future testing.

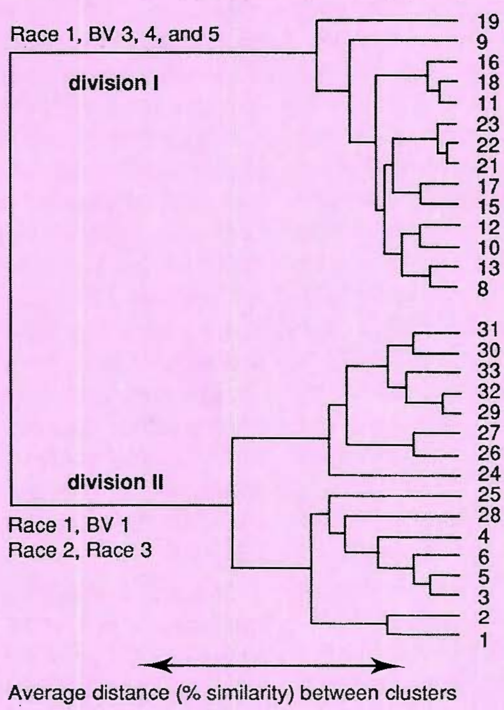
Studies on the integrated control of BW showed that better control was provided by planting on flat land rather than the usual hilling, or by hilling up very early and using a tolerant variety.

United States. At the University of Wisconsin, a DNA probe was developed by subtractive hybridization to enrich race 3-specific DNA sequences in total race 3 genomic DNA. This procedure produced a 2 kb clone homologous with DNA from the 28 race 3 strains tested. Only 5 of 90 non-race 3 strains showed homology with the probe. Procedures are now being studied to develop a non-radioactive probe for field use. Two larger regions of the genome were identified, which contained a minimum of 23 kb of DNA that was specific for race 3. Deletion of this DNA did not affect virulence. Several of these restriction fragments were found to be adjacent to the 2 kb region that was cloned, and thus may be suitable for diagnostic purposes.

In taxonomic studies to better classify the bacterium and to develop an appropriate strategy to breed for resistance, the phylogenetic relationship among strains of *P. solanacearum* was examined by restriction fragment length polymorphism (RFLP) analysis. Of 9 different DNA probes used, 7 specify factors important in pathogenicity. The DNAs of 150 strains were analyzed, including many of

Australian, South-east Asian, and Latin American origin. The analysis showed 33 distinct patterns, which were classified in 2 divisions. Division I contained all members of race 1, biovars (Bv) 3, 4, and 5 (mostly of Old World origin). Division II contained all members of race 1, Bv 1, and races 2 and 3 (mostly of New World origin). Similarity coefficients were calculated and cluster analyses were completed, as shown in Figure 3-4.

The RFLP data support the hypothesis that race 3 (all included in Bv2) is endemic in the Andean region of South America and constitutes a homogeneous group (groups 26 and 27 in Fig. 3-4). The 25 lowland biovar 2 strains from CIP's collection that originated at sites with altitudes ranging from 150m-1500m on the eastern slopes of the Andes in Peru and Brazil were contained in groups 29 to 33. These were closely related to, but clearly distinguishable from, the highland Bv 2. Thus the lowland strains, which are mostly pathogens from the introduced potato, constitute a natural grouping that may have originated from a common ancestor that is widely disseminated on native plants in the Amazon basin.



Single RFLP groups include strains that have 100% similarity by RFLP analysis (far right of figure). Similarity decreases as the RFLP groups are clustered, moving leftward in the figure. Division I and II are joined at 13.5% similarity.

Figure 3-4. Average linkage cluster analysis of 30 RFLP groups of *P. solanacearum*.

Soft Rot and Blackleg

Peru. At La Molina studies were begun to improve methods for screening for resistance to *Erwinia* spp., causing soft rot and blackleg. To study the virulence of isolates CIP-004 and CIP-367 of *Erwinia chrysanthemi* (Ech) under laboratory conditions, 6 concentrations of inoculum per treatment were injected into 10 tubers of the potato cultivar Revolucion. After three days of incubation at 26° C under anaerobic conditions, CIP-367 was found to be significantly more virulent than CIP-004, at all of the inoculum concentrations from 1 x 10^2 to 1 x 10^7 bacteria/ml.

Using the same 6 levels of inoculum on potato cultivars Desiree and Yungay, the isolate 367 was evaluated for its ability to produce blackleg under greenhouse conditions. The tubers were inoculated with bacterial suspensions by vacuum infiltration and then planted in pots of sterile soil. The optimum concentration for producing blackleg was 1 x 10^7 bacteria/ml. Yungay was significantly more resistant than Desiree at this inoculum concentration.

Cuttings of 33 hybrids from crosses between *Solanum brevidens* x *S. phureja-stenotomum*, and *S. brevidens* x *S. tuberosum*, which were maintained in vitro, were evaluated for resistance to blackleg caused by Ech (6.8 x 10^5 bacteria/ml). Five hybrids were shown to be moderately resistant, 13 susceptible, and 15 highly susceptible.

In CIP's work on selection for resistance, the lack of consistency in the reaction of the progenitors to different screening methods has slowed the breeding program as well as the studies on the heritability of soft rot resistance. Inoculation procedures are being improved because use of the less aggressive strain of Ech allowed many escapes, with even more occurring when the lower concentrations of the infectivity titration method was used. The new procedures will use a more aggressive strain and a new evaluation scale to compensate for escapes. Because of the small size of the incubation chamber, consecutive screenings have been done with groups of tubers of increasingly greater age with periods of storage up to 3 months. To reduce this variation, an incubation misting chamber has been constructed, periods of that is large enough to complete the screening of a population of 2,000 clones in 3 weeks.

China. Research in collaboration with the Institute for Plant Protection-CAAS has identified 6 hybridoma cell lines secreting monoclonal antibodies (McAb) specific to *Erwinia carotovora* subsp. *atroseptica* (Eca) and *E.c.carotovora* (Ecc). Five of the 6 McAb showed strong reactions with 17 strains of Eca and Ecc. None of the McAb reacted with 13 bacterial strains from other species. Such McAb can play a major role in detection of latent

Harvest of variety INIAA-Canchan at Canchan, Huanuco, by Peru's INIAA's staff.

infection and confirmation of the bacterial pathogen.

Scotland, UK. In collaboration with the Scottish Crop Research Institute at Dundee, studies were made on the resistance of several cultivars to tuber rotting by Eca when the pathogen was introduced by 1 mechanical inoculation into the cortex, 2) vacuum infiltration of lenticels, and 3) deposition on a bruised area of skin. Incubation was done at 20° C either in air, in a mist chamber, or in nitrogen at 100% RH. Relative resistance was shown to be more affected by inoculation method than by incubation conditions. In comparisons with a hybrid with low resistance, an *S. tuberosum* x *S. brevidens* hybrid clone maintained its resistance level when tubers were treated with cell-free pectate lyase (PL), but its resistance level was lower when a mixture of PL and tomato pectin methyl esterase (PME) was used. Resistance level appears to be affected when enzymes produced by Eca fail to degrade cell-wall pectic components, possibly due to a high degree of methyl esterification.

An agglutination test using a polyclonal antiserum against Eca Serogroup I has been used to rapidly identify Eca in vitro and in rotting potatoes. The lower limit of sensitivity of the antibodies is 10^9 to 10^6 cells/ml.

The lack of specificity of Eca polyclonal antibodies used in ELISA tests for Eca, even after absorption with Ecc, has been explained by the presence of soluble antigens common to both Eca and Ecc released in the microtiter wells during the assay.

Tunisia. In monitoring the importance of *Erwinia* diseases during the different phases of the seed multiplication program, little infection was observed, probably because seed had been produced during unusually dry weather in Europe. As observed in the previous year, the early losses were found in both seed and ware crops. Pathogens associated with this disease complex were *Erwinia* spp. (especially *Ech*), *Verticillium* spp., and *Colletotrichum coccodes*. Cyst nematodes also were present.

Early Blight

Peru. At San Ramon, 403 clones were evaluated for resistance to early blight (EB) caused by *Alternaria solani.* Of these, 40% were discarded because of PVX and PVY infection. Twenty-two clones were selected for resistance to EB, PVX, PVY, and for heat tolerance and earliness. The best clones for resistance, earliness, and yield were (XY-4 x Maine 47). 63, (XY-10 x BL2.9). 61, and (XY-20 x Maine 47). 51. Artificial inoculation was used on a sample of 72 segregating progenies to evaluate for EB resistance. Progenies (EB87.002 x YY-2), (84C-32.3 x YY-2), and (84C-32.3 x YY-3) showed high yields, earliness, and acceptable resistance to EB. Progenies (EB87.002 x XY-13) and (EB85.008 x XY-13) were resistant and later maturing, but yielded less. Among an additional 22 clones from a second generation that were evaluated for resistance to EB, three clones were resistant and early maturing (numbers 1, 7, and 9, Table 3-7).

Research on the identification of strains or species of *Alternaria* at Lima showed that four *Alternaria* spp. could be isolated from potato plants collected from several fields: *A. dauci*, *A. alternata*, *A. tenuissima*, and *A. solani*. All *Alternaria* spp. were pathogenic to the potato cultivar DTO-33 and tomato. *Alternaria solani* isolates from La Molina and San Ramon were morphologically similar; however, they differed in pathogenicity. Isolates from La Molina caused strong defoliation, necrotic lesions on stems of DTO-33 seedlings, and numerous blight spots on *Solanum cha-*

coense and *Capsicum pendulum* var. *baccatum*. The San Ramon isolate caused chlorosis, with little defoliation on DTO-33 seedlings and mild symptoms on *S. chacoense* and *C. pendulum*.

Brazil. Families sent to EMBRAPA as TPS in 1989 and 1990 have been screened for virus X (2 tuber generations) and virus Y (1 tuber generation) and will be used for future field testing for EB resistance. Families generated in 1988 have been studied in two tuber generations, the second of which was planted for exposure to *A. solani*. Check cultivars were Aracy (resistant), Delta (intermediate), and Bintje (susceptible). The field was inoculated at 30 and 38 days after planting (DAP), using inoculum from infected leaves. Plants were rated for EB incidence at 40, 50, 60, and 70 DAP, and the average for the four disease ratings was used as the composite score. Clones from TPS received in 1987 were included for retesting, as well as some genotypes of local interest and from CIP's pathogen-tested list. Of these, 70 were selected for further testing. Detailed results were sent to CIP for possible choice for use in the center's breeding program.

Table 3-7. Top-performing second generation clones, from a sample of 22 early blight- resistant clones, evaluated at San Ramon.

Clone	Average resistance	Earliness
1. (XY-19 x I-1035).63	3.0	7
2. (XY-19 x NDD277.2).110	3.0	5
3. (XY-10 x BL2.9).61	3.0	5
4. (XY-4 x Maine-47).63	3.0	5
5. (XY-17 x Maine 47).64	3.5	5
6. (XY-5 x I-1035).47	3.5	5
7. (XY-19 x NDD277.2).116	3.5	7
8. (XY-17 x Maine 47).103	3.5	5
9. (XY-17 x I-1035).55	3.5	7
10. (XY-2 x NDD277.2).61	3.5	5
11. (XY-5 x I-1035).52	3.5	5
12. (XY-20 x NDD277.2).64	4.0	7
13. (XY-5 x NDD277.2).51	4.0	7
14. (XY-4 x Maine 47).101	4.0	7
15. (XY-3 x NDD277.2).115	4.0	7
16. (XY-20 x Maine 47).51	4.0	7

Earliness
1 :very late 5: medium 9: very early
Early blight
1: no damage 4: up to 25% 9: 100% damage

Uruguay. The most recently-received TPS families were screened for PVX and PVY as seedlings, then field-tested for EB resistance at Tacuarembó, where 76 selections were made at harvest. Yields were high, but the new X and Y-resistant progenitors apparently had negative effects on maturity and agronomic quality. Materials selected by screening for viruses X and Y followed by clone tests for EB, led to 58 selections that were tested in 1990 in 20 plant plots. Of these, 19 clones were selected, and the best three (387660.10, 387752.1, and 387760.1) established in tissue culture. Materials received in 1987 were tested for the third time, and of 36 clones tested, 12 were selected and the three best (385071.26, 386483.12, and 386482.10) placed in tissue culture. The best progenitors were Maine 47 x NDD 277.2, Katahdin, 3777964.5, CFS69.1, 7XY.1, Atlantic, LT-7, WNC 521.12, and Y84.007.

Common Rust

Ecuador. Previous studies on chemical control of common rust (*Puccinia pittieriana*) by INIA, of the Ecuadorian Ministry of Agriculture, showed that the most effective chemical combination was Plant Vax (26g) + Tilt (6.6 ml) per 20-liter knapsack sprayer. To determine the best time and frequency of applications under the conditions of Tungarahua (3450 m) in northern Ecuador, applications were begun

40, 66, 87, 108, and 129 DAP. Treatments are shown in Table 3-8. Applications begun at 40 days were more effective than at later dates, and 4 (or 5) applications gave the best control. However, two applications gave adequate control (Fig. 3-5).

Table 3-8. Response to different fungicide application treatments to control potato rust (*Puccinia pittieriana*) at Tungurahua (3450 m). Data by INIAP, Ecuador.

Treatment No.	Days (DAP[a]) of fungicide application 40	66	87	108	129	No. of Applic.	Rust Infection (%)[b]
1	x	x	x	x	x	5	1.9
2	x	x	x	x	-	4	1.4
3	x	x	x	-	-	3	3.5
4	x	x	-	-	-	2	5.9
5	x	-	-	-	-	1	19.9
6	-	x	x	x	x	4	4.6
7	-	-	x	x	x	3	11.9
8	-	-	-	x	x	2	22.4
9	-	-	-	-	x	1	28.0
10	-	-	-	-	-	0	30.4

[a]DAP= Days after planting
[b]Average of the last disease readings for four replications of moderately resistant cultivar Sta. Catalina.

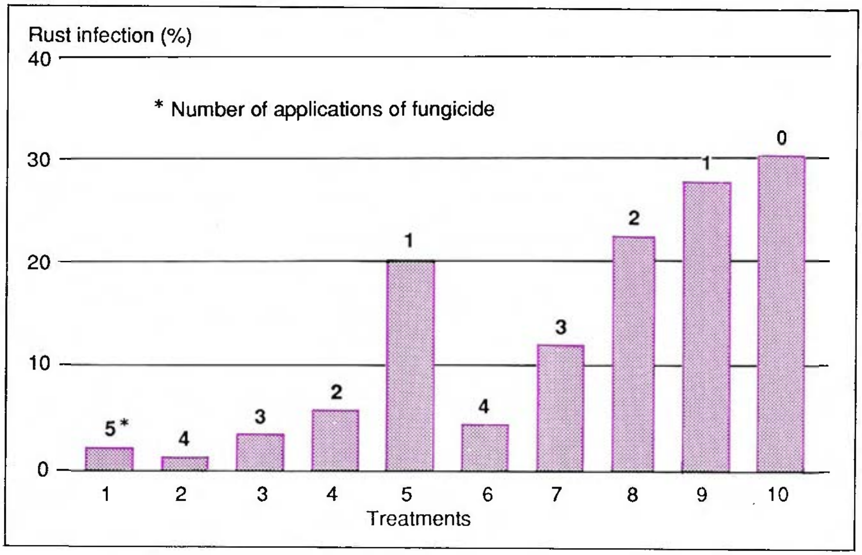


Figure 3-5. Chemical control of potato rust.

Other Soilborne Diseases

Peru. In collaboration with the INIAA potato program, advanced clones continued to be evaluated for resistance to powdery scab (*Spongospora subterranea*). A field trial was conducted in naturally infested soil at Anta, Cuzco, where cultivars Gabriela and Esperanza, which had shown resistance during three consecutive seasons, were re-evaluated in a four-replication RCBD trial, using cultivars Yungay and Valicha as controls. On a disease scale of 1-9, Gabriela and Esperanza were assigned infection grades 2 and 3, respectively, while Valicha and Yungay each had an infection grade of 6. The resistance of Gabriela and Esperanza was confirmed in these trials, in which Gabriela had only 0.14% diseased tubers and Esperanza 0.84%. Valicha and Yungay had 16.33% and 25.31% diseased tubers, respectively. Gabriela can be recommended as a resistant variety; however, Esperanza has a high glycoalkaloid content.

At La Molina, clones on the pathogen-tested list continued to be evaluated under greenhouse conditions for resistance against *Verticillium dahliae*. Among 64 clones evaluated, Seseni, Cruza 155, Sellestani, 278096.10, Haille, Mi Peru, and 701241 were rated as resistant. Of these, 34 were moderately resistant and 24 susceptible. Among the resistant clones, Seseni had been tested and found resistant in a previous test. Among the moderately resistant clones, P4, Ticahuasi, Tomasa Condemayta, Mex 750847, CIPA Viru, Mariva, Jatun Huanca, and JB-13 were shown to be moderately resistant in one or two previous tests.

Bolivia. In collaboration with PROINPA, about 22,000 tuber samples were evaluated in three potato-producing regions: Cochabamba, Chuquisaca, and Potosi. Due to drought (third consecutive year), the incidence of soilborne diseases was relatively low. Overall, the average percentages of incidence were wart, 0.22%; powdery scab, 10.0%; black scurf, 82%; late blight, 0.19%; *Erwinia* soft rot, 0.15%, and; *Fusarium* dry rot, 0.31%. No regional differences were found in incidences of powdery scab and black scurf. Wart was found in the higher altitude zones of Cochabamba and Potosí, and absent in Chuquisaca. Wart incidence was highest in Imilla Blanca, lowest in Waych'a, and absent in Alpha.

Sweet Potato Diseases

Survey work is under way to obtain more information about the distribution and importance of diseases of sweet potatoes. Such information is essential in Peru to determine which pathogens should be used in screening for needed resistance. Screening is under way in Peru and China.

Peru — Surveys of Disease Incidence. Surveys were conducted at mid-season and at harvest time in the same three departments surveyed last year (Lima, Loreto, and Junin), and in three more departments that were surveyed for the first time: Ancash, Cajamarca, and Lambayeque. The original three departments had the same diseases found previously, plus Pythium spp., which causes storage root rot. At Ancash, Cajamarca, and Lambayeque, the reported diseases damaged storage roots and were detected at harvest or in storage.

Disease	Department Where Found
Aspergillus sp.	Lambayeque
Fusarium solani	Ancash, Cajamarca, Lambayeque, Junin, and Loreto
Rhizopus stolonifer	Ancash, Lambayeque, and Junin
Diplodia gossypina	Cajamarca, Lambayeque, Junin, and Lima.
Macrophomina phaseolina	Cajamarca and Junin.
Pythium sp.	Junin

For the first time, the *Aspergillus* sp. was found in Lambayeque and *Pythium* sp. was found in Junin. Pathogenicity tests confirmed that they were causal agents.

A student from the University of Huancayo monitored the incidence of diseases at San Ramon regularly during both the wet and dry seasons, in a replicated trial with 10 cultivars. Minimal incidences of white rust (*Albugo ipomoea-panduratae*) and *Cercospora* blight were found on foliage; the cv. Japones-portugues RCB 64-IN was found to be the most susceptible to both diseases. At harvest, storage roots showed low incidences of surface rot caused by *Fusarium oxysporum*, but there were significant losses in storage. Other diseases recorded in the field were Java black rot (*Diplodia gossypina*) and *Fusarium* root rot. In storage, the diseases recorded were foot rot (*Plenodomus destruens*), soft rot (*Rhizopus* sp.), and charcoal rot (*Macrophomina phaseolina*). Cv. Amarilla de Quillabamba (RCB-173-IN) was most damaged by foot rot and soft rot, while Paramonguino (RCB 276-IN) showed no symptoms of storage rots.

Screening for Resistance. Evaluations were made of 25 accessions (native cultivars) from CIP's collection and 45 breeding lines harvested at San Ramon to determine resistance to the soft-rot fungus *Rhizopus stolonifer*, which is widely prevalent when roots are improperly cured prior to storage. Four accessions and eight lines were found to be slightly resistant, with restricted fungal growth. The remaining 21 accessions and 37 lines were susceptible and the fungus rapidly colonized the roots. The resistant accessions were RCB63-IN, RCB161-IN, RCB2679-H, and DLP-71; the lines were LM-88075, RCB122-IT, SR-89103, ST-87075, LM-88021, LM-89182, LM-89123, and ST-86006. Further screening is planned to improve resistance levels.

Other Disease Surveys

Argentina. In the San Pedro area, the fungus *Rhizoctonia solani* was found to cause stem canker in plant beds, with losses ranging from 1% to 40% of sprouts in cv. Morada INTA, and up to 5% in cv. Bolivar. Foot rot due to *Plenodomus destruens* caused losses of up to 5%.

Kenya. A nationwide survey of diseases on sweet potato was begun in Kenya during 1990. Four of 13 selected districts have been surveyed completely and in 3 others surveys are under way. A computerized database has been established. Diagnosis of specimens collected in the survey is incomplete and pathogenicity of isolates has not yet been established.

Four fungal leaf spots have been identified and are listed here in order of greater to lesser incidence and damage: *Phomopsis* sp., *Alternaria* sp., *Cercospora* sp., and *Septoria* sp. A more serious disease has been found that distorts leaves and kills vines with symptoms that suggest the causal agent may be *Elsinoe batatas*; however, the fungus has not been isolated. Vine fasciation is another disease of unknown etiology that is being investigated. Incidence of excessive hairiness, caused by a mite, is being recorded to determine its importance.

China. In 1988, 170 sweet potato (SP) cultivars were screened for bacterial wilt resistance and cv. No. 1088 was selected as the resistant check for the screening of 181 cv. in the Guangdong germplasm collection at the Puning Agricultural Research Institute. The Institute is located in a region with high incidence of bacterial wilt, caused by *Pseudomonas solanacearum*. Two replications of 20 plants each were inoculated by dipping the planting slips in a suspension of bacteria prior to planting, followed by several field inoculations through soil infestation. Two clones were immune (clones 134 and 718) while 9 had infection levels of 2.5% to 20.0% under the high inoculum pressure, and were rated as resistant. The resistant check was found to have a infection level of 5.0% while the susceptible check, No. 69, had 100%.

Fusarium Wilt Resistance. In a screening of 195 cultivars of the sweet potato germplasm collection, 5 tip cuttings of each were placed in a spore suspension of the fungus *Fusarium oxysporum* f. sp. *batatas* for 20 min., with 3 replications, after which they were planted individually in pots. Wilt symptoms were recorded after 10 and 15 days and cv. No. 635, with a 20.0 disease index, was found to be the most resistant. Seven cultivars had indices of 24.7 to 41.4: clones 681, 445, 729, 662, 709, 123, and 33, in order of increasing disease index. No immunity was found to this disease, which is serious in southern China. The resistance developed in the United States will be explored to determine if it is useful in China.

United States. At Louisiana State University, collaborating scientists found the causal agent of chloritic leaf distortion (CLD) to be ***Fusarium lateritium***. Isolation studies, coupled with scanning electron microscopy of plant surfaces and light microscopy of sectioned material, located the fungus primarily on and in a mucilaginous-like material deposited on the surface of apical meristems and axillary buds on the sweet potato vine, and between halves of the laminae of unfolded leaves. The fungus has not been found internally in any part of the plant so far examined, with the possible exception of true seed, thus its apparent systemic infection is not confirmed.

A test was conducted to determine if *F. lateritium* could be eradicated from true seed by infusion with benomyl in either water or acetone. Although the frequency of isolation from "floaters" (generallly nonviable seed) was significantly reduced by benomyl treatment, the fungus was still isolated from 4% of the seed. Fungicide treatment of "sinkers" (generally viable seed) was also related to decreased incidence of CLD on seedlings in the field, but again, the lowest incidence was 15%.

Future research will explore levels of resistance to CLD in commercial cultivars, agents of transmission, survival in soil, and presence in true seed from different parts of the world to provide an indication of its worldwide distribution.

Chlorotic flecks caused by C-4 sweet potato virus in the indicator host *Ipomoea setosa*.

Thrust IV

Control of Virus and Virus-Like Diseases

Thrust Profile: 1991

DEVELOPMENT OF RESISTANT CULTIVARS is the most effective long-term approach to controlling virus diseases of potatoes and sweet potatoes. Genotypes resistant to potato leaf roll virus (PLRV) have been developed. However, because of the complexity of this resistance, current research emphasizes characterization of individual resistance components, such as antixenosis and antibiosis (vector resistance factors) and resistance to virus infection and multiplication. When this characterization is completed, the resistance components should be easily incorporated and the overall resistance to PLRV should be more stable. The strong antixenosis factor found in cv. Tomasa Condemayta was shown to be non-transmissible to the progeny of crosses between this cv. and other genotypes. Another complication in developing durable overall resistance to PLRV is the large variability of infectivity of geographically distinct PLRV isolates. This highlights the need to challenge resistant cultivars against a wide spectrum of PLRV isolates. The resistance to PVX and PVY, also factors for the stability of PLRV resistance, is well addressed and several PVX and PVY immune genotypes are now available. Genotypes with combined resistance to PVX, PVY, and PLRV are under field evaluation in the regions. Thirteen accessions with a high level of resistance to SPFMV were found in CIP sweet potato germplasm, and several others are under evaluation for resistance. The stability of this resistance is also being studied.

Some diseases of probable viral origin are still unidentified in potatoes. At the request of the Bolivian potato program, studies were begun on two recently observed potato virus diseases, saq'O and "amarillamientos." These diseases were found to be prevalent in farmers' fields in Bolivia. Similarly, two undescribed viruses have been detected in potato cultivars from Mexico and Peru.

For sweet potatoes, identification, characterization, and determination of prevalence of viruses are the first priorities. The C-2 virus has already been identified and found to have a serological relationship to the tentatively named "sweet potato symptomless virus" described in Japan. This is an elongated virus (approx. 750-800 x 12nm) and its host range is restricted to Fam. *Convolvulaceae* and *Chenopodiaceae*. No vector has been found and the virus is widespread in Peru, Japan, and China.

Because economical virus control relies on prevention, the efficiency of the techniques for virus detection is being improved. These include serological investigation in national seed programs to produce low-virus seed for the more rigid requirements of quarantine programs. Research now emphasizes reducing the cost of these techniques by replacing expensive reagents, while maintaining their sensitivity and precision. DAS-ELISA kits for potato virus detection are now produced and distributed in China. NCM-ELISA kits for detection of four sweet potato viruses are available at CIP headquarters.

Potato

Resistance to Viruses

Potato Virus X (PVX), Potato Virus Y (PVY), and other viruses. In evaluations of CIP clones for resistance to the most important viruses, the immunity of cultivar Kufri Lalima (CIP 800971) to PVX has been reconfirmed. Cultivars San Juan (CIP 800977), Anett (CIP 800981), Nata (CIP 701131), Santanlalla (CIP 701171), Curipamba (CIP 703350), and clones BW-4 (CIP 379690.8), 381371.81, 384327.42, and 384329.21 were found to be immune to PVX.

A collaborative project with the University of Helsinki, Finland, allowed CIP to continue its search for resistance to the most important potato viruses in wild species. Resistance to PVX^{C}, PVX^{HB}, PVS, PVA, TSV, and CMV was found in several accessions of *S. brevidens*. However, they were susceptible to AIMV and PVT. Susceptibility to PVM was shown only when *S. brevidens* was graft-inoculated to a PVM-infected scion. Moderate resistance to PVX^{C}, PVX^{HB}, and PVY^{O}, in addition to a high level of resistance to PLRV, has been determined in *S. etuberosum*.

PLRV. In the PLRV resistance complex, resistance to the vector is a valuable component that might yield an immune behavior when used in combination with other components, such as resistance to virus infection or resistance to virus multiplication in one genotype. Studies of resistance to the PLRV aphid vector *M. persicae* continued and 18 new clones with some degree of antixenosis to the aphid *M. persicae*, have been identified from the CIP pathogen-tested clones. Preliminary experiments have shown, however, that the strong antixenosis exhibited in the Peruvian cultivar Tomasa Condemayta against *M. persicae* was not transmitted to the progeny of crosses with other genotypes. Further studies are needed to determine whether other sources of antixenosis behave in a similar fashion.

In searching for new and better sources of resistance to the virus, 80 clones from the CIP pathogen-tested list were screened for resistance to PLRV infection. Only 3 clones showed an acceptable level of resistance. However, quantitative ELISA tests showed that 25 of these clones have a very low concentration of PLRV in the infected plants; this was probably due to resistance to PLRV multiplication.

Because the variability of the virus becomes extremely important in developing overall resistance to PLRV, experiments were made to analyze the behavior of PLRV isolates on resistant genotypes. In inoculation experiments of ten PLRV isolates on two potato clones developed by the Scottish Crops Research Institute, Scotland, 67445(1) and 67446(1), which have resistance to PLRV multiplication, the infectivity was found to vary widely among geographically different PLRV isolates (Fig. 4-1). Transmission-efficiency studies using different aphid species also confirmed these results, suggesting that the genetic resistance to PLRV in potatoes will depend on the PLRV isolate prevalent in one region. These findings stress the need for challenging resistant genotypes against a wider range of geographically different isolates to determine their resistance stability.

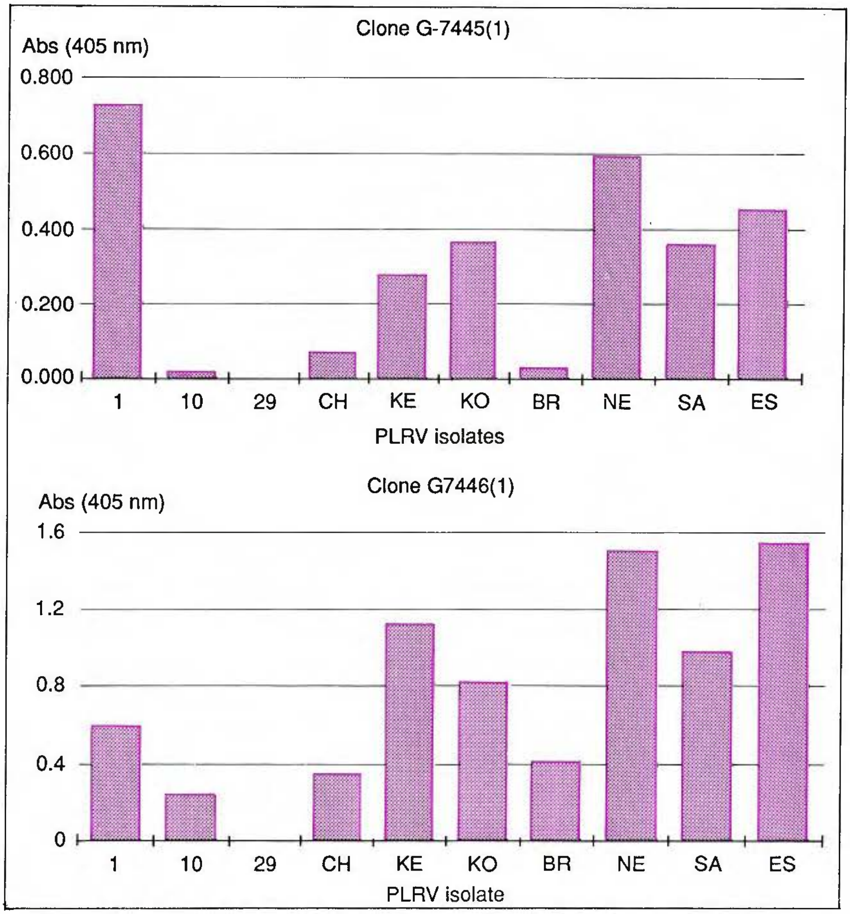


Figure 4-1. Relative concentration of several PLRV isolates in the two resistant British clones G7445(1) and G7446(1).

Combined virus resistance is gradually being incorporated in CIP's genetic materials. Twenty-three families were screened for combined resistance to PVX, PVY, and PLRV, and 221 clones with resistance to these viruses have been selected from those families for further evaluation.

Detection Methods

Antisera purification and production. CIP studies are further improving the production and efficiency in detection of the potato and sweet potato viral and bacterial antisera, for which the NARS continue to make a strong demand. Research activities focused on the elimination of non-specific reactions in polyclonal PLRV antisera produced at CIP, to make it available to NARS in developing countries. The affinity chromatography procedures used in these experiments are also useful as a final step for purifying PLRV.

Specific antisera to *E. carotovora carotovora*, *E. carotovora atroseptica*, and *E. chrysantemi* were also produced and a NCM-ELISA kit was produced for reliable detection of these bacteria in potato tissues, soil, and water sample. The kit is being evaluated in collaboration with scientists of selected countries.

In China, through a collaborative project with Inner Mongolia University, monoclonal antibodies to PLRV and PVX have been produced, and these specific monoclonal antibodies have been used to determine serological variability of PLRV isolates in China. Polyclonal antisera to PVX (165 ml) and PVS (80 ml) have also been produced by this project. CIP continues to provide training and guidance in production of antisera for potato viruses in several countries, including Thailand and Colombia.

Anti-idiotyping. The anti-idiotyping technology will help NARS to produce their own antisera supply, without having to purify the viruses. Anti-anti-idiotypic antibodies (Ab-3) against PLRV and PVX have been produced, but the antisera obtained still show a variable degree of cross-reactivity with PVY, PVS, and healthy plant proteins. Studies are under way to determine the nature of non-specific reactions and how to eliminate them.

Use of penicillinase. Enzyme alkaline phosphatase is one of the most expensive chemicals used in the application of the current DAS-ELISA procedure, and in an attempt to reduce the cost of the assay, a search has begun for equally efficient substitutes. The enzyme penicillinase was tested and results show no differences in the sensitivity of the assays using alkaline phosphatase and those using penicillinase as an enzyme in detecting potato viruses by DAS-ELISA. The cost per test using penicillinase is only one-tenth of that for alkaline phosphatase. The penicillinase-ELISA is a qualitative test and it will be easier to use in laboratories in developing countries where a spectrophotometer is not available to make quantitative assays.

Distribution of serological kits. CIP continues to promote NARS use of serological assays as the best approach to detecting potato viruses. In China, the use of DAS-ELISA kits produced at Inner Mongolia University has spread to the potato-production areas of Kunming, Lulian, Zhaotong, and Huize of Yunnan province, and Weichuan of Sichuan province. About 5050 samples were collected from 119 farmers' fields and the kits were used to test the samples against five different viruses. In Yunnan and Sichuan, the more prevalent viruses are PVX, PVY, PVS, and PLRV. Kumming and Weichuan reported low incidences of PVX and PVY. In Zhaotong and Huize, PLRV was the main virus infecting potatoes. For the first time, PVM was detected in southwest China.

The DAS-ELISA and NCM-ELISA kits produced at CIP headquarters and distributed to the regions and national programs were sufficient to assay more than 900,000 samples.

NASH. The NASH test was introduced at CIP to develop more efficient methods for detecting viroids and viruses. Because of its higher sensitivity and higher cost as compared with ELISA, this test could be more efficiently used to distribute virus-free germplasm rather than to produce seed with low virus content in national seed programs. Thrust research now focuses on improving its sensitivity and ease of application, broadening its spectrum of pathogen detection, and reducing its cost. A recombinant plasmid with a fragment 151 base pairs (bp) long of Hop Stunt Viroid (HSVd-cDNA) and a 220-bp fragment of PSTVd-cDNA has been constructed as the initial step in obtaining wide-spectrum probes for the detection of plant viroids. The HSVd-PSTVd cDNA hybrid plasmid allows simultaneous detection of both viroids, and also of the PSTVd-related citrus exocortis viroid. Wide-spectrum probes will

Potato yellow vein disease in Colombia.

be a useful tool for viroid identification and detection of viroids whose existence in sweet potatoes has been reported by Prof. R. Sänger at the Max-Planck Institute in Germany. A similar approach is under way to develop a probe that could detect PSTVd and PVT (both seed-transmitted in potato) in only one test, a procedure that will cut the cost of NASH application by 50%.

Previous work at CIP has successfully introduced cDNA sequences from several potato viruses into suitable plasmid vectors for use as molecular probes. The importance of appropriate selection of the molecular probe for routine virus detection has been demonstrated, using two different probes against PVXcp and a European strain of PVX against a large pool of PVX isolates in the PVX^A and PVX^O serotypes. Both probes are highly specific to viruses in their respective groups. Recent sequencing analysis revealed that the probe pX61 is 1100 bp-long and corresponds to a region between nucleotides 3008 and 4107 of the genomic PVXcp RNA. The RNA sequence of PVXcp reveals significant differences with the genomic RNA of the European PVX strains. A mixture of probes can be used during hybridization; however, wide-spectrum probes following linkages of cDNA specific to each PVX group are being developed. So far, probes have proven to be more reliable than ELISA in detecting PVX, while allowing better discrimination of virus strains.

In China, the use of NASH to screen 27 TPS parents has indicated that most parents were infected with PSTVd. The PSTVd-free TPS parents of the main potato varieties and lines produced at Inner Mongolia University have been distributed to Wumeng, Humeng, and Bashang Potato Institutes for propagation and field trials. Introducing PSTVd-free parental lines to the potato Institutes should reduce the negative effects of the dissemination of this viroid in China.

Identification and characterization of potato viruses and vectors. Even though identification of potato viruses is no longer a thrust priority, virus diseases of economic importance to some regions or countries, as well as those having quarantine significance, continue to be studied. Studies on two important diseases of potatoes in Bolivia, which are probably of viral origin and are commonly referred to as "amarillamientos" and "saq'O" by the farmers, were initiated this year, at the request of the Bolivian potato program. Plants of cv. Runa with "saq'O" are chlorotic with proliferation of weak axillary buds. The size of infected plants varies with the locality, and disease damage makes tubers unmarketable. Proliferation of roots is common, and the tubers' normally cream-colored flesh shows abnormal white flesh and elongated eyes. The disease incidence in farmers' fields was 10% to 30% in the locality of Pisqo Mayu.

About 20% of the plants in farmers' fields showed "amarillamiento" symptoms, and preliminary data indicate a yield loss of 60%-70% due to the disease. Though this disease shows similar symptoms to those of PMTV, it appears that other still unknown viruses are also involved in the disease. Two previously unreported viruses, code-named SB23 (isometric particles with spherical outline) and SB 24 (a flexous rod), were isolated from Mexican and Peruvian cultivars, respectively, which were sent to CIP for cleanup. These viruses are currently being identified at CIP headquarters.

The transmission efficiency of PVY by aphid vectors other than *M. persicae* was studied under Tunisian field conditions. Seven other aphid species, with more than 10% efficiency in transmitting this virus, were found. Among them, *Halopterous pruni* was even more efficient than *M. persicae* in transmitting PVY under these conditions.

"Amarillamientos" caused by viruses in Bolivia resembling infection by PMTV.

Sweet Potato

Resistance to Viruses

Development of virus-resistant cultivars can provide farmers in less developed countries with an effective method of control, thus the search for resistance to the most important sweet potato viruses is given a high priority. Of 13 resistant accessions from the CIP germplasm collection evaluated last year, two appear to carry genes for resistance (immunity) to SPFMV. In another evaluation of 103 resistant accessions, in the first cycle of inoculations, 27 showed resistance to SPFMV and 18 to SPMMV infections.

Detection Methods

Identification and characterization of sweet potato viruses. The precise identification of causal viruses is a prerequisite to effective control of virus diseases, which is a major thrust priority. In serological studies using polyclonal and monoclonal antibodies for different strains of SPFMV, strain C was found to have more antigenic determinants in common with the other strains (RC and YV) than other SPFMV strains and the Peruvian isolates. An antiserum to strain C with a broad spectrum of SPFMV detection has now been produced.

In China, NCM-ELISA was used to test 400 sweet potato samples collected from four provinces (Jiangsu, Sichuan, Beijing, and Shandong) for virus infection. SPFMV was found in 15.2% of the samples tested. Results of a 2-year survey indicate that 90% of the sweet potato samples collected in China were infected with viruses, especially SPFMV and SPLV. No SPMMV has been detected in China. Studies of the effect of viruses on the yield of sweet potatoes in China estimated that the use of virus-free planting materials could increase yield by 115%.

The fact that, due to limited facilities, both potato and sweet potato are sometimes grown in the same greenhouse can cause inadvertent cross-infection. For this reason, sweet potatoes were challenged against potato viruses and viroids found in previous years. In one experiment some sweet potato cultivars, including cv. Paramonguino, were infected with PSTVd by mechanical inoculation. One month after inoculation, PSTVd could be detected by NASH in cv. Paramonguino and *Ipomoea setosa*, with cv. Paramonguino showing greatly reduced vine and root production (Fig. 4-2). PSTVd in sweet potato reached higher concentrations in the non-tuber roots, as compared with infection by viroids in other plant species, where the PSTVd concentration was higher in the apical parts of the plant (Fig. 4-3). Even though sweet potato has not been considered a host of the potato viroid, these results indicate that some cultivars can be infected with PSTVd, causing severe reactions. Similarly, PSTVd also has been found in avocados (*Persea americana* L.) in Peru, suggesting a wider host range of PSTVd than previously reported. Therefore, there is a high probability of having sweet potatoes infected with PSTVd if we consider that in many regions potatoes, sweet potatoes, and avocados are planted as mixed cropping during the year. Sweet potatoes entering CIP's pathogen-tested system are now tested for PSTVd by NASH.

The C-2 virus reported previously was found in CIP germplasm in 7.5% of the accessions. It has elongated flexuos particles c. 750-800 x 12nm, and infects hosts in the families *Convolvulaceae* and

Figure 4-2. Vine-size reduction by PSTVd in sweet potato cv. Paramonguino (lower plant). Healthy conrol in the upper part.

Chenopodiaceae. In the indicator host plant *I. nil*, fine chlorotic spots and vein clearing develops on the first and second true leaves after mechanical inoculation of cotyledons. C-2 only produces transient vein clearing in *I. setosa* therefore, it is unsuitable as an indicator host. No vector has yet been discovered for this virus. Antiserum is now available which makes possible the detection of C-2 by NCM-ELISA. Using this antiserum the virus has been found in the Peruvian provinces of Trujillo and Chiclayo, with an average incidence of 8.78% and 1.1%, respectively. The virus has also been found in China and Japan. In Japan the virus has been given the name of sweet potato symptomless virus. However, discussions are being held to change this name since, translated into some languages, it could be confused with the term for sweet potato latent virus.

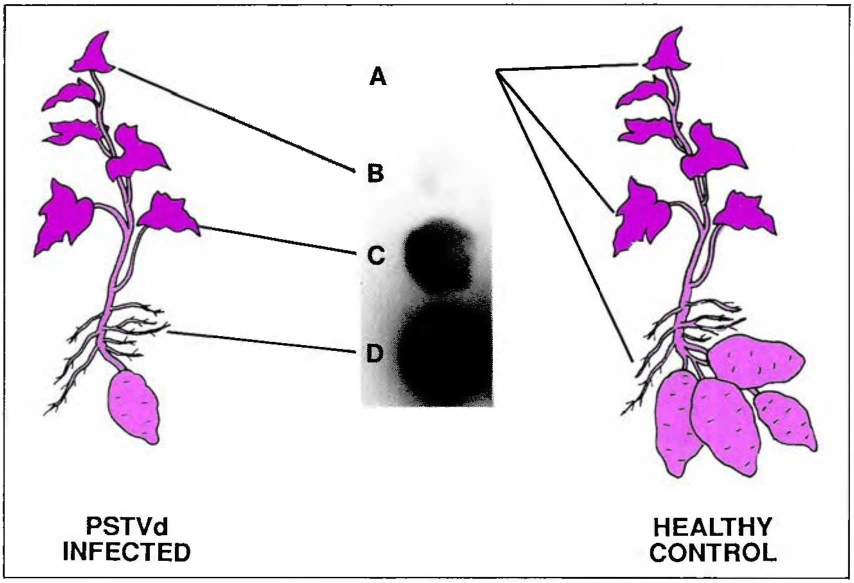
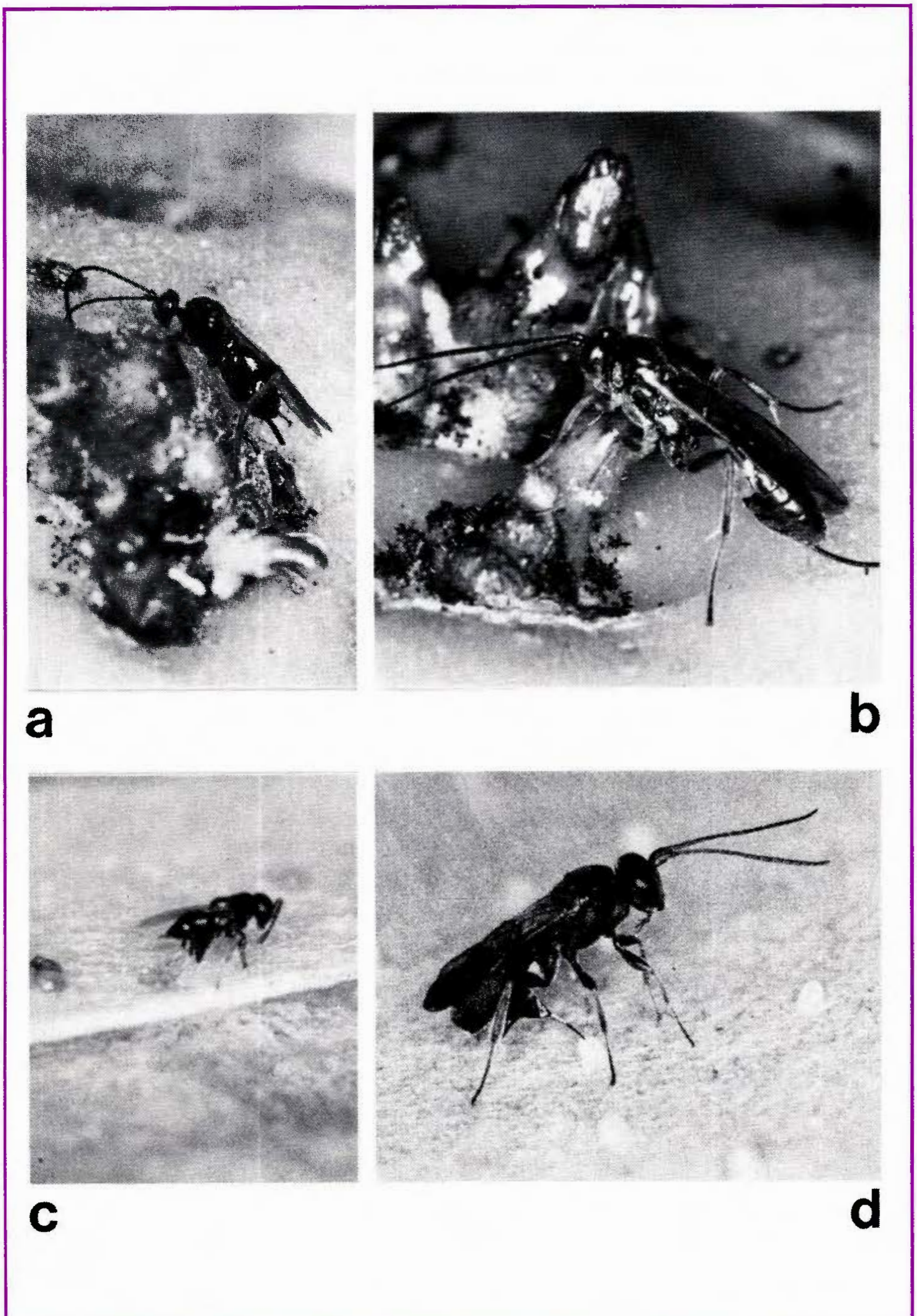


Figure 4-3. Relative concentration of PSTVd in different parts of a sweet potato cv. Paramonguino plant. A, no viroid detected; B, C, and D, increasing concentration of viroid detected by NASH.

Another virus currently being identified has been code-named C-4. This virus appears to have isometric particles *c.* 26 nm in diameter. It causes chlorotic flecks in the indicator host *I. setosa* (See Thrust photo). C-4 has been found alone, or in combination with SPFMV, in 15 of 57 accessions tested from CIP's germplasm, and in 25% of field-grown plants in Trujillo and Chiclayo.

NCM-ELISA. Because DAS-ELISA has shown low accuracy in detecting viruses in sweet potatoes, and produces background reactions, the NCM-ELISA procedure has been developed. The cost of the NCM-ELISA test for the detection of sweet potato viruses is about equal to that of DAS-ELISA for potato viruses. Therefore, there was a need to undertake studies aimed at reducing its cost. The cost was reduced substantially by changing some chemicals used in the test. One of them is the addition of 0.2% sodium sulphite to the extraction buffer as an antioxidant, instead of 0.1M diethyldithiocarbamic acid (DIECA). The use of sodium sulphite did not reduce the sensitivity of the test. The other modification included the use of Triton X-100 during the blocking step to reduce the green color on the spotted samples which otherwise would have interfered with the interpretation of the results. Using these new modifications, serological test kits for NCM-ELISA were developed and are being distributed to detect SPFMV, SPMMV, SPLV, and the C-2 virus.



Parasitoids of Potato Tuber moth which are being mass produced in Colombia. a) *Cotesia* (=Apanteles) *gelechiidivoris.* b) *Enytus* sp.c) *Copidosoma desantisi.* d) *Chelonus phthorimaeae.*

Thrust V

Integrated Pest Management

Thrust Profile: 1991

THRUST V RESEARCH continued to focus on the identification of non-chemical methods for the integrated control of major potato and sweet potato pests. In Ecuador, 5 advanced clones, G-85043, G-85044, G-85244, G-85101, and 720075, were selected as resistant to potato cyst nematode (PCN). These clones are now in the final stages of evaluation for possible variety release. In Peru, several sources resistant to the three races of PCN, P4A, P5A, and P6a were selected in greenhouse and field trials. Several advanced PCN materials have been field-tested in collaboration with the Instituto Nacional de Investigacion Agraria Agroindustrial (INIAA).

In economic evaluations at two sites in Junin, Peru total net profits when using clone 279139.5, which is resistant to PCN and late blight, were 81.1% versus 34.7% obtained with the traditional cultivar. This more resistant clone is now being tested in national trials. In Bolivia, the PCN species *Globodera rostochiensis* and *G. pallida* were identified. The fungal isolate from *Trichurus sp.* was effective for biological control in Peru.

In root-knot nematode (RKN) research in Peru, clones Line 76 and 381446.3 were selected as moderately resistant and 7 clones from the diploid population were selected as highly resistant. In Burundi, a clone selected from family 387559 produced yields 60% greater than the locally grown variety, Ndinamarga. Three species of RKN were identified in this country: *Meloidogyne incognita*, *M. hapla*, and *M. javanica*. In other studies in Peru, plant growth-promoting rhizobacteria and root extracts from *Lonchocarpus* were effective in RKN control. In sweet potato, several 4x hybrids obtained from crosses of *Ipomoea batatas* and *I. trifida* have been selected for a high level of resistance to RKN. Clones identified as resistant in the greenhouse were also resistant under field conditions. For the root nematode, *Ditylenchus destructor*, two clones were selected as highly resistant. Control of false root knot nematode(FRKN), *Naccobus aberrans*, was studied in Bolivia, where screening methods were developed to detect resistance from the Bolivian potato collection and 63 clones were selected as resistant. Crop rotation and other cultural practices were identified to control FRKN. In Peru, various extraction methods were developed for ease in screening and to evaluate the different life stages of this nematode. Interaction of this nematode with PCN was also studied. Knob formation by FRKN increased substantially when both FRKN and PCN were inoculated together; however, PCN had reduced FRKN egg production.

New sources of resistance to potato tuber moth (PTM) were identified in the diploid population. Electrophoretic studies of PTM population clones indicatesd that the protein bands of those reared on resistant clones differed from those reared on 5 susceptible clones. Such studies are important for identifying PTM biotypes that are capable of breaking down resistance. In Colombia, 9 clones were selected from progeny derived from crosses involving *S. phureja* (cultivar Criolla) and *S. berthaultii.* For biological control, 4 parasitoids were identified: *Enytus* sp., *Copidosoma koehleri*, *Chelonus phthorimaeae*, and *Cotesia gelechiivoris*. Parasitism of PTM by *Enytus sp.* reached 60% on volunteer potato plants. In cultivated potatoes parasitism due to *C. gelechidivoris* and *Enytus* sp. reaches 52%. The parasitoid *C.* koehleri for use in biological control has been introduced from Peru to India and Tunisia. Other biological agents tested included the use of granulosis virus (GV), and *Bacillus thuringiensis* (Bt), both of which were effective in trials in Peru, Tunisia, and Egypt. A locally occurring strain of GV was identified.

In Peru, an integrated control program for Andean potato weevil, *Premnotrypes spp.* was tested in Cuzco, where the fungus *Beauveria brogniartii*, and the barrier crop *Lupinus mutabilis* were shown to be effective. Progenies developed from the grandular trichome showed multiple resistance to PTM, to green peach aphid, *Myzus persicae*, to red spider mite, *Tetranychus urticae*, to broad mite, *Polyphagotarsonemus latus*, and to leafminer fly, *Liriomyza huidobrensis*. Each of these pests contributes to substantial yield losses in the potato production of developing countries.

Sweet potato weevil (SPW) management research concentrated on identifying sources of resistance and investigating the potential of biological control. In Peru, 3 promising clones were selected and a field test was developed to control infestation. The fungus *Beauveria bassiana* was effective when applied at the hilling stage, and studies were made of the biology of the parasitoid *Eurydinoteloides* sp. In the Philippines, 10 strains of *B. thuringiensis* (Bt) were isolated from infected weevils, and are now being investigated for use in biological control of this pest. A locally occurring strain of the fungus *Beauveria bassiana* was effective in the control of this pest under greenhouse conditions. In other regional studies, the sex pheromone traps were effective in monitoring this pest. Biotype identification studies using both cytological and electrophoretic techniques showed no differences in the chromosome patterns for the SPW collected from two regions. Two varieties, Sinksuk and Miracle, were identified as less damaged by SPW. Several on-farm trials showed that the use of clean planting material was effective in reducing weevil populations. In China the accession ZS 1 was selected as promising for SPW resistance. In India, the SPW pheromone has been synthesized using locally available materials. In the Caribbean two SPW species, *E. postfasciatus* and *Cylas formicarius*, were identified as major pests. Low-cost traps, designed for the sex pheromone, were effective in monitoring *C. formicarius*. On-farm surveys in this region have identified several farmer practices effective in SPW management. In Argentina, *Typophorus nigritus* was identified as a major pest of sweet potato storage roots. Two weevil species, *C. puncticollis* and *C. brunneus*, were identified in Kenya. Insect specimens collected from Paraguay, Bolivia, Argentina, Peru, Ethiopia, and Cameroon have been identified. Research contracts in Peru identified several sources of resistance to leafminer flies. In the Philippines, several promising potato progenies have been selected for resistance to thrips and mites. Research at Cornell Univeristy, USA concentrated on the utilization of glandular trichomes for insect resistance in potato. Clone L235-4 was shown to be resistant to the Colorado potato beetle (CPB), *Leptinotarsa decemlineata*. In other collaborative research with ENEA in Italy, progress has been made in the use of grandular trichomes and genes of *Bacillus thuringiensis* to develop potatoes with resistance to PTM and CPB. Several insect specimens received from NARS were identified. This information is vital in the development of IPM for developing countries.

Potato

Potato cyst nematode: (PCN)

Field and greenhouse studies emphasized the use of host-plant resistance, and biological control methods to manage this pest in Peru, Ecuador, and Bolivia.

Screening and breeding for resistance

In **Ecuador**, 18 tuber families resistant to PCN were retested for their adaptation and resistance to late blight. Ten families with a total of 56 clones were selected for resistance to late blight as well as for good plant and tuber type. Resistance to PCN in these clones is now being reconfirmed. To avoid escapes, 17 clones were retested in PCN-infested fields. All of these clones showed a resistant reaction, with a Pf/Pi ratio of less than 1. Five advanced clones, G-85043, G-85044, G-85101, G-85244, and 720075 were compared with the two local cultivars, Gabriela and Maria. The advanced clones of CIP were more resistant (Pf/Fi of 0.59 - 1.68) than the local cultivar Gabriela.

Multilocation trials were conducted in **Peru**. The appearance of a new nematode race, called P6A, which is capable of breaking resistances obtained from races P4A and P5A, created the need to select for combined resistance to all the known races. A total of 18,000 seedlings from 198

Field evaluation of potato cyst-nematode-resistant clones in Huancayo, Peru.

families were screened for resistance to the three races using the plastic cup method. Fifty-two percent were resistant to P4A, 39% to P5A, and 50% to P6A. These clones are now being used in breeding for resistance to all the three races of PCN. The petridish test was used to confirm resistance in 48 clones selected under greenhouse conditions. Of these clones, 90% were resistant to the races P4A and P5A. A total of 270 clones from Cornell University, USA were also tested. About 50% were selected for resistance to races P4A and P5A. Potato clones maintained as advanced pathogen-tested material were tested and 20 clones were identified for resistance to P4A and P5A. Of the 121 clonal selections made in earlier years and screened for the three important PCN races, 65 were identified as resistant to P6A, and 49 showed combined resistances to the three races. In Peru, 61 promising clones were field tested at 5 locations, selections were made of 31 clones in Cuzco, 41 in Humachuco and 48 in Cajamarca. In studies of PCN/virus resistance, 180 clones were selected in Huancayo with resistance to P4A and P5A. Of these, 112 showed combined resistance to both races. Collaborative work with the Instituto Nacional de Investigacion Agraria Agroindustrial (INIAA) in Peru to field-test PCN-resistant material has identified cultivar Maria Huanca, which remains partially resistant to races P4A and P5A and produces very good yields. However, this cultivar was observed to be susceptible to a new aggressive race P6A, found in Peru in the area around the city of Cajamarca and in the departments of Cuzco and La Libertad. The best PCN advanced resistant materials from groups G 84 and G 85 continue to be field-tolerant with high yields. Figure 5-1 shows the yield and multiplication rate of the race P4A in four advanced tolerant clones

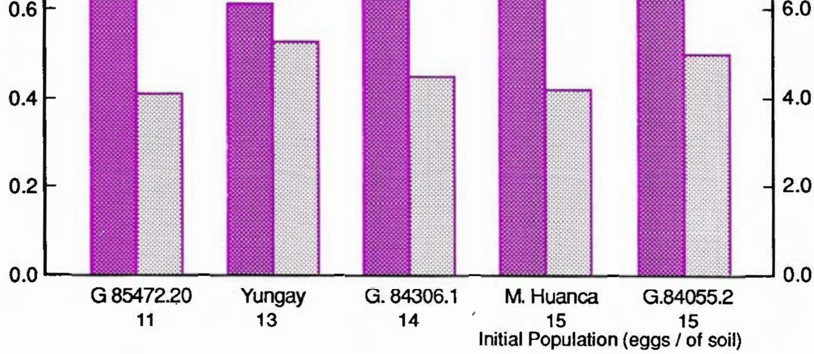


Figure 5-1. Field performance of advanced potato-cyst-nematode (PCN)-tolerant clones during 1989-90 in Junin, Peru.

tested at two locations in Junin. Economic evaluation of advanced clone 279139.5, which is resistant to PCN and late blight, showed that the total net profit when using this cultivar was 81.1% versus 34.7% when using the traditional cultivar. A cost-benefit analysis was used to calculate this data. This clone is now being tested in national trials prior to its possible release as a new variety in Peru.

In **Bolivia**, PCN has been found to be widely distributed. In most of the cases both species *Globodera rostochiensis* and *G. pallida* have been identified.

Biological control

Four fungal isolates selected in the laboratory were field-tested in Cajamarca, **Peru**. The fungal isolate from *Trichurus* sp. was the most effective when applied in the furrow at the rate of 10 g of boiled rice plus fungus per plant. Nematode reproduction in this treatment was significantly reduced (Pf/Pi for *Trichurus* sp. was 1.2 vs 15.5 for the check).

Root-knot Nematode

Research on RKN management was concentrated in **Peru** and **Burundi**, and emphasized utilization of resistance and study of the effects of plant-growth promoting Rhizobacteria (PGPR) of the plant species *Lonchocarpus* sp.

Screening for and Utilization of Resistance to RKN in Potato

A total of 85 clones from the pathogen-tested list at CIP were evaluated for resistance. The clones Line 76 and 381446.3 were found to be moderately resistant. Within the diploid population, 163 clones were evaluated, and 7 have been selected as highly resistant. These new sources of resistance can now be used to broaden the genetic base. In other tests, over 16,000 seedlings were evaluated, representing tetraploid genotypes of 34 progenies developed from crosses between selected material resistant to RKN and bacterial wilt, with adaptation to heat and immunity to viruses X and Y. From this population, 371 resistant genotypes have been selected and some will now be tested under field conditions.

In Burundi, 7 clones have been selected from 3 families: 2 clones were from family 387551, 4 from 387568, and 1 from 387559. The yield for the clone from 387559 was 60% greater than that of the locally grown variety, Ndinamagara, and this resistant clone is now being multiplied for multilocation trials. At least three species of RKN have been identified in infested fields: *Meloidogyne incognita*, *M. hapla*, and *M. javanica*.

Effect of Rhizobacteria and *Lonchocarpus* sp. on RKN

When 50 isolates of plant-growth promoting Rhizobacteria (PGPR) were tested for control of *M. incognita* on potato and tomato plants, the findings showed an increase in weights of foliage and fresh and dry root of both these crops, when PGPR isolates were added to pots at planting time. The presence of PGPR isolates reduced the RKN root-galling index in tomato plants by at least 50%, as compared with the control. Some of these same isolates reduced the root-galling index in potatoes by 100%. In general, however, the PGPR isolates controlled *M. incognita* on tomatoes more effectively than on potatoes. The findings that potato and tomato plants inoculated with this nematode grew better than those that were not inoculated, suggest the utility of these PGPR isolates in areas severely infested with RKN.

Plant species *Lonchocarpus nicou*, *L. urucu*, and *L. utilis* were studied to determine their effects on RKN using ground, dried roots applied as a soil amendment. The root-galling index generally decreased as the amount of soil amendment increased (from 3g to 9 g/500 cc pot), but differences were not significant. In a separate test, a suspension obtained by soaking the ground roots in water was applied to the soil and found to be effective. Thus, these 3 plants, which are common in many tropical countries, may be useful for RKN control.

False Root-knot Nematode (FRKN)

Fifteen *Nacobbus aberrans* populations collected from Argentina, Bolivia, Ecuador, Mexico, Peru, and the United States are being analyzed to identify any physiological races within this species. Research efforts were concentrated in **Peru** and **Bolivia** to develop a reliable method for detecting this nematode in soil samples. In Bolivia, the standard bioassay test was improved by pre-treatments of the soil sample, and through the use of a transparent, closed-container test at 20C. The root nodules caused by this nematode can be observed through the container walls at 50 days after planting. To date, 660 clones from the Bolivian potato collection have been screened and 63 selected as resistant. Crop rotation studies showed that FRKN populations were reduced by use of *Vicia villosa* and *Chrysanthemum cinerarealifolium* during one season. Weed control and fallow also were effective. Studies are continuing on population dynamics, distribution, host range, and dissemination of this nematode.

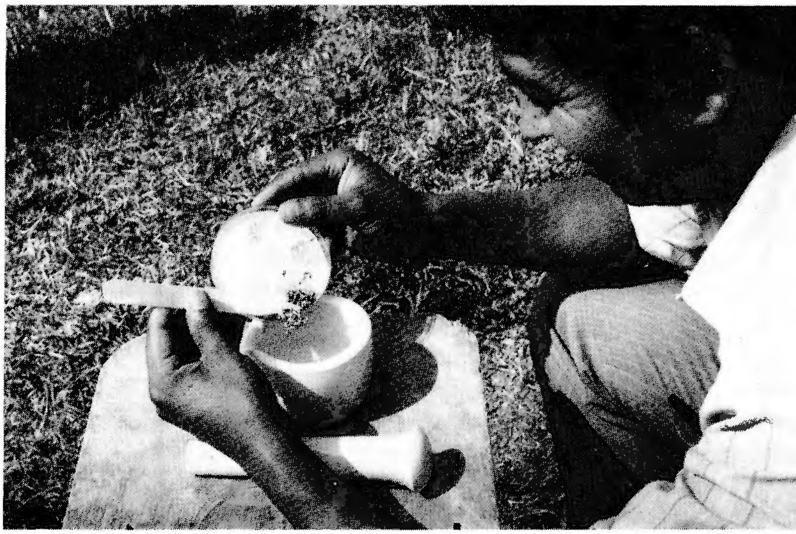
Preparing the granulosis virus with talc for use in storage.

Extraction methods and sources of inoculum for nematode reproduction are being studied in Peru. Sodium hypochlorite followed by sugar centrifugation was effective for extraction of eggs from roots. The tray method was effective for the extraction of juveniles. Blending the root pieces for 2 to 3 minutes at high speed gave good results in extracting adult vermiform females from the roots.

Infested soil promoted nematode reproduction. In the interaction studies involving PCN and FRKN, there was a significant increase of knob formation when FRKN and PCN were inoculated simultaneously, or when FRKN was inoculated seven days before PCN. PCN had an adverse effect on egg production of FRKN but FRKN did not have any effect on PCN population.

Insect and Mite Pests

In developing non-chemical control methods for an integrated pest management (IPM) strategy, research emphasized the utilization of host-plant resistance and biological control for the major insect and mite pests of developing countries.



Macerating potato tuber moth lavae infested with a granulosis virus.

Potato Tuber Moth (PTM)

Screening for Resistance

In **Peru**, 319 clones of a diploid population were studied to identify tuber resistance to PTM. Promising clones identified in the laboratory test include 84-11.4; 84-16.13; 84.37.6; KW PTM 102; 88.120.8; 88.134.8, and KW PTM 24. In storage tests, 5 clones were selected: 87HW 2-5; 87HW 5-9, 87HW 8-2; 87HW 8-19, and 87HW 11-12. Electrophoretic studies on PTM populations reared in resistant clone P82144.5 and suceptible cultivar "Desiree" showed clear differences in protein bands. The protein band of PTM in the cultivar "Desiree" had a high molecular weight. Additional studies of these populations are under way to identfy possible PTM biotypes.

In **Colombia**, progenies derived from crossing *S. phureja* (cultivar Criolla) and *S. berthaultii*, PI 473331.7 were evaluated and 9 clones were selected, which will now be backcrossed to cultivar Criolla to improve its resistance. Cultivars Parda pastusa (resistant) and Criolla (susceptible) were infested with first instar larvae with densities ranging from 5 to 20 and pupation was evaluated at 3 weeks after infestation. A significantly higher number of female pupae were observed in the susceptible cultivar Criolla. Both pupation and development of female pupae were significantly lower in the resistant cultivar Parda pastus (Fig. 5-2).

Biological control

Surveys were made in **Colombia** to identify the important natural enemies of PTM. Volunteer potato plants in the field were heavily parasitized by the parasitoid *Enytus* sp. (Hymenoptera:Icneumonidae). The level of parasitism reached 65%. This species is native to Colombia and attacks PTM species *Phthorimaea operculella* and *Eurysacca melanocampta*. Other parasitoids of PTM identified included: *Copidosoma koehleri, Chelonus phthorimaeae*, and *Cotesia gelechiidivoris* (see Thrust photo). In cooperation with the Colombian potato program, a lab facility was installed for mass-rearing of these parasitoids to be used in biological control. These parasitoids have been studied under field conditions to determine their effectiveness. At 60 days after planting, 43% of the PTM population was parasitized by *C. gelechiidivoris* and 9% by *Enytus sp.* The parasitoid *C. koehleri* has now been introduced to India for further trials.

In **Peru**, the granulosis virus (GV) and *Bacillus thuringiensis* (Bt) were tested in storage. The shelf life of GV was determined using three GV samples (infected larvae, liophilized larvae, and as GV suspension in water), which were stored at -10°C for 2 years in the deep freeze. These samples were compared with freshly prepared sample of GV. A 100% larval infection was obtained with larval samples stored in the deep freeze for 2 years. In other tests Bt was mixed with lime, talc, and GV and tested for PTM control. The treatments Bt+lime, Bt+talc, and GV+talc were the most effective in controlling larval infestation. Bt was used @ 15g, lime and talc @ 300g, and GV @ 20 diseased larvae per 100kg of stored potatoes. Inert materials, (lime, talc, and kaolin) were not effective in controlling the initial infestation from eggs of PTM. In collaboration

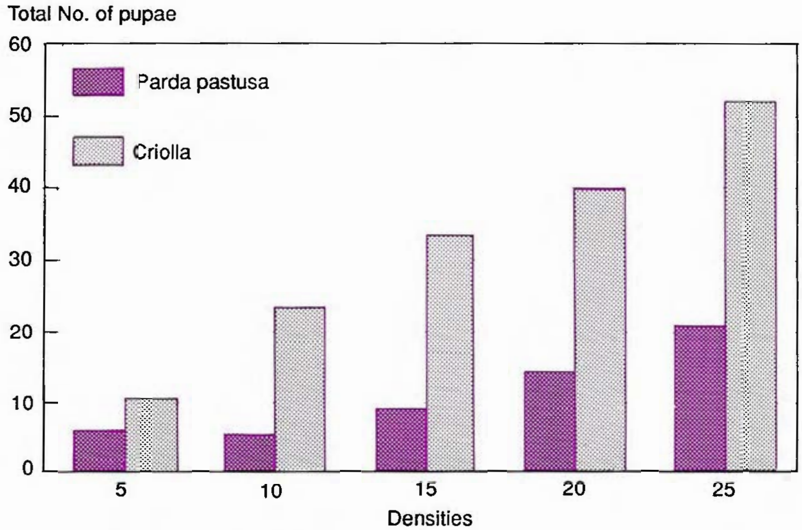


Figure 5-2. Effect of the potato cultivars Parda pastusa and Criolla on potato tuber moth, *P. operculella* population. Bogotá, Colombia, 1990.

with INIAA/SEINPA, this virus has now been multiplied and applied to 200 tons of potatoes for study of control of this pest in storage. Simple rural facilities to mass produce this virus are being set up in different regions of Peru.

In **Tunisia**, the effect of GV on reducing tuber damage in the field was investigated by applying the GV spray solution on the soil surface around the base of potato plants at 50, 75, 88, and 94 days after plant emergence. Tuber samples were taken one week prior to harvest and evaluated for PTM damage. PTM damage in GV-treated plots was low (1.08% vs 10.66% in control plots treated with water alone). In another trial, GV + talc @ 1.2 t per hectare was applied to the elevated surface of soil ridges using flour-sifting trays at 50 and 75 days after emergence of plants. At harvest tuber damage for GV + talc treated plots was 14.33%, as compared with 29.33% for untreated plots. On-farm storage trials were conducted in collaboration with 11 farmers to test the effect of GV and Bt. In heaps treated with GV or Bt at three months after storage, infestation was 4%, as compared with 8% infestation in the farmers traditional heaps.

A survey comparing current farm practices with those of 1986, indicated a substantial increase in the number of farmers using irrigation practices to reduce PTM infestation. Farmers generally have avoided using chemical insecticides against this pest. (Fig. 5-3)

In **Egypt** both Bt and GV were shown to be effective in storage. After 4 months' storage, tuber damage was 17% when using Bt + talc, 15.7% for GV + lime, as compared with 39% in untreated tubers. In other trials, dried, shredded *Lantana camara* applied on top of storage heaps, provided good protection: after 4 months storage, only 9 % tuber damage was observed in these heaps.

In **Kenya** the presence of GV in PTM larvae was confirmed. This virus has now been mass multiplied for use in biological control of this pest.

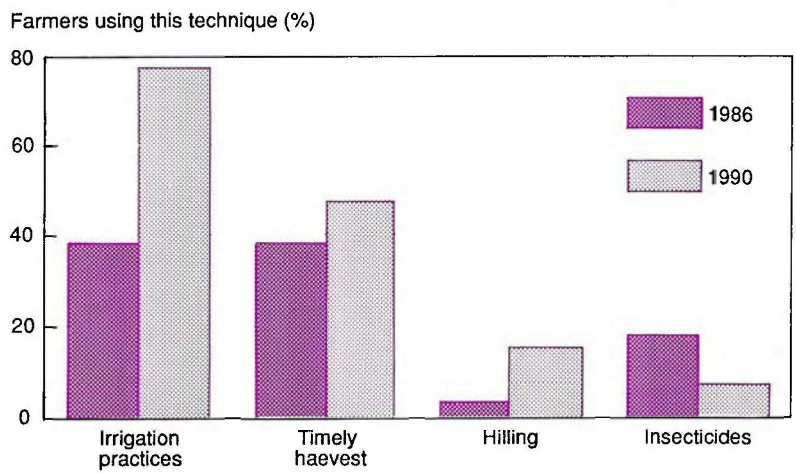


Figure 5-3. Farmer management of potato tuber moth, *P. operculella* in potato fields of Tunisia during 1990.

Andean potato weevil

An integrated control program is now being tested for this pest in Cuzco, **Peru**. The fungus *Beauveria brogniartii*, grown on barley husk, was applied at hilling at 10g/plant. When tuber damage was evaluated at harvest, a 24% reduction in damage was noted with the use of this fungus (36% versus 60% in untreated plots). Adult weevils in fungus-treated plots were infected at the rate of 2 to 3 adults / 5 plants. The population dynamics of this pest was determined in stores. During the migratory phase of this pest a total of 6,000 adults were captured by using plastic-covered trenches dug around the storage heap and filled with water. Maximum captures of 1400 adult weevils were obtained during December. The use of *B. brogniartii* at the bottom of storage heeps was very effective, when 500 gms of the barley husk with the fungus was applied per square meter of soil surface. This application was mixed with the top-5 cm soil layer and tubers were stored on this treated soil surface. Mortality for larvae was 87%, for pupae 83%, and for adults 60%. In other trials, where the plant species *Lupinus mutabilis* was grown around the potato plants to act as a barrier to migrating adult weevils, tuber damage was substantially reduced: 18% as compared with 34% without the barrier crop.

An integrated management approach using clean seed, improved cultural practices, and *B.brogniartii* was implemented in several farmer communities of Cuzco. The fungus is being multiplied in very simple facilities and is now being used by over 100 farmers in this region to control this pest in their stores.

Identifying multiple resistance to pests

Emphasis was made on identifying clones with glandular trichome as a source of

Resistance to red spider mite in potato progenies with glandular trichomes. Clone on left is resistant to RSM.

broad based resistance to major pests. From the 86 advanced glandular trichome clones screened in Peru, 8 clones, T87709.2, T87703.1, TA 19.4, TA 44.4, TA 50.4, TA 59.1, TA 59.3, and T86798.1 were selected for resistance in foliage to PTM, to green peach aphid (GPA), *Myzus persicae*, and red spider mite (RSM), *Tetranychus urticae*. In other tests 5 glandular trichome clones, K 411.2, K 419.8, K 421.2, K 432.5, and K 434.1 obtained from Cornell University, USA were evaluated for resistance to several pests. The clone K 432.5 was resistant to the broad mite, *Polyphagotarsonemus latus*, clone K 432.5 to RSM, and clone K 419.8 to GPA. Both survival and reproduction of this pest were affected. Clones K 421.2, K 432.5, and 434.1 exhibited a high level of antixenosis (non-preference) to egg laying by PTM. The level of resistance in K 434.1 was similar to that exhibited by the wild species *S. berthaultii*. Tubers from K 411.2 and 421.2 were resistant to PTM larval damage. For leafminer fly, *Liriomyza huidobrensis*, clones K 434.1, K 432.5, K 419.8 and K 411.2 were found to be resistant during the first 45 days after plant emergence.

Sweet Potato

Root Knot/Root Rot Nematode

Several clones from different sources have been tested. Of these, 305 were from the world germplasm collection (in which the majority of the accessions are from Peru), 48 from a population selected for resistance to high soil salinity, and 30 represented the 4x hybrids obtained from crosses of *Ipomoea batatas* and *I. trifida*. A high level of resistance to RKN has been identified from these hybrids with 15 clones from this population rated highly resistant. These materials can be used as sources of RKN resistance in the breeding program. Some of these hybrids have also been found resistant to the west-Indian sweet potato weevil, *Euscepes postfasciatus*. In other tests, 2,866 seedlings representing F1 progenies of polycrosses made from selected clones with adaptation to soil salinity and RKN resistance were evaluated. A total of 294 were selected as highly resistant. In order to evaluate the inheritance of resistance to RKN, 30 resistant clones were open-pollinated. From these crosses, 625 seedlings representing the open-pollinated genotypes of 10 clones were obtained for screening against RKN. Results indicate that 55.5% were highly resistant and 22.1% resistant. This trend was observed in all the progenies, indicating the high heritability in this resistance character. Clones identified as resistant under greenhouse conditions were later tested in the field in the Peruvian valley of Cañete. A 100% resistance correlation was obtained in the reaction of 34 clones to RKN.

The root rot nematode, *Ditylenchus destructor*, is an important nematode parasite of sweet potatoes in China. Over 560 clones from the world germplasm collection were evaluated and two clones rated as highly resistant and 41 clones rated as resistant were selected.

West Indian Sweet Potato Weevil

In **Peru**, mass-rearing methods to obtain large numbers of the adult West Indian sweet potato weevil, *Euscepes postfasciatus*, have been developed for use in host-plant resistance identification. In laboratory tests, a total of 237 sweet potato accessions from the world collection were screened for storage resistance. Three clones, DLP 237, ARB 89, and DLP 2307 were selected. A field test using controlled infestation of this pest has been developed. Roots of uniform size were caged in the field with clip-on cages containing adult weevils. At 45-50 days after caging these roots were excised and evaluated for resistance. Five clones, DLP 101, DLP 1959, ARB 320, ARB 539, and ARB 597 were selected with low population developement in field and lab tests conducted during the summer and winter seasons in La Molinà. Biological control of this pest was evaluated using three isolates of the fungus *Beauveria spp.* collected from La Molina, San Ramòn, and Cuzco. The most effective was *B. bassiana*, isolated from infected *E. postfasciatus* adults collected in La Molina. In lab tests, after 12 days, 100% mortality occurred at 20C and 84% at 18C. In field tests the application of this fungus grown on barley husk at 10 g/plant at transplanting followed by a second application at 60 days, reduced weevil populations (7.37 vs 16.73 in untreated plots). The biology of the parasitoid *Eurydinoteloides* sp. attacking this pest, is being studied to aid in mass-rearing for use in biological control. Results indicate that this is a solitary ectoparasitoid of the last stages of weevil larvae and prepupa. Attempts are being made to introduce this parasite in weevil-infested areas of Brazil, Venezuela, and the Caribbean.

In the **Philippines** several control components were investigated for the control of sweet potato weevil, *Cylas formicarius*. Mass-rearing methods for the fungus *B. bassiana* were developed using cornstalk as substrate. A spore weight of 0.39g with 96% germination was observed in this substrate. In greenhouse tests this fungus was effective in reducing weevil populations (1.5 vs 3.3 in untreated plants). Ten strains of the bacteria *B. thuringiensis* were isolated from field-collected weevils. The toxicity level of these strains is being studied. The sex pheromone water trap was evaluated as a monitoring tool for this pest. Weevil populations were monitored for 9 months beginning in December 1989. Maximum captures occurred during the dry season, with a maximum peak of 40,000/trap during the month of May. The dry season in the Philippines is characterized by fairly high temperatures, high relative humidity, and little rainfall. In other studies biotype identification of SPW is being done using cytological and electrophoretic techniques. The chromosomal observations were the same for SPW collected from the Quezon and Los Baños areas.

The resistance of 4 varieties was evaluated. The varieties Sinksuk and Miracle had significantly less weevil populations and damage. On-farm experiments were conducted in three sites. Results showed that the use of clean planting material proved effective in reducing root infestations at harvest. Other pest species identified include aphids *(Aphis gossypii)*, flea beetle *(Chaetocnema basalis)*, black mirid bug *(Halticus minustus)*, and capsid bug *(Helopeltis collaris)*. In **China** two groups of sweet potato germplasm were tested for resistance. The first group consisted of 128 accessions from Guangdong Academy of Agricultural Sciences (GAAS) and the second 117 accessions from Xuzhou Sweet Potato Research Institute (XSPRC). All the materials from GAAS were susceptible. From the XSPRC collection one accession ZS 1, was selected as promising for weevil resistance.

In **India**, the SPW pheromone has been synthesized at the Regional Research

Laboratory (RRL), in Trivandrum. Field testing is under way to determine its effectiveness and longevity.

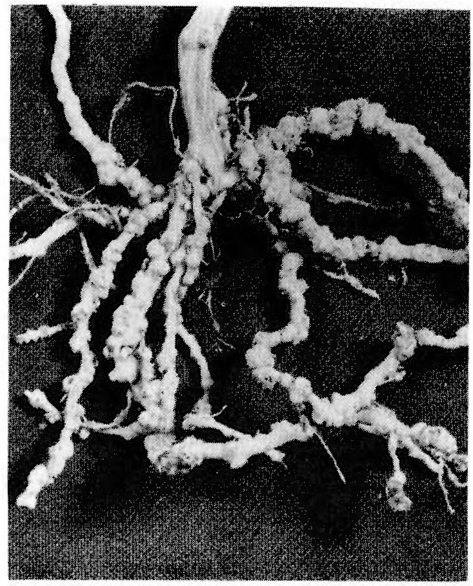
In the Caribbean, surveys were conducted to identify the major SPW species. Both *E. postfasciatus* and *C. formicarius* are widely distributed in this region. On-farm surveys were conducted in San Juan, **Dominican Republic** to identify farmer practices used in SPW control. Results indicate that many of the producers were aware of the importance of using crop rotation, clean planting material, irrigation, and hilling up. In other trials different designs of SPW sex pheromone traps were tested. Low-cost plastic containers with small windows caught significantly more males than standard cone traps (P=0.05). In **Jamaica** trapping studies were done to rate the island in terms of weevil population. From the data obtained sweet potato-growing areas located above 400km in Jamaica had significantly lower SPW populations.

In **Argentina,** *Typophorus nigritus* was identified as a major pest of storage roots. The life cycle of this pest is under investigation with a view to developing mass-rearing methods for use in resistance identification.

In **Kenya,** Nyanza province is the most important sweet potato-growing area. Surveys in this region indicate the presence of two major SPW species, *C. puncticollis* and *C. brunneus*. CIP is collaborating with various institutions in developing an IPM program for these pests.

Identification of pests/natural enemies

Several institutions collaborated in this study, including the United States Dept. of Agriculture (USDA), the International Institute of Entomology (IIE) and the Universidad Nacional Agraria (UNA). Samples



Root knot nematode damage in sweet potato roots.

were received from Paraguay, Bolivia, Argentina, Peru, Ethiopia, and Cameroon. Five species of aphids were identified from Ethiopian specimens. These were *Myzus persicae* (Sulzer), *Aphis craccivora* (koch), *Macrosiphum euphorbiae* (Thomas), *M. rosae* (Linnaeus), and *Brevicoryne brassicae* (Linneaus). Samples from Cameroon include 5 species of aphids, *M. persicae*, *Aulacorthum solani* (Kaltenbach), *Macrosiphum salviae* (Bartholomew), *Pentalonia nigrovervosa* (Coquerel), and *A. nasturtii* (Kaltenbach). More details of identification for material collected from other countries are given in Table 5-1.

Research Contracts

Research contracts with the Universidad Nacional Agraria, La Molina, Lima, **Peru** focused on the identification of resistance to leafminer fly, *L. huidobrensis*, in True Potato Seed (TPS) families developed at

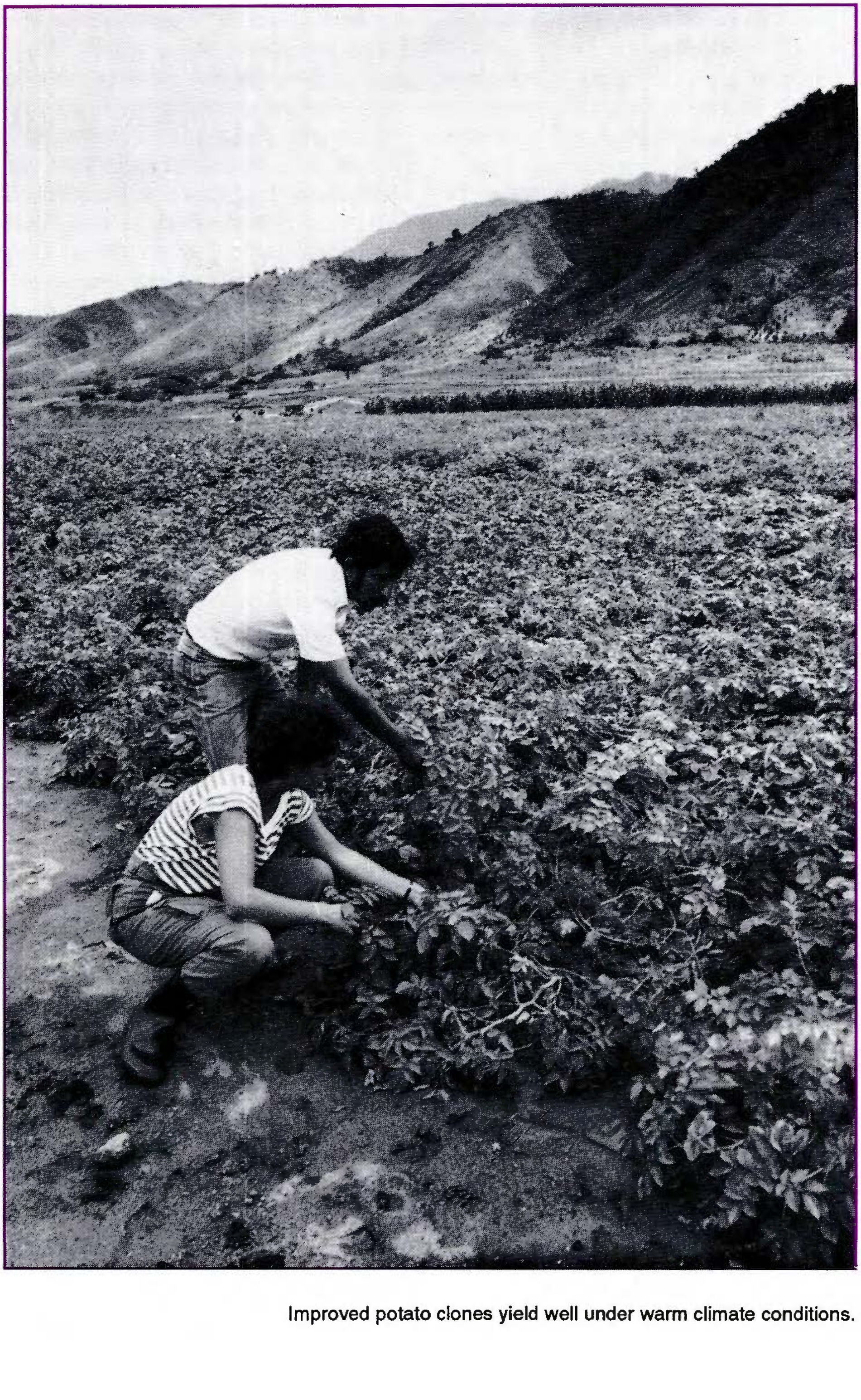
Table 5-1. Details of identification of insect specimens received from national and regional programs. 1990.

Country/ location	Crop[a] importance	Species	Habitat	Economic[b] imporatance
Paraguay	SP	*Ptericoptus* sp. prob. *sinuatus* Berg.	Stem borer	1
	SP	*Eriopis* sp.	Predator	2
	SP	*Chrysodina* sp.	Phytophagous	2
	SP	*Epicauta atomaria* (Germ.)	Phytophagous	2
	SP	*Symmetrischema striatella* (Murtfeldt)	Phytophagous	2
Bolivia	P	*Epicauta adspersa* (Klug)	Phytophagous	2
	P	*Paraschema detectendum* Pov. (new sp)	Phytophagous	2
Argentina	P	*Colaspis prasina*	Phytophagous	2
Peru (Lima)	SP	*Melanagromyza caerulea* (Malloch)	Phytophagous	1
	SP	*Condylostylus* sp.	Predator	2
	SP	*Myzinum* sp.	Predator	2
	SP	*Eriopis* sp.	Predator	2
(Arequipa)	P	*Russelliana solanicola* Tuthill	Phytophagous	1
	P	*Opius* sp.	Parasitoid	2
	P	*Apanteles gelechiidivoris* Marsh.	Parasitoid	1
	P	*Chrysocharis bedius* (Walker)	Parasitoid	1
(Cuzco)	P	*Symmetrischema plaesiosema* Turner	Phytophagous	1
(San Ramón)	SP	*Dichelops furcatus*	Phytophagus	3
	SP	*Trigona recursa* Smith	Pollinator-Phytophagous	2
	SP	*Garganus* sp.	Phytophagous	3
	SP	*Halticus bractatus* (Say)	Phytophagous	3
(Yurimaguas)	SP	*Hyperaspis* sp.	Predator	2
	SP	*Lema dorsalis* Oliv. or near	Phytophagous	2
	SP	*Diabrotica* sp.	Phytophagous	2
	SP	*Omophoita aequinoctialis* (Linn.)	Phytophagous	3
	sp	*Stolas* sp. near *lateralis* (L.)	Phytophagous	2
	SP	*Coptocycla consobrina* Boh or near	Phytophagous	3
	SP	*Metriona* sp. or near	Phytophagous	2
	SP	*Deloyala* sp.	Phytophagous	2
	SP	*Neopamera bilobata* (Say)	Phytophagous	3
	SP	*Atrachelus tenuispinus* Champion	Predator	2
	SP	*Oedancala* sp.	Phytophagous	3

[a] P = Potato
SP = Sweet potato

[b] 1 = Very important
2 = Important
3 = Somewhat important

CIP. Several clones have been identified as resistant. The Centro de Introducción y Cria de Insectos Utiles (CICIU) of Peru has collaborated in supplying CIP with the polyembryonic parasitoid *C.* koeleri of PTM and *Eurydinoteloides* sp., a parasitoid of *E. postfasciatus*. In the Philippines collaborative studies with UPLB have evaluated several potato progenies for resistance to thrips and mites. The most promising materials selected for the broad mite, *P. latus*, were entries 379693.110, 380584.3, Kufri Jyothi, 382309, SC 151, SC 439A, and P-3. The newly approved Philippine seedboard variety T-204 showed greater resistance than the commercial variety Cosima. Among the bulked tuber families the most promising were T 86711.1 x I-1039, G 159.5 x I 1039, and G 168.3 x BKKSR. In the TPS yield trial, 43 individual plants showed resistance to thrips and mites. From the glandular trichome progenies 4 entries, T88719, T88791, T88797, and T8805 showed some degree of resistance to the broad mite. The selected entries had both type "A" (4-lobed) and "B" (simple stickies) trichomes. In other studies the predacous mite, *Amblyseious* sp., was identified as an important natural enemy of the broad mite. For the control of thrips, the predator *Campylomma* sp. was effective. The CIP research contract at Cornell University, **USA** concentrated on the utilization of glandular trichomes for insect resistance in potato. Clone L235-4 is seven generations removed from the wild diploid species *S. berthaultii*, two of them being backcrosses to *tuberosum*. The last cross was to a *neotuberosum-tuberosum* hybrid. L235-4 has "A" trichome traits equal to the wild species but lacks "B" trichome droplets. In Colorado potato beetle (CPB), *Leptinotarsa decemlineata*, exposure trials the same clone reduced the density of third and fourth stage CPB larvae by more than 50%. This clone is also resistant to PVX and PVY. In an unreplicated seed multiplication plot of 48 hills, this clone produced an average yield of 1.7 kg per hill (41 t/ha), 87% of which were greater than 5cm in diameter. The total glycoalkaloid level was as low as standard varieties. This clone represents a major breakthrough in developing insect resistant potato varieties. In other collaborative research with ENEA in **Italy**, rapid progress has been made by using conventional and innovative technologies. Testing procedures for identifying resistance to Colorado potato beetle have been refined by developing antibiosis tests. Mutant induction by irradiation using invitro plantlets from the promising lines (K 405 100) has been initiated to facilitate the recombination of useful characters. For PTM resistance identification, both antibiosis and non-preference tests were conducted using CIP clones. One clone, TM 4, was identified as less susceptible in both tests.



Improved potato clones yield well under warm climate conditions.

Warm-climate Potato and Sweet Potato Production

Potato

Drought and Salt Tolerance

The Philippines. At Canlubang 4, potato cultivars were re-evaluated for their response to 3 levels of soil moisture (Table 6-1). In general, canopy growth and dry matter production were significantly inhibited by drought stress. Due to P3's good canopy development and well-developed root system, it gave good tuber yields, both with and without water stress conditions. Early maturing cultivars such as Cosima and Berolina were able to escape mild and transient drought, because of their early and fast tuber bulking. Eight additional potato cultivars were also evaluated, using stem cuttings under drought conditions. Yield reduction under water stress was lowest for the clones LT-8, 378597.1, and Up-To-Date.

Table 6-1. Fresh tuber yield components of 4 potato cultivars at 3 soil water levels at 70 dap.

Water	Cultivar	Yield t/ha	Tuber no./m^2	Avg. tub wt g	Harvest index %
Drougth at 30-50 dap	Cosima	13.1	63	21	72
	Berolina	21.1	48	25	72
	P3	11.7	45	20	83
	P7	2.0	19	11	30
Half-water	Cosima	18.6	77	24	74
	Berolina	18.2	52	35	73
	P3	27.5	78	42	72
	P7	9.9	25	40	30
Full-water	Cosima	20.4	79	26	78
	Berolina	19.9	55	23	68
	P3	26.0	58	45	76
	P7	10.8	32	34	40
Grand Mean		15.8	53	16	64
LSD (0.05)	Water level	7.2	ns	0.1	
	Cultivar	4.0	10	0.1	
	Interaction		ns	ns	

China. Thirty-one varieties were evaluated for drought tolerance at the research institutes in Datong, Hohhoti, and Wumeng. Data collected included root pulling resistance (RPR), root fresh weight, canopy cover, and yield components. Eleven varieties performed well in the three institutes, with CIP varieties B71-240.2, and N-565-1 giving good yields under drought. There was a positive linear correlation between root pulling resistance and tuber fresh weight, and the number of tubers and yield/plant, indicating that RPR can be used as an index for drought resistance in the early growth stages.

The line-source sprinkler irrigation approach was used to evaluate the water use efficiency of potato genotypes. Field data compiled using this system over a 3-year and 2-location series are currently being analyzed using multivariate analysis. The effect of irrigation management practices on physiological parameters under water deficit conditions is also being studied.

Field, greenhouse, and growth-chamber studies continued to improve understanding of the stomatal behavior associated with better water-conservation mechanisms for plants. Physiological parameters such as leaf diffusion, (i.e. diffuse resistance, water potential, and stomatal content and density) were measured under a range of water-deficit levels. Clone LT-7 had a significantly lower stomatal density than did clone ST-7. Although the clone LT-7 usually had lower chlorophyll a and b levels and thinner leaves when stressed, water deficits generally induced a significant increase in leaf chlorophyll content in this experiment. In growth-chamber studies, genotypic differences in diffusive resistance was more marked at dawn than at midday. Diffusive resistance increased with water deficit, but was strongly influenced by the ambient temperature and radiation levels.

Growth regulators

India. The use of plant-growth substances for improving the quantity and quality of potato yields was investigated in replicated trials. The seed tubers of cv. Kufri Bahar were treated for 4 hours before planting, using aqueous solutions of Cycocel, S-3307, and Triadimefon at concentrations of 50, 100, 200 ppm; 0.25, 0.50, 1.00 ppm; and 2.5, 5.0, and 10 ppm, respectively.

The results obtained are summarized below:

All CCC treatments increased yields significantly. Yields ranged from 16.2t/ha to 23.8t/ha, with the highest yield of 23.8t/ha obtained with 200 ppm of CCC. There was a significant increase in the total solids in most of the treatments, with values ranging from 18.0% to 22.5%. The highest value of 22.5% was obtained with S-3307 at 0.5 ppm. All the growth retardants increased the protein content in potato tubers. The values varied from 1.75% to 2.56%, with the highest obtained with 200 ppm of CCC, and the lowest in the control. Sugar content varied from 14.4 mg to 18.6 mg/100 gr of dry weight. A minimum sugar content of 18.6 mg was found in tubers from the 0.5 ppm S-3307 treatments. The application of 100ppm of CCC provided for an additional gross profit of Rs. 4855/ha (US$ 189.64/ha).

Seed size and spacing

Uganda. In studies of the effects of seed size and spacing, potato yields increased linearly with the increase in seed size for both crop seasons. Plant density also influenced yield significantly, with the 70cm x 30 cm and the 70 cm x 30 cm spacings yielding the highest. Two-factor interactions also were significant. Large-sized seed planted at densities of 47,619 or 71,428 plant/ha gave the highest yield. Medium-sized tubers planted at spacings of 70 cm x 30 cm or 90cm x 20cm appear to be ideal for maximizing potato yields with a large proportion of seed-sized tubers.

Intercropping

Egypt. Trials conducted at the Kafr El-Zayat CIP Station showed that potatoes could be planted as an early Fall (August) crop when intercropped with maize. Further experiments were carried out using maize and sunflower as intercrops to potato varieties Claudia and Spunta. Maize or sunflower seeds, planted six weeks before potatoes, increased plant emergence and stem number. At 90 DAP, potato yield also was significantly higher than that of control. An additional 6t/ha of maize or 2.4 t/ha of sunflower was obtained.

China. A maize intercropping experiment with 19 potato clones was conducted at 1005 m. The new clone 860803 was found suitable for intercropping.

Clonal Selection

Peru. In the summer of 1990, 1746 potato clones carrying several resistances were evaluated in different environments. Although a severe tuber-moth infestation decreased yields significantly, 225 genotypes were selected and planted again during the 1990 winter at La Molina. Part of the selected clones were evaluated for processing quality and 9 clones showed good characteristics for frying. The past 2 years of evaluation have shown wide genetic variability in the storability of potatoes. Yields ranged from 11 t/ha to 48.4 t/ha, with 57% of the clones producing yields of more than 20t/ha. Of the best clones, 50% have been distributed to farmers for on-farm testing.

Cameroon. Ten CIP clones were tested with and without mulch during the dry season. Irrigation was poor, due to a lack of proper facilities. The use of mulch had a suppressing effect on weeds and increased yields significantly. In a trial conducted during the first (rainy) season of 1990 in Babungo (1,175 m), three locally available pre-emergence herbicides (Patoran, Lasso GD, and Linuron) were tested along with hand weeding and mulching. The results showed that Lasso GD controlled the weeds reasonably well, while Patoran and Linuron proved unsatisfactory. In particular *Setaria* sp., a weed common to the region, was not effectively controlled. Mulching increased yields compared with the controls.

Sweet Potato

Drought and Salt Tolerance

The Philippines. The water-use efficiency of the sweet potato cultivars Bureau, Miracle, and VSP-5 were evaluated using the line-source sprinkler irrigation system. Dry-matter production and storage-root yields increased with increasing soil moisture, indicating the ability of the cultivars to respond to supplemental irrigation. Yields ranged from 2.8 t/ha to 48.4 t/ha (Table 6-2) with the lowest yields, average root weight, and root number obtained at moisture level of 84 mm.

In vitro screening of sweet potato for salt tolerance was continued. In vitro stem segments of a range of sweet potato cultivars and clones were exposed to higher NaCl salt concentrations (up to 102 mm) during a 4-week period. Some breeding

Table 6-2. Yield and yield components of 3 sweet potato cultivars as affected by different soil moisture regimes.

Water Added (mm)	Cultivar	Yield (t/ha)	Ave SR wt (g)	SR/ plant No.	SR size distribution Sm	Med (% by weight)-	Lrg
	Bureau	2.8	47	2	32	66	0
84	Miracle	4.6	62	3	31	69	0
	VSP-5	12.3	82	4	8	48	44
	Bureau	15.1	140	3	6	43	51
124	Miracle	18.8	86	5	9	34	57
	VSP-5	17.5	84	5	10	45	45
	Bureau	25.2	194	3	4	28	68
224	Miracle	20.1	137	4	4	33	63
	VSP-5	35.5	124	5	6	53	49
	Bureau	24.8	177	4	4	23	73
404	Miracle	20.8	166	4	6	33	63
	VSP-5	32.3	126	5	4	34	62
	Bureau	36.4	315	4	2	19	80
704	Miracle	24.4	141	5	4	49	47
	VSP-5	48.4	193	5	3	32	66
Grand Mean		22.6	138	4	9	41	51
CV (%)		28.0	37	21	37	29	24
LSD (.05)	Water Level	3.0	46	1	3	10	11
	Cultivar	3.2	20	0.3	2	n.a.	5
	Interaction	7.1	45	n.a.	5	14	12

lines selected as tolerant, based on root yields in the field, were compared in vitro. Genotypic differences were found in their ability to produce leaves and roots under in vitro salt-stress conditions, indicating the potential for screening for salt tolerance in vitro.

Photoperiod, Shade Tolerance, and Flooding

The cultivars Bureau, Miracle, and VSP-5 were evaluated under 12-, 18-, and 24-hour photoperiods. Dry-matter production and fresh storage-root yield were not significantly affected by photoperiod, indicating the extreme adaptability and insensitivity of sweet potato to photoperiod. This study is being repeated, using more diverse germplasm, to see if this insensitivity is valid for a broad range of cultivars.

Southeast Asia. In Asia, large areas of sweet potato are grown under coconut or corn. In the Philippines, experiments using controlled shading and the cultivars Bureau, Miracle, and VSP-5 indicated that dry matter .production and storage root yields were significantly reduced by shading. The cultivar Bureau showed the most sensitivity to shade. In another experiment, yields were significantly affected by time and duration of shading. Shading for 30 days resulted in higher yields than did shading for 60 days. No yields were obtained at shading for 90 days. Shading continuously for 0-60 days resulted in lower yields, as compared with shading continuously for 30-90 days or shading for 0-30 and 60-90 days. Yields were very low due to the high amount of rainfall (1152 mm) and low solar radiation (10 MJ/m^2/day) received by the crop.

Flooding effects on sweet potato

In an experiment using pots under greenhouse conditions, two clones, Jewel and YM-88-026, were exposed to four flooding durations (0, 5, 10, and 15 days) and to 12 combinations of flooding cycles (1, 4, 8, and 16 weeks after planting). Records were made of number of new and yellow leaves; plant height; fresh- and dry- foliage weight-, fresh- and dry-root weight; and number of storage and fibrous roots. Jewel produced better storage-root yields than did YM-88-026. Root-yield reductions of 25%, 52%, and 62% were observed when plants were exposed to 5, 10, and 15 days of flooding, respectively. A similar reduction was obtained when plants were exposed to this stress at different growth stages. Jewel was less affected by different durations and cycles of flooding than was YM-88-026. Plants exposed to only one cycle of flooding gave better yields than did those exposed to two or more cycles. A significant yield reduction was observed when plants were exposed to flooding durations of 10 and 15 days throughout the growth period and even more when exposed to three successive cycles. There was a tendency to produce more fibrous roots when plants were exposed to this stress, with Jewel producing more fibrous roots than did YM-88-02. Storage-root dry matter was significantly increased by flooding for 10 and 15 days and this increase was greater when plants were exposed to 2 and 3 cycles. Dry-matter content also increased by using combinations of 10 and 15 days flooding duration and 12 cycles for both clones.

In a bed experiment, three clones (Canchari, Jewel, and YM-88-026) were exposed to flooding for 10 days at 8 weeks after planting. The plots were innundated by rain, and then irrigated. The control furrows were drained for fast removal of excess water. Jewel and clone YM-88-026 produced similar foliage yields (23.4t/ha and 24.7t/ha, respectively) although both clones should a 10% reduction in foliage yield after the plants were exposed to flooding for 10 days. Foliage dry matter was higher in YM-88-026 than in Jewel (18.9% vs 16.7%), indicating that YM-88-026 was more efficient in carbohydrate accumulation under flooded conditions. Flooding reduced root yield by approximately 40% as compared with the control; Jewel produced a better yield than did YM-88-026 (42.9t/ha vs 33.0t/ha.) Storage-root production was reduced by approximately 30% for Jewel and 20% for YM-88-026, indicating that YM-88-026 has a greater tolerance to flooding. Flooding reduced root dry-matter content by approximately 4 t/ha for Jewel and 2 t/ha for YN-88-026.

Fertilization and Field Management

Egypt. In a study of plant spacing, two plant spacings (25 cm and 40 cm) were used for clone NCSU 925. Planting at the closer spacing (25 cm) resulted in increased total yield.

The effect of 3 rates (50 kg, 100 kg, and 150 kg n/ha) of nitrogen application (ammonium sulphate, 20.5%) was investigated using the clone NCSU925. Application of 100 kg/ha increased yield over the 50 kg rate, but no further increase was obtained at the 150kg rate. In another experiment, K_2O (potassium sulphate, 50%) was used at rates of 187.5 kg/ha and 375 kg/ha, with a slight yield increase obtained at the higher rate.

India. A field experiment investigated the effects on various plants morphology and root traits of fertilizers (F_o= no fertilizer, F_1= 80:50:80 kg/ha, and F_2= 40:25:40 N_1:P_2O_5:K_2O_2 kg/ha); spacing

(S_1= 60 x 10cm and S_2= 60 x 20cm) and method of planting (M_1= vertical planting of vines on ridge and M_2= horizontal planting of vines on ridge). The variety Sri Vardhini was studied to identify suitable planting methods and fertilizer requirements of sweet potato for the western Indo-Gangetic plains. Planting was done every month and harvesting was carried out at 90 and 120 DAP, at which time observations on plant growth and root characters were recorded. At 90 DAP, fertilizer type did not influence growth and yield parameters, except for total root yield/plant and root girth. The highest root yield/plant was obtained with the 40:25:40 treatment. Marketable root yield and root girth were greater at 60cm x 20cm spacing than at 60cm x 10cm. However, spacing did not affect other characters. Horizontal planting of vines improved total and marketable yield and root girth as compared with the vertical planting method.

At 120 DAP, fertilizers differenced in their effects on height, number of branches/plant, and root number/plant. At 120 DAP, vertically-planted vines produced greater marketable yields, but horizontally-planted vines had greater plant height, number of branches, fresh top weight/plant, number of roots and root length.

Fertilizer applications and storability

Egypt. Experiments were conducted to study the effect of fertilizer on storability. Sweet potato roots of NCSU 925 showed lowest weight losses and decay at the lowest nitrogen rate (50kg n/ha). Application of 187.5kg K_2O/ha produced the lowest weight losses and decay, as compared with the losses in the unfertilized lots and in those receiving the higher K_2O rates. Also, the 187.5kg K_20 treatment was associated with higher sugar content at the end of the storage period, as compared with the sugar content of the unfertilized lots.

Clonal Selection

The Philippines. A total of 12 cultivars were evaluated at Tanauan and Tarlac to determine the varietal preferences of commercial farmers and their criteria for selecting cultivars. In their evaluations, male participants used quantitative characters (yield, storage root number, and size), whereas female participants used qualitative characters (root color, texture, dry matter content). These differences in preference may indicate the close association of men with production activities, whereas women are closely associated with marketing of the sweet potato. Marketability of cultivars is also an important selection criterion for sweet potato commercial production systems.

Egypt. Clone 925 NCSU was evaluated and compared with the local variety Mabrouka. Both were planted on May 1, 1989 in a randomized-block design with 3 replications using 18.75m^2 plots. Clone 925 NCSU yielded 23.2t/ha, while Mabrouka yielded 12.3t/ha.

Peru. At Tacna, 300 early-maturing clones showing potential for adaptation to tropical conditions were tested during the summer to evaluate their tolerance to salinity and adaptation to long photoperiods. Additionally, 187 clones were planted at Tacna during the winter of 1990 and 34 were selected for further evaluation. Another set of 197 clones of the same lot was evaluated and the 10 best clones were selected (Table 6-3). At San Ramon, 814 clones were planted.

During the summers of 1989 and 1990, 197 clones were evaluated in Lima, Peru. Several clones showed an unstable performance, as compared with evaluations in

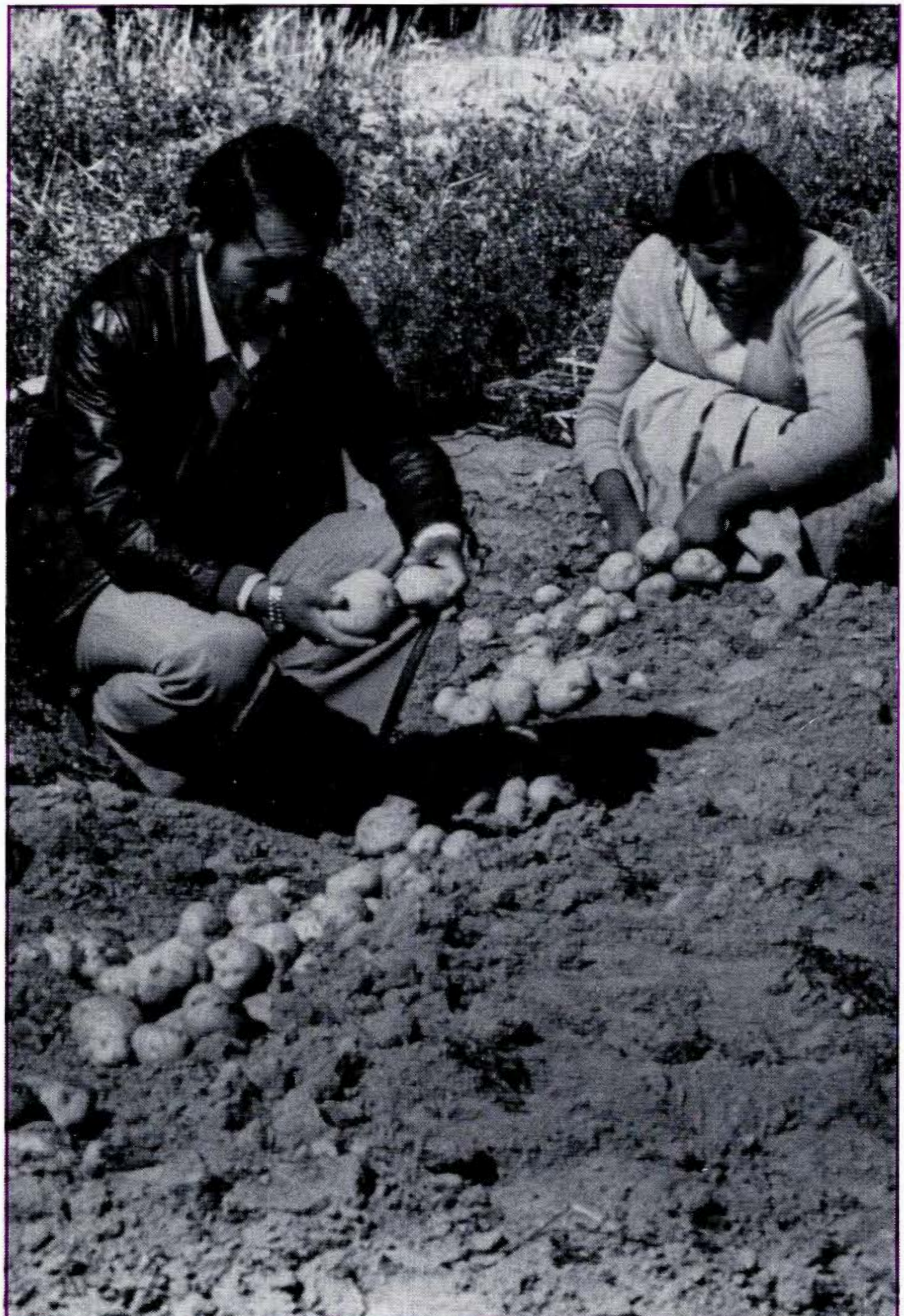
Table 6-3. Top performing clones from a sample of 187 planted in Tacna, winter 1990.

Pedigree	Yield/plant (g)	Vigor 60 days	Burning
1. E86.911	967	9	1
2. LM86.42	900	7	3
3. LM86.192	850	7	3
4. (I-1035 x C83.119).11	840	7	1
5. 377835.13	830	9	5
6. LM86.76	830	7	3
7. LM86.131	790	7	3
8. E86.735	760	9	5
9. LM86.661	760	5	1
10. LM86.63	750	5	1

Leaf burning: 1 = no damage 9 = dead

previous seasons. However, clones ST87.009, LM87.045, and ST87.070 showed stable yields and promising potential as new varieties. These clones also will be utilized as progenitors in future polycrosses. Good performance for yield and earliness was also shown by another group of sweet potato clones selected in Lima (hybrid group LM89). The clone LM89.125 was particularly stable in yield performance. However, its dry matter varied in Lima and San Ramon. In Lima, 230 first-generation clones selected from 45 early maturing salt-tolerant families were evaluated in the field. High yields were obtained, indicating progress in selection utilizing polycrosses of selected clones. A sample of 20 of the clones selected were field-evaluated in Lima and a smaller number was then re-evaluated at La Molina. At San Ramon, 169 clones previously selected for tolerance to heat and high humidity were field-evaluated. These materials possess good agronomic traits and high yield potential that can be used to generate new populations. Another group of clones obtained from OP populations from the American clone Jewel showed acceptable yield and earliness. Re-evaluation of advanced clones confirmed their stable performance and their potential as progenitors. Twenty-six clones, previously selected at Tacna for tolerance to salinity and drought, showed good adaptability to tropical conditions when evaluated at San Ramon.

A group of selected second-generation clones, evaluated in Tacna, showed good yields but were variable in plant survival. A set of 58 clones from CIP's germplasm collection (31 from the series DLP, 19 from RCB, and 8 from ARB), was evaluated to measure adaptability to saline soils. Seven clones gave medium yield, but their relatively low rates of plant survival showed that these materials are not well adapted to salinity. To evaluate clones under conditions of low soil fertility, selected clones were planted in soil with an average electrical conductivity of 9.6 mmhos. The resultant yields were acceptable suggesting that these clones have potential for production on poor soils and that their performance could improve when planted under better conditions. Similarly, clones previously selected for tolerance to salinity showed good yield performance when re-evaluated. Based on the above results, 16 highly adapted clones were selected and submitted for pathogen cleanup, before distribution to CIP regions and national programs.



Thrust VII research develops advanced breeding materials with tolerances to major abiotic and biotic stresses that limit potato and sweet potato production in cool environments.

Thrust VII

Cool-climate potato and sweet potato production

Thrust profile: 1991

THRUST VII RESEARCH focuses on 1) the development of advanced breeding materials with tolerances to the major abiotic and biotic stresses that limit potato and sweet potato production in cool environments, and 2) physiologic and agronomic principles and practices needed for sustainable production.

In Peru, germplasm being developed for frost tolerance in combination with other major biotic stresses has been moved from CIP's Huancayo Station to a new site in the northern highlands (Cajamarca). Only agronomic selection has been performed at this location, and 537 clones were selected from approximately 2000 clones in different stages of improvement. At La Molina, approximately 16% of 38,876 seedlings survived a frost-shock treatment of -4° C, and from this group 387 clones were selected for further testing. In addition, 550 crosses were made to improve the earliness of the frost-resistant population and to combine other sources of resistances.

Recent reports by the Peruvian potato program on the use of improved frost-tolerant materials developed at CIP listed 7 clones with outstanding performance: 381128.5, 381128.151, 375070.53, 375553.22, 375558.5, VH-22, and UFP-49.1. These materials also showed frost tolerance at several locations around the country and are being considered as potential variety releases.

In Bolivia, a number of CIP-derived clones are being selected and tested for locally important characters in addition to agronomic performance.

A contract research project with the Potato Program of INIA, Chile is exploring the adaptation of potato to suboptimal temperatures. In tests of a wide range of materials, long exposure to unfavorable cool conditions reduced plant growth and development, as well as tuber production. CIP clones DTO-28 and DTO-33, which are early to mature, showed promising performance. At the two locations studied (Frutillar and Osorno), planting 43 days before the spring set proves satisfactory for screening large populations of segregating germplasm for adaptation to unfavorable cooler-than-optimum temperatures.

In comparisons of station versus farmer technology, collaborative projects with the Potato Program of INIA, Chile have confirmed that production technology developed by the station is more effective under both rainfed and irrigated conditions. This technology is designed to narrow the yield gap identified in the comparisons and to improve the productivity level of the farmer.

In Indonesia, in a screening of a previously introduced lot with late blight resistance, 23 clones were selected for their adaptation, low late blight infection rates, and acceptable yields. Of 154 new introductions, 43 promising clones were retained for further testing and selection. Agronomic trials indicated that tuber yields increase progressively when nitrogen rates were increased from 150 kg/ha to 375 kg/ha.

Potato production from seedling tubers in Cameroon outyielded check varieties and showed some late blight resistance. Outstanding pedigrees included CIP 985001 (Atzimba x 104.12 LB), CIP 980003 (Atzimba x 7XY.1), and CIP 987004 (CFK-69.1 x 104.12 LB).

In a study of sweet potato production in cool environments, sample germplasm entries were tested and selected for comparison in three cool environments: Vitarte and Ica (winter on the coast) and Cajamarca (highlands). The clones showed acceptable yields at the three locations; however, further improvement is needed for better adaptation, earliness, and agronomic characters. The most promising materials are now being crossed.

Potato In Cool Environments

Potato improvement for cool environments concentrated on breeding for stress-limiting factors such as frost tolerance, adaptation to growing conditions under suboptimal temperatures, drought, major disease and pest resistances, and for the development of physiologic and agronomic principles and practices to help improve and maintain sustainable production in a wide range of environments.

Breeding for Stress tolerance

Peru. At La Molina 38,876 seedlings were screened for frost tolerance at -4° C for two hours in a growth chamber. A total of 6,247 seedlings (16%), survived the test and were transplanted to the field. At harvest, 387 clones from single-hill plants were selected based on their tuber characters. These clones will be further tested for frost tolerance and agronomic characters.

To obtain new advanced generations for further improvement and distribution to requesting countries, emphasis was placed on intercrosses of the most advanced clones (300) and on crosses to other sources of resistances, such as potato cyst nematode and late blight (250), in each sub-population under improvement for the Andean and non-Andean cool environments. In changes of experiment sites, botanical seeds are useful for more efficient management.

Clonal samples (10 tubers) of most materials in different stages of selection were taken to Cajamarca, (2,700 m) for further testing and selection. This new location has been temporarily established by CIP station to complement the highland station at Huancayo. Expected difficulties with a new experimental site, currently equipped with minimum facilities, affected the regular management and selection of new material, but not the overall results. Of the approximately 2,000 clones planted, 537 were selected on the basis of their agronomic performance. A sample of advanced clones tested in replicated trials at this location yielded up to 2.0 kg/plant, with a population density of 33,333 plants/ha (Table 7-1).

A collaborative project with the national potato program at the experiment station in Puno, (southern plateau of Peru) field-tested 857 new clones and 110 others previously selected for frost tolerance. All tests were lost due to severe drought and concurrent killing frosts during the growing season, when temperatures dropped to -10° C, causing large, general crop losses in most parts of southern Peru.

The Peruvian potato program, which has received most of CIP's advanced clones with tolerance to frost, reported that 962 clones were tested for frost tolerance and agronomically important traits in 12 experiments conducted at 8 experiment stations throughout the country, at an average altitude of 3,580 m. Approximately 90% of these clones originated at CIP and approximately 80% were first tested in Puno. The experiment station at Illpa in Puno (3,850 m) was chosen as the primary screening site for frost tolerance because this location reports annual severe frost damage to potatoes.

Table 7-1. Yield performance of the best 18 late blight-resistant clones tested in a simple lattice 10 x 10 in Cajamarca, 1990.

Clone No.	Yield kg/plant
85LB54.24	2.0
85LB54.9	1.4
85LB65.8	1.4
85LB4.11	1.4
85LB55.6	1.3
85LB15.19	1.3
85LB54.17	1.3
85LB53.12	1.3
85LB53.9	1.2
85LB65.7	1.2
86LB4.1	1.2
85LB51.4	1.2
Perricholi (check)	1.2
85LB75.3	1.2
85LB54.55	1.1
85LB51.15	1.1
Yungay (check)	1.1
85LB27.8	1.1
85LB4.38	1.1
85LB53.4	1.1
T. Condemayta (check)	0.8
Mariva (check)	0.7
C.V. %	27.7 %
LSD (0.05)	0.480
Plant density	33,333 plants/ha

At Illpa, which experienced 3 severe frosts and a 3-week drought, 135 clones were selected for their tolerance to frost, resistance to black wart, high yields, and good commercial appearance. These clones are being multiplied for further trials at other locations around the country. The potato program identified 7 outstanding clones from this lot (381128.5, 381128.151, 375070.53, 375553.22, 375558.5, VH-22, and UFP-49.1), with tuber yields exceeding 2.0 kg per plant. These clones markedly outyielded local frost-tolerant cultivars. The clones are considered promising for future variety releases.

Bolivia. The PROINPA/IBTA project is selecting and testing frost-tolerant advanced materials from CIP's frost project, in the form of advanced clones, tuber families, and botanical seed. Of approximately 600 native clones from the local germplasm bank, which were tested at the highland station at Toralapa, 60 clones were selected for tolerance to frost and 154 clones showed some resistance to *Nacobbus* and to cyst nematode. The development and improvement of a parallel native breeding population is under way to provide resistance to these three major problems.

Suboptimal temperatures

Chile. Contract research has been initiated with the potato program of INIA to explore the feasibility of selecting clones better adaptated to growing conditions in non-traditional, non-optimal environments (particularly regions at intermediate latitudes with mild cool winter or cool late winter to early spring seasons) and to the increasing demand for better adapted varieties. A sample of 16 clones, including local varieties of diverse origin, were planted at two locations in southern Chile (Osorno), during the late winter and early spring season. This trial was designed to identify the most representative location and appropriate planting date for use in screening germplasm, in addition to evaluating the performance of materials. The tests were made at Remehue and Frutillar, and the planting dates were 43 and 23 days before the spring season. Tuber yields in both locations ranged from 30 g/plant to 300 g/plant for the earlier date (43 days) and from 300 g/plant to 1000 g/plant for the later date (23 days). Neither of these planting dates is optimal. Early sprouting clones DTO-28 and DTO-33 performed best at the earlier (43 days) planting date, and varieties Norland, Urgenta, and Mirka performed better than the rest at the later (23 days) date. (Figs. 7-1 and 7-2).

These findings indicate substantial reduction in plant growth and development when materials were exposed to long and suboptimal cool temperatures following the earlier planting date. Tuber yields were greater for the later plantings, when environmental growing conditions began to improve. Delayed harvesting, from 90 to 120 days for both planting dates, also resulted in improved yields. These findings also suggest that early sprouting may be a critical character in adaptation to suboptimal temperatures.

The two locations used to screen for suboptimal temperatures did not differ significantly in results. The earlier planting date (43 days) seems most appropriate for screening large amounts of segregating materials for adaptation to growth under suboptimal temperatures; however, more information is needed about the response of other characters.

Additional segregating material, including botanical seed introduced from

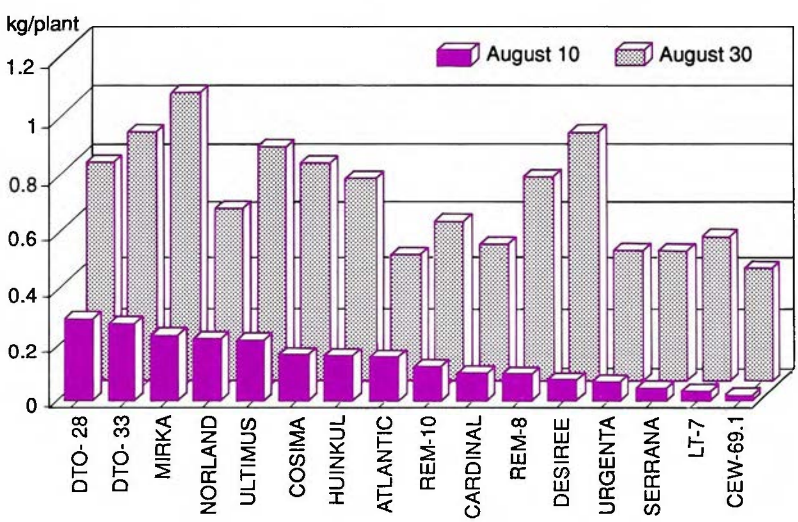


Figure 7-1. Yield response of 16 potato genotypes planted on two dates under suboptimal temperatures at Frutillar (Osorno), and harvested 90 DAP.

CIP, was transplanted to the field and harvested at the Remehue Experiment Station during the regular season. Sets of unselected tuber families were chosen at harvest for testing and selection under the conditions described above. Similarly, a new experimental site near Santiago was established for planting potatoes during the mild winter, under slightly different suboptimal conditions and short days.

Agronomic and Physiologic Research

Chile. A collaborative project with the potato program of INIA to study the factors affecting productivity confirmed previous preliminary findings. Simple production technologies applied by the experiment station to increase potato productivity were more effective than farmers' technology under both irrigated and rainfed conditions

Potato production experiments examine both the farmers' and the experiment station's technologies.

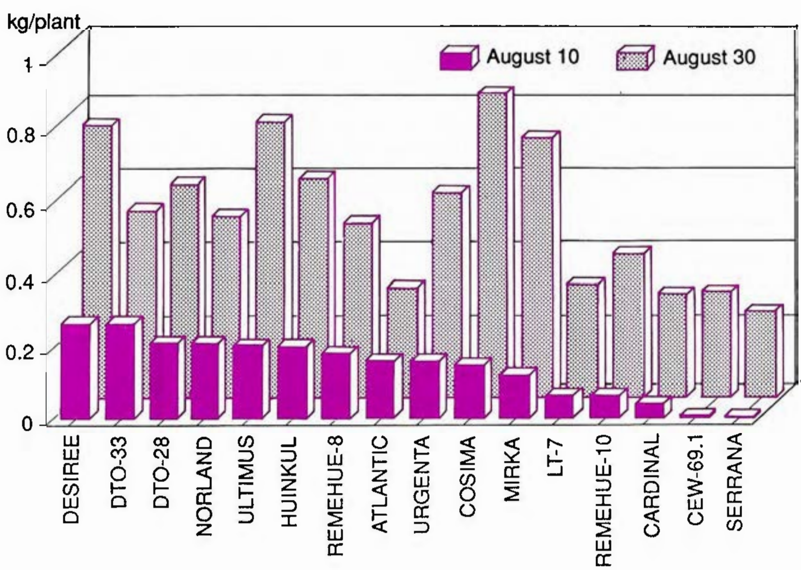


Figure 7-2. Yield response of 16 potato genotypes planted on two dates under suboptimal temperatures at Remehue (Osorno) and harvested 90 DAP.

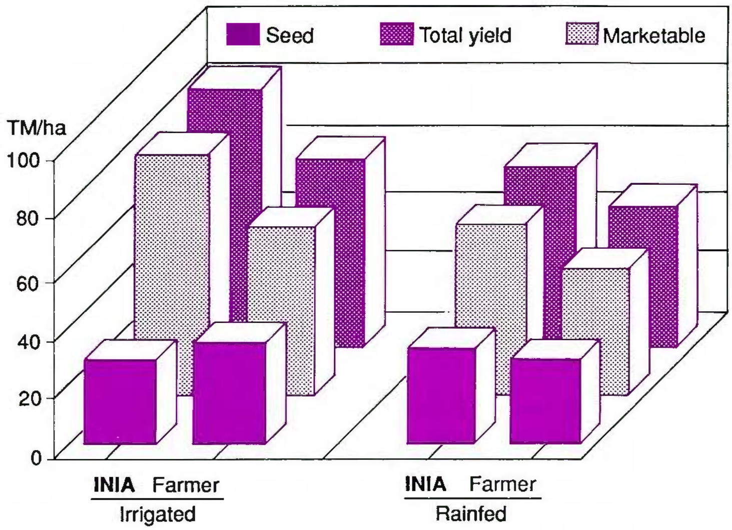


Figure 7-3. Yield performance of variety Desirée with technology as used by the farmer and by INIA station under irrigation and rainfall.

(Figs. 7-3 and 7-4). The results also showed that the yield gap between the two technologies can be easily reduced under both conditions when practical measures are recommended and channeled to farmers.

Indonesia. Following retesting of 68 previously selected clones for resistance to late blight in replicated trials during the wet season, 23 clones were selected. These selected clones were found to have

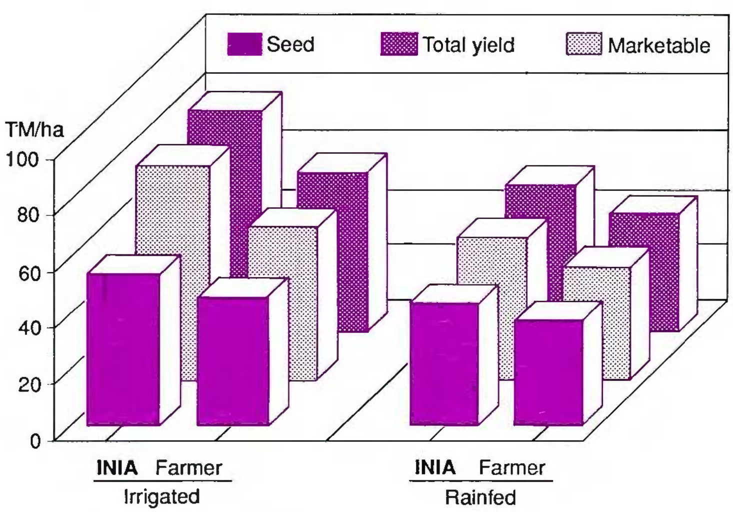


Figure 7-4. Yield performance of variety Pimpernell with technology as used by the farmer and by INIA Station under irrigation and rainfall.

low rates of late blight infection and acceptable yields. Six other varieties with potential for processing (Atlantic, Katahdin, Kennebec, Norchip, Norland, and Monserrate) and controls (Desiree, Granola, and Katella) were highly susceptible and had poor yields.

Of 154 clones retained from previous CIP introductions, 44 were selected for resistance to late blight and good preliminary yields.

Results from an agronomic trial to determine optimal nitrogen (N) level at time of application in rice paddy soils (70% silt plus clay), showed a progressive increase in tuber yield (from 415 g to 532 g per plant) with increasing N (urea) from 150 kg/ha to 375 kg/ha). Yield was not influenced by split dressing at planting and at hilling.

Cameroon. Seedling tubers stored for approximately 8 months in diffused light stores were tested this year in two locations with altitudes of 1,350 m and 2,000 m. Both places are usually affected by late blight during the season, although infection was late this year. Several pedigrees outyielded check varieties (Escort and Desiree) and showed some late blight resistance. These included CIP 980003 (Atzimba x 7xy.1), 985001 (Atzimba x 104.12 LB), and 987004 (CFK-69.1 x 104.12 LB) (Table 7-2).

Table 7-2. Yield, late blight and other agronomic traits obtained from seedling-tubers evaluated at Upper Farm (2,000 m) Bamenda, Cameroon - Third tuber generation trial.

Progeny	Late Blight Scores			Total No	No. of	Yield
CIP No.	70 Days	77 Days	85 Days	of Plants	Tuber	(g/plt)
978004	1	2	3	29	14.1	552
987003	2	2	3	28	10.9	582
983011	1	2	3	14	20.2	429
987004	2	2	4	29	16.9	597
984001	1	1	2	17	15.9	400
781002	1	2	3	28	19.6	564
987002	3	6	7	9	14.4	300
980003	2	2	5	6	27.3	717
986004	2	3	3	30	17.4	567
985001	1	2	4	30	14.8	603
985009	2	3	5	19	7.5	321
Escort	2	4	8	28	8.0	326
Desiree	1	2	5	26	7.9	307

* CIP's scale
Days after planting

Sweet Potato

Evaluation in cool environments

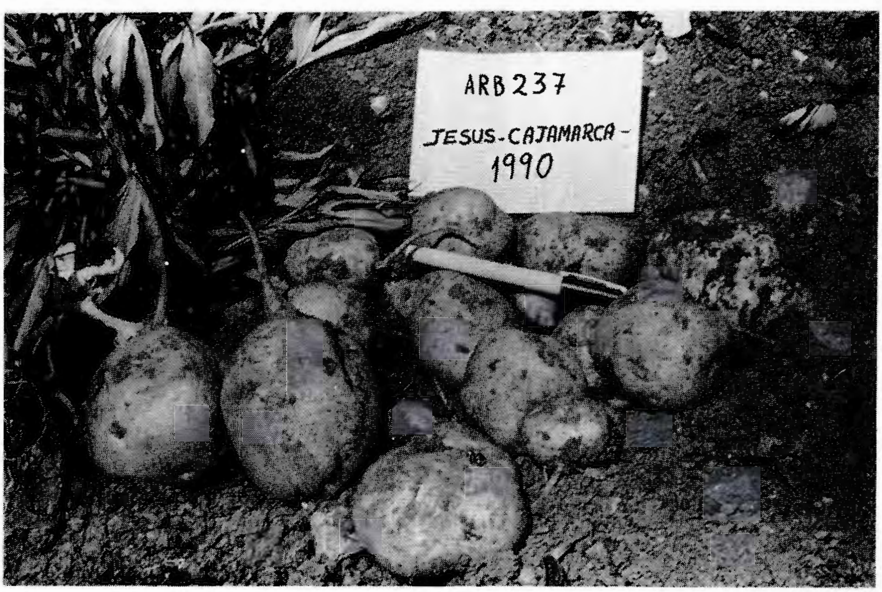
Sweet potatoes are gradually expanding to non-traditional areas, such as the cool lowlands and highlands of developing countries, because of their greater genetic plasticity in adapting to diverse environments and their potential for producing food and feed.

Among countries harvesting more than 50,000 ha of sweet potatoes, including large areas of cool highlands, are Papua New Guinea, Rwanda, Burundi, Madagascar, Indonesia, and Uganda. These countries report sweet potato production at altitudes of 2,500 m. In South America, sweet potatoes are grown on a smaller scale in the cool climate regions of Peru, Ecuador, Colombia, and Mexico. In Peru, approximately 17% of the total production area for sweet potatoes is found in the highlands at altitudes of up to 2,700 m.

Peru offers a rich source of germplasm that could be used to develop novel improved varieties adapted to cool climates in Southeast Asia and East Africa.

Peru. At CIP headquarters, replicated trials of clones selected during the winter in Lima (97 out of 397 clones), are being grown at two locations in Peru, Cajamarca (2,700 m) and Lima.

At Cajamarca 326 new sweet potato clones from the germplasm bank were planted in 10-hill plots in the field for preliminary screening and selection for adaptation to cool highland environments. At harvest, 66 clones were selected for further evaluation in larger plots.



At Cajamarca 326 new sweet potato clones from the germplasm bank were planted in 10-hill plots in the field for preliminary screening and selection for adaptation to cool highland environments.

In comparisons of a sample of clones that performed well during the cool winter last year in Vitarte, Lima and Ica, (along the lowland coast of Peru), and in the highlands of Cajamarca, some of these clones (Table 7-3) were shown to be insufficiently adapted to become potential varieties, despite their high yield potential. All clones were slow to maturity (approximately 7 months from planting to harvest) with poor root appearance.

To make sweet potato an attractive crop for this type of environment and to offer a good alternative to the farmer, improved adaptation is needed for cooler conditions, earliness, and the other valuable agronomic characters that farmers need.

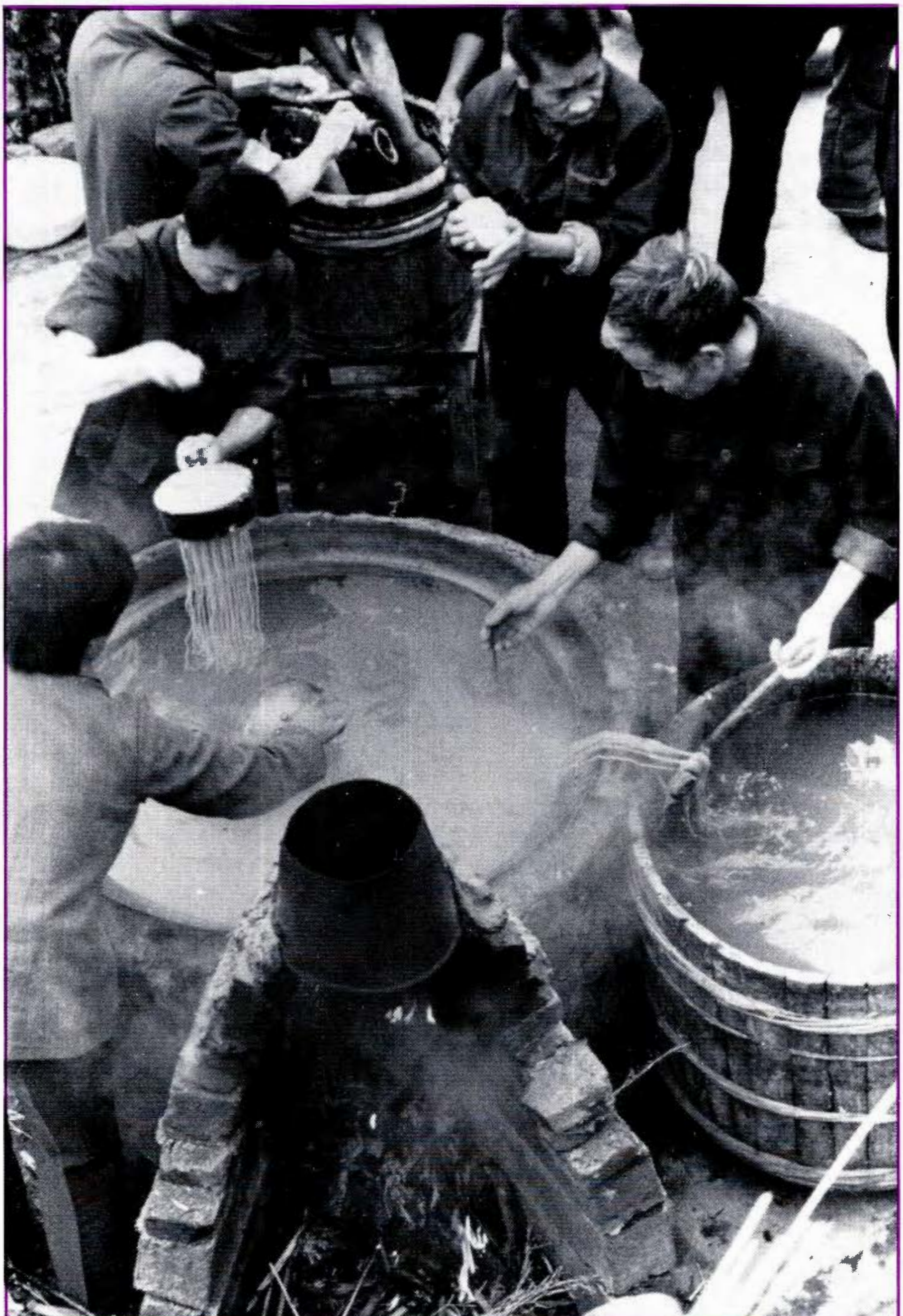
Some promising selected clones, identified in the germplasm, will be used as parentals in breeding to develop new generations for selecting materials better adapted to cool temperatures and with improved agronomic characters.

Table 7-3. Performance of the 15 most promising clones of sweet potato in cool environments. Winter season in Vitarte and Ica and in Cajamarca at 2,700 masl altitude (1989-90).

	Ica		Vitarte		Cajamarca
Clone	Yield[a] kg/plant	Ratio[b] L/S	Yield kg/plant	Ratio L/S	Yield kg/plant
DLP 895	1.50	90/10	1.65	90/10	0.94
ARB 351	0.95	90/10	1.30	80/20	0.52
RCB265IN	0.81	90/10	1.27	90/10	0.50
RCB85IN	0.85	90/10	1.17	80/20	0.48
UNT 9	0.91	90/10	1.42	90/10	0.46
DLP 321	1.10	100/0	1.30	90/10	0.45
RCB83IN	0.88	80/20	1.15	90/10	0.43
ARB 428	0.88	100/20	0.95	95/5	0.42
UNT 12	0.67	70/30	1.96	90/10	0.40
DLP 2176	0.71	80/20	1.04	95/5	0.38
DLP 32	0.98	90/10	0.54	95/5	0.38
ARB 2365	1.15	95/5	1.46	90/10	0.37
DLP 2314	-.-	-	1.45	90/10	0.37
DLP 2695	1.20	90/10	1.39	90/10	0.36
ARB 506	1.30	90/10	1.11	90/10	0.35

[a] Yields are preliminary and from 10-hill observation plots.

[b] Ratio of large to small roots.



Traditional method of noodle making from sweet potato starch in Sichuan Province, China.

Thrust VIII

Postharvest Technology

Thrust Profile: 1991

OPPORTUNITIES and problems in the postharvest phase of potato and sweet potato production and use continue to take on increasing importance in developing countries. Each crop, however, has its peculiar requirements. Continued growth in potato production and area planted has generated mounting interest in table potato and seed tuber storage as well as the potential for rustic and industrial processing. For sweet potatoes, the recent decline in several countries of area planted has prompted initiatives to develop alternative markets. In Thrust VIII, interdisciplinary research, training, and the dissemination of information aim to develop and diffuse postharvest technologies as well as strengthen national capacity in these areas. In 1990, these activities consisted of some 12 research projects, an equal number of contracts with developed and developing country institutions, 9 theses, and a series of training workshops and seminars held in collaboration with national program networks in over 20 countries in Latin America, Africa, and Asia. As long-standing projects related to potatoes are completed, increasing attention is being devoted to sweet potatoes.

During the last three decades, potato production has grown particularly fast in the subtropical lowlands of the Indo-Gangetic plain, the irrigated deserts of the Mediterranean region, and the highlands of East Africa. For that reason, highest priority has been given to improved storage technology for consumer potatoes under warm, dry and warm, and humid conditions. Experiments on the effect of evaporative cooling on inhibitors was conducted in the Philippines. Chemical control of sprouting was analyzed at Silsoe College in the United Kingdom. Research on seed potato storage was also carried out in Egypt, Cameroon, and Uganda. Low-cost methods to control storage losses due to potato tuber moth were evaluated in Thailand. Social scientists conducted a survey of traditional storage practices in India to determine how tubers were kept, and for how long, and to estimate storage losses. A storage workshop for Asian researchers was held in Thailand in collaboration with SAPPRAD. The apparent availability of improved storage technology for the lowland tropics raises questions about the diffusion of these results, the impact from their application, and the constraints yet to be overcome to ensure wider use.

Potato processing research in Peru continues to emphasize clonal evaluation of new cultivars for the fast food and snack industry. Methods developed at CIP-Lima are now being used in clonal evaluation of material in the Philippines and Thailand. Thesis research focused on clonal evaluation (Peru) as well as on simple processing (Kenya and Zaïre). Socioeconomic research on potato processing involved backstopping work done through the regional networks PRECODEPA and PRACIPA on the market potential for simple and industrial products in Colombia, Costa Rica, Guatemala, and Honduras. It also included collaboration in the preparation of case studies synthesizing the years of experience with rustic processing in India and Peru. These studies offer insights into the important lessons learned, for example, the need to carefully evaluate the economic feasibility of such techniques at the outset as well as to consider possible alternatives (e.g. storage).

Sweet potato postharvest research has placed considerable emphasis on collaboration in baseline surveys that include analysis of current processing and utilization patterns as well as constraints to further expansion. Much of this research is of a diagnostic nature because of the acute shortage of empirical information on these topics. The need for this type of study is further reinforced by the results of the CIP constraints survey, which found postharvest problems to be far more important than production problems (see also Thrust X). The farmer-back-to-farmer approach, which has been so successful in potato research, was adopted to elicit the opinions of growers, traders, and consumers for helping to set priorities for postharvest research on sweet potatoes. Surveys were begun in 1987 in Peru and China; in 1988 in Argentina, Uruguay, and Kenya; in 1989 in Vietnam, Paraguay, and the Philippines. Results published to date (see also Thrust X) and more recent work still in progress in Indonesia, India, and Thailand point to the need to reinforce the tendency in many of these countries to employ a growing percentage of sweet potato production as animal feed and, to a lesser extent, as processed products for human consumption in an effort to expand utilization of the crop.

Product-specific processing research during 1990 emphasized village-level techniques and products for human consumption. This work included research on sweet potato noodles (China); flavored, dehydrated chips, ketchup, and a hot-cake mix (the Philippines); solar-dried chips, strips, and flour (India); and starch extraction from different sweet potato varieties (Thailand). Promising sweet potato clones were evaluated for their processing characteristics (Peru). An MSc. thesis focused on a chemical and nutritional analysis of sweet potato clones for use in breadmaking (Peru). Simultaneously, a rapid appraisal of the socioeconomics of sweet potato bread made from raw, grated roots was conducted in Lima, Peru.

A by-product of the processing research in China was documentation of the tremendous growth in sweet potato utilization during the last three decades. Over 50% of production — some 60 million tons a year — is now processed with the bulk going to animal feed. These findings suggest that ample opportunity exists for expanded domestic processing. A sweet potato beverage is being commercially bottled in the Philippines. Two clones with a dry-matter content of over 30% are ready for regional distribution from CIP-Lima. Promising results from the nutritional and socioeconomic analysis of sweet potato bread call for more detailed research on the economics of this product. Plans are already under way for two student theses on this topic next year, as well as a closer assessment of the potential for animal feed from sweet potatoes in a number of developing countries.

Training activities in Thrust VIII during 1990 included workshops, seminars, and theses studies, as well as the development of national program capacity through collaborative research projects and support to the PRACIPA, PRECODEPA, PRAPAC, and

UPWARD networks. A manual on improved production, marketing, and utilization of processed roots and tubers is being prepared in collaboration with scientists at CIAT and IITA. Training national program scientists for sweet potato postharvest research will receive increasing attention in the years ahead.

Potatoes

Consumer Potato Storage

Potato production is highly seasonal in developing countries, particularly in the lowland subtropics where relatively short, cool winters allow a crop to be grown only during this time of year. Consequently, harvesting and marketing of fresh tubers is concentrated in a brief period of two to three months. The resulting pressure on the transportation system, available labor supply, and marketplace infrastructure is intense, often causing a glut of potatoes, followed by a shortage several months later. As potato production has increased in these ecoregions, farmers in many developing countries have sought alternatives to harvest-time sales at very low prices or relatively expensive, refrigerated cold storage. CIP's potato storage research and training has focused on means to alleviate the problems associated with keeping seed and consumer potatoes for up to 2-3 months under both warm and dry and warm and humid conditions. Promising results from Peru, the Philippines, Thailand, India, Kenya, Egypt, Cameroon, and Uganda all point to the need for adoption studies.

Peru. Studies on the management of low-cost stores for table potatoes to reduce postharvest losses were carried out at CIP's experiment station in San Ramon. The effect of evaporative cooling on storage losses was studied in stores equipped with charcoal-filled walls that could be soaked with water. Application of evaporative cooling increased the average relative humidity from about 70% to 83%. Mean maximum and minimum air temperatures in the store were reduced by 4° C and 3.5° C, respectively, by means of evaporative cooling system. The most important effect of evaporative cooling was to reduce the incidence of potato tuber moth (PTM) damage. As a result, tuber weight losses at 60, 120, and 180 days after storage were significantly reduced by evaporative cooling. The findings also showed that dipping of tubers in a sodium hypochlorite solution and dusting tubers with thiabendazole to control storage diseases caused by *Erwinia* and *Eusarium spp.* was not effective and, in some cases, increased storage losses due to rotting. These tuber disinfection treatments, therefore, should not be recommended for use in this type of low-cost storage system. Highly successful disease control was achieved by holding tubers for 2 weeks prior to storage and removing those that developed disease symptoms.

The single most important constraint to prolonged storage in low-cost systems is early sprouting. The sprout suppressant CIPC proved ineffective in the trials, due to rapid vaporization of the active ingredient, preventing its prolonged action. As a result, the storage period was limited to a maximum of 3 months.

United Kingdom. At Silsoe College in England, various chemical methods to control sprouting were compared at 17° C, 20° C, and 25° C. Results confirmed that the sprout-inhibiting effect of CIPC rapidly

Low-cost storage for consumer potato in India.

decreased at higher storage temperatures. Application of maleic hydrazide as a foliar spray three weeks prior to harvesting, showed some sprout-inhibiting effect, but it was less effective than CIPC.

The Philippines. Studies on sprout control also were carried out at the University of the Philippines-Los Baños (UPLB) with co-sponsorship from CIP. At UPLB, plants of the *Labiatae* family were screened for identification of natural sprout inhibitors. Experiments conducted in 1990 used oil extracts from solasi (*Ocimum sanetum*) and patchouli (*Pogostemon cablin*) at various concentrations (0.5%, 1.0%, 20%) and involved a storage period of one month. Patchouli seems to be more effective in controlling the sprouting of the top eye, although neither extract was able to control growth of the lateral buds.

Thailand. Ten different low-cost storage systems, including some used by farmers, were tested at the Fang Experimental Station in cooperation with the Horticultural Research Institute of the Department of Agriculture. The use of a nylon net to protect tubers from potato tuber moth (PTM) was studied as an alternative to the farmer's method of using toxic insecticides. Results showed that the use of a nylon net effectively protected tubers from PTM (Table 8-1). Weight losses in stores where tubers were covered by a net were similar to those observed with the farmers' method, where tubers were treated with insecticide. Tuber weight losses after 2 months' storage ranged from 5.9% to 10.6% in storage systems where tubers were protected from PTM, compared with 21.1% to 31.0% in stores without PTM control. During the storage period, prices for consumer potatoes increased from 6 to 8 baht per kg (1 US$=25 baht), and this increase was sufficient to make storage profitable.

Table 8-1. Thailand: Storage losses of consumer potatoes in different types of naturally ventilated stores during a storage period of 2 months at Fang (cultivar Spunta).

Store type	Amount of tubers stored (tons)	Tuber weight loss (%)	Tubers damaged by PTM (% by weight)
Uncovered heap in farm building (CONTROL 1)	0.5	31.0	55.7
Heap covered with straw in farm building (CONTROL 2)	0.5	21.1	30.8
Heap covered with straw + insecticide (farmer's method)	1.0	9.4	0.8
Heap covered with nylon net + straw	1.1	8.5	9.0
Shaded box with raised floor + nylon net + rice husk	1.2	9.5	1.6
Shaded box with ventilation ducts + nylon net + rice husk	1.2	10.6	1.3
Round store, double walls filled with rice husk, placed on raised, shaded platform. Nylon net + rice husk	0.5	9.2	0
Round store, single wall - same as 7	0.5	8.1	0
Mud building with thatched roof, raised floor + nylon net + rice husk (small store)	1.1	8.3	0
Mud building with thatched roof, raised floor + nylon net + rice husk (large store; walk-in design)	3.0	5.9	0
LSD 0.05		3.2	5.3

India. A range of store designs has been developed and continues to be tested at experimental stations, in cooperation with the Indian Council for Agricultural Research. In West Bengal, 20 stores were built with farmers' participation based on the needs expressed by the farmers. These stores were designed to be suitable for both seed and consumer potatoes.

A collaborative survey of traditional storage practices found that potatoes are frequently kept for 1 to 2 months at the farm or household level. Tubers are stored in covered heaps, baskets, earthen pots, on a raised floor, or under the bed. Estimated storage losses vary considerably, but can reach as high as 40% (Table 8-2).

Several low-cost storage methods were compared in cooperation with SOTEC, a development-assistance organization based in Bareilly. Total tuber weight losses after 2 months storage in low-cost, naturally ventilated stores ranked from 7.0% to 8.1% compared with 3.4% in samples placed in a commercial cold store (Table 8-3). Temperature regimes measured outside and at various places in the stores were also recorded, and returns from storage were calculated for the maximum possible storage period in each storage

Table 8-2. India: Indigenous methods of potato storage in three different areas.

State/storage method	Quantity stored	Duration of storage	Purpose	Reported losses (%)
Gujarat				
Heap storage	up to 35 t	up to 45 days	table	0
Country store	up to 50 t	up to 90 days	table	10-40
West Bengal				
Country store	up to 10 t	up to 90 days	table	10-30
Below the cot	up to 1 t	up to 120 days	table	10-20
Baskets	up to 200 kg	up to 100 days	table	15-35
Tripura				
Small room	up to 7 t	up to 90 days	table	10-25
Below the cot	up to 2 t	up to 120 days	table	0-20
Below the cot	up to 200 kg	up to 210 days	seed	20-35
Over the false roof	up to 300 kg	up to 210 days	seed	10-20
Earthen pots	up to 200 kg	up to 210 days	seed	0

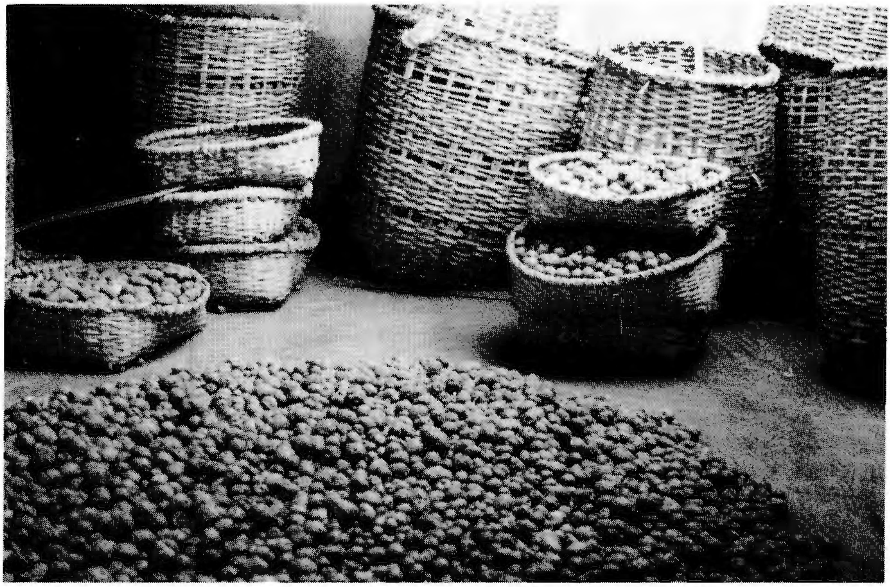
Table 8-3. India: Total tuber weight losses (%) of consumer potatoes at storage intervals of 4,8, and 10 weeks, near Bareilly, Uttar Pradesh.

Store type	4 weeks	8 weeks	10 weeks
Cold store (4C)	2.77	3.37	3.70
NVS[a] with EC[b]	3.89	7.01	8.20
NVS without EC	3.84	8.05	12.51
Duct ventilation	4.22	6.99	-
Gunny bags	5.29	-	-
LSD 0.05	0.74	0.74	0.74

Source: Wiersema, S., A. Buck, M. Upadhya. "Low-cost Storage of Consumer Potatoes on the North Indian Plains." Paper prepared for the Asia Potato Association meetings. Bandung, Indonesia. June 1991.

[a] NVS = Naturally ventilated store.

[b] EC = Evaporative cooling.



Seed-storage studies investigate the effects of length of storage on performace of seed.

system. Net returns per ton of potatoes were US$45 for naturally ventilated stores (NVS) with evaporative cooling (EC), US$40 for NVS without EC and for bulk storage with ventilation ducts, and US$ 10 for storage in bags. Except in the case of bag storage, returns after one storage season were sufficient to pay back the investment on store construction.

Kenya. Storage research has now been completed on nearly 15 years of on-farm evaluation of various low-cost store designs. Future work will concentrate on transfer of storage technology and evaluation of clones for storability under local climatic conditions.

Need for adoption studies. During an international storage workshop held in Thailand, scientists concluded that suitable technology for short-term storage of consumer potatoes is now available for both warm and dry and warm and humid climates. Workshop participants therefore expressed concern about non-technical factors, such as risk and credit, that they believe adversely affect farmer adoption of storage technologies. They indicated that a socioeconomic analysis of the non-technical constraints related to the adoption of storage technologies should receive high priority in future research.

Seed Potato Storage

Cameroon. Research was conducted at three locations to study the effects of length of seed potato storage and their relation to the effects of post-storage performance of seed after planting under field conditions. Tubers were harvested in July 1989, and some were stored in rustic DLS, while another portion was planted and harvested in January 1990. At final planting date (April 1990), tubers were used from the same clones that had been stored under DLS for 8- and 3-month periods. Results indicate that there were no significant differences for stand count, number of tubers per plant, and yield per plant, between tubers stored for 3 and for 8 months (Table 8-4). There was a significant difference in the average tuber weight from tubers stored for different time periods. The trials will be repeated during 1991.

Uganda. Tubers from 10 TPS progenies were evaluated for storage behavior in diffused light stores. Ninety days after storage, 9 out of 10 progenies were in good physiological condition, with tuber weight losses ranging from 4.9% to 11%. It was observed that smaller tubers generally showed better storability.

Egypt. An experiment was designed to test the effect of TPS progeny, tuber size (<5g and 5-20g), plant density, and storage conditions, i.e. cold store (4° C) and rustic store (ambient temp.) on the productivity of seedling tubers of the fall potato crop. Slight differences were found between the

Table 8-4. Cameroon: Yield and other agronomic traits of clones stored in rustic DLS.

Clone	Average stand count		Average No. of tubers		Average yield gms/stand	
CIP No.	3 mo.	8 mo.	3 mo.	8 mo.	3 mo.	8 mo.
Upper farm[a]						
720084	9.7	8.0	12.4	11.9	423	327
676171	4.3	7.7	7.6	9.9	294	300
381378.3	9.0	7.7	8.9	7.0	420	255
381381.13	9.7	3.3	9.3	24.7	520	958
382122.23	8.7	7.7	9.9	16.0	339	278
Mfonta[b]						
386290.5	9.0	9.0	26.0	22.0	612	582
386321.4	9.7	9.3	10.7	12.3	428	464
386297.6	9.7	9.3	20.4	19.2	558	518
381317.2	9.3	9.3	8.8	8.5	307	470
386290.6	9.3	9.7	13.1	15.0	401	419
Babungo[c]						
800946	10.0	9.7	6.5	11.1	635	517
379706.34	9.7	8.3	5.0	7.2	503	570
800222	8.3	6.0	10.1	10.5	590	520
720109	9.7	10.0	7.1	10.2	630	620
800174	10.0	6.7	6.8	10.3	593	550
375333.1	9.0	9.7	9.2	13.1	707	840
8000938	9.7	10.0	8.6	7.9	467	400
800942	8.7	3.0	7.1	10.0	387	477
800950	10.0	8.7	13.6	19.6	647	520
Cardinal	10.0	8.3	6.6	11.5	567	580

[a] Altitude: 2,000 m; average max. and min.: 12.5-20.9C; average rainfall: 2,350 mm.
[b] Altitude: 1,350 m; average max. and min.: 14.2-16.2C; average rainfall: 1,900 mm.
[c] Altitude: 1,175 m; average max. and min.: 13.6-27.3C; average rainfall: 1,200 mm.

storage methods (Table 8-5). More stems per plant were obtained from treatments planted with two tubers per hill, regardless of progeny. In general, bigger seedling tubers outyielded smaller tuber seedlings, and the use of two tubers per hill produced higher yields than did one tuber per hill. Serrana x DTO-33 and Serrana x LT-7 yielded relatively better than did two other progenies. The findings support the conclusion that seedling tubers can be safely stored at ambient temperature under rustic conditions for about three months, as an alternative to storage in costly cold stores.

Processing

Peru. The fast food and snack industry is expanding rapidly in developing countries — particularly Southeast Asia, Central America, and Mexico. This trend has generated demand for suitable processing varieties that are adapted to tropical growing conditions. During 1991, CIP's breeding program in Peru evaluated over 300 clones and more than 100 progenies for yield, dry matter, reducing sugars, and color of chips and french fries. Clones were evaluated in La Molina and San Ramon

Table 8-5. Egypt: Comparison between seedling tuber progenies under cold store and rustic conditions.

	Cold store					Rustic store[a]				
Progeny/Variety	Germ (%) 45 days	Stem.# Avg.10 plant	Avg 3 reps. 3kg	Yield t/ha	Mark-etable (%)	Germ (%) 45 days	Stem.# Avg.10 plant	Avg. 3 reps. kg	Yield t/ha.	Mark-etable (%)
Serrana x DTO-33										
5 gm-1 tuber/hill	96	1.7	11.5	22.0	80	93	1.7	11.2	21.4	80
5 gm-2 tuber/hill	97	2.2	14.9	28.5	80	100	3.2	15.9	30.5	80
5-20 gm-1 tuber/hill	99	2.1	16.8	32.1	85	100	2.8	16.9	32.4	85
5-20 gm-2 tuber/hill	100	3.8	20.8	39.9	90	100	3.1	19.4	37.1	90
Atximba x LT-7										
5 gm-1 tuber/hill	91	1.6	8.8	16.8	75	86	1.8	8.1	15.4	75
5 gm-2 tuber/hill	100	2.4	11.2	21.4	75	93	2.5	11.8	22.6	75
5-20 gm-1 tuber/hill	93	1.7	13.2	25.2	80	94	1.8	11.6	22.1	80
5-20 gm-2 tuber/hill	100	3.5	17.5	33.6	80	100	3.5	16.0	30.6	80
Serrana x LT-7										
5 gm-1 tuber/hill	82	1.2	11.4	21.8	80	91	1.5	9.8	18.8	75
5 gm-2 tuber/hill	95	1.9	16.3	29.2	80	100	1.8	12.6	24.2	85
5-20 gm-1 tuber/hill	97	1.7	17.4	27.6	90	89	1.4	13.8	26.5	90
5-20 gm-2 tuber/hill	100	1.7	20.8	39.9	90	100	3.2	20.3	38.8	90
Atlantic x LT-7										
5 gm-1 tuber/hill	99	1.1	8.5	16.3	75	100	1.6	7.3	13.9	75
5 gm-2 tuber/hill	99	1.8	12.4	23.8	80	97	2.7	10.2	19.6	80
5-20 gm-1 tuber/hill	97	2.5	13.6	26.0	85	97	1.5	12.0	23.0	85
5-20 gm-2 tuber/hill	100	3.2	16.4	31.6	90	100	3.4	15.5	29.7	85
LSD 0.05%		0.429	0.493				0.606	1.395		

[a]Nawalla is a traditional, Egyptian rustic store for keeping potatoes at ambient temperature.

using the commercial processing varieties Atlantic and Russet Burbank as checks. Several selections were made, of which some will be used to generate breeding populations with suitable characteristics for processing (Table 8-6).

A methodology to evaluate clones for processing quality at the national level was developed and reported in previous years. Countries such as Thailand and the Philippines are already applying these methods in their regular clonal evaluation program.

Zaïre. Thesis research at the Institute for Rural Development at Bukuvu in the Kivu region involved a pre-feasibility study for simple potato processing, thereby building on earlier work by CIP-Lima social scientists. This study was supported by PRAPAC, the network for francophone Central Africa. About half of national potato production in Zaïre, (approximately 120,000 t) is produced in Kivu. But, given the region's geographic isolation from major urban markets, only about 15% is sold. Results of the thesis (based on formal interviews with traders in the Lubero production area, estimates of the costs and returns to simple potato processing, and laboratory experiments) indicate that locally produced, dehydrated potatoes, french fries, and potato flour would be much cheaper than imported products, and could thus expand the volume of potatoes that could be sold in other parts of the country.

India. Research on low-cost processing of potatoes into chips, strips, and flour continued in cooperation with SOTEC. Conversion rates and quality of products obtained from processing of tubers derived from TPS families were similar to that obtained from tubers of commercial varieties.

To document the experience of CIP and related institutions in the area of simple

Table 8-6. Peru: Potato clones selected for processing by CIP-Lima.

Clone	Pedigree	Yield g/plt	Dry matter (%)	Use
(E86.231 x 379706.34)21	E86-231 x 379706.34	1000	20.780	french fries
LM86.197	BL2.9 x 378015.3	1000	21.710	chips
LM86.914	983001-1	830	20.720	chips, french fries
LM89.083	(KERPONDY x C83.302) x (ALTEMA x LT07)	1300	21.130	chips
LM89.381	(MS1C.2 x ATLANTIC) x (TITIA x C83.302)	1200	20.650	chips
LM89.408	(CLEOPATRA x LT-7) x (I-1035x575049)	930	20.800	chips
(AVRDC1287.19 x ATLANTIC)31	AVRDC1287.19 x ATLANT	700	20.040	chips
(ALTEMA x ATLANTIC)220	ALTEMA x ATLANTIC	1100	21.710	chips
(B71-240.2 x ATLANTIC)220	B71-240.2 x ATLANTIC	1400	21.510	chips
(377964.5 x ATLANTIC)220	377964.5 x ATLANTIC	940	21.970	chips
(377964.5 x ATLANTIC)210	3779964.5 x ATLANTIC	1000	22.270	chips
(SERRANA x ATLANTIC)1	SERRANA x ATLANTIC	700	23.880	chips
(ATLANTIC x NDD277.2)200	ATLANTIC x NDD277.2	710	21.040	chips
(MAINE 28 x 378015.16)100	MAINE 28 x 378015.16	940	22.240	french fries

potato processing in India, a case study was prepared to review and explain the principles and procedures associated with this type of processing, as well as the institutional and socioeconomic factors that have influenced its evolution over the last 7 to 8 years. Principal findings include the following:

- Village-level potato processing has certain basic prerequisites, including 1) a suitable drying season; 2) a sufficient, cheap, and timely supply of potatoes; 3) storage capacity for two or three months; 4) easy to operate, relatively inexpensive equipment; 5) credit to finance the costs of setting up and operating village plants; and 6) a potential market.

- Management and institutional arrangements are equally, if not more, important than purely technical bottlenecks. The latter may be solved through temporary outside support, whereas the former requires on-the-job training, and coordination with public and private organizations over a longer time.

- Economic considerations may suggest alternatives to the original project design that can facilitate diffusion of the entire package as well as adoption of particular components (e.g. storage) by prospective users.

Building national capacity. In addition to backstopping the research on the socioeconomics of simple potato processing in Colombia and Peru as part of the PRACIPA marketing network (see Thrust X), CIP-Lima social scientists visited Guatemala, Honduras, and Costa Rica to help local researchers attempting to evaluate future prospects for potato processing. A UNDP-sponsored training workshop is planned for next year in collaboration with CIAT to help national programs address this issue. In that regard, several case studies and methods papers on assessing the socioeconomic feasibility of potato processing have been prepared for a manual to be published jointly with CIAT and IITA.

Color is an important characteristic in evaluating quality for potato frying.

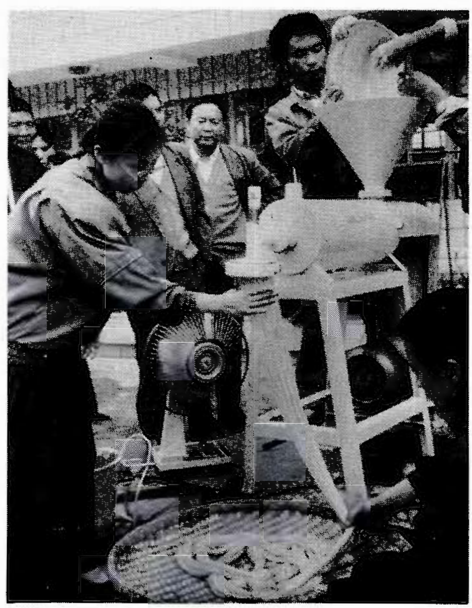
Sweet Potato

Baseline Studies

Information on sweet potato processing and utilization in developing countries is notoriously weak. Partly for that reason, postharvest research on sweet potato at CIP has given high priority to the collection of benchmark data in major producing countries. This work provides more location-specific facts on past trends and future prospects for sweet potato processing. It is seen as complementary to the analysis of production statistics, ecoregional zones, results of the constraints survey, and Thrust X review of the scientific literature on this topic. The combined set of information provides CIP scientists as well as national program personnel with a clearer picture of the products, processes, and techniques that have the greatest potential for expansion. Baseline studies on current utilization patterns of sweet potatoes are in progress in China (in collaboration with IFPRI), Indonesia (through the UPWARD project), Vietnam (in collaboration with CGPRT), and Thailand (through UPWARD). Similar work is under way in the Dominican Republic, Peru, Argentina, and Kenya (see also Thrust X).

China. Drastic changes in sweet potato utilization have occurred in recent years. In the 1970s, about 60% of annual production was used for home consumption, another 30% for animal feed, 5% for processing, and 5% for other uses. Figures for 1990 show that 40% (or more) of production goes to animal feed; 10% to processing into starch, noodles, and alcohol; 5% to other uses; and less than 40% to human consumption. This shift reflects, in part, the dynamism in the cottage and village-level industry sector of the Chinese economy in response to the incentives created by the household "responsibility system."

According to a CIP-supported IFPRI study, the demand for feed in China will increase quickly over the next 15 years, and one major source should be sweet potatoes. Key factors affecting this scenario are the government's policy to increase per capita consumption of meat and livestock products; and the relative price of sweet potatoes versus maize. Sweet potatoes' prospects for the future in China appear bright, because 1) livestock production, particularly pork production, is done at the farm household level; 2) most sweet potatoes do not enter marketing demands, but are consumed or processed at the farm level; and, 3) sweet potato prices are less than those of competing feeds.



Making sweet potato noodles with a starch extruder in Sichuan Province, China.

Small scale machinery for sweet potato processing at the village level at Sichuan Province, China.

Vietnam. The baseline study — in cooperation with the CGPRT Center — found that over 60% of annual production is consumed as fresh roots (see also Thrust X). Use of unmarketable roots as animal feed is of considerable importance. A range of traditional village-level technologies for processing into starch have been identified and described.

Indonesia. A diagnostic survey of Java's sweet potato processing was conducted by researchers with the Central Research Institute for Food Crops, Bogor (see also Thrust X). This survey emphasized the identification of products and processes for transforming sweet potato into alternative uses for human consumption. It was supported by UPWARD, the regional network for Southeast Asia, with backstopping from CIP postharvest scientists. Results indicate that of the annual production, 1.8 million tons go for food, 0.2 million tons for waste, and about 40,000 t for feed. Processed sweet potato products for human consumption currently available include: shredded, fried roots coated with carmel sugar (*Kremes*); fried thin chips covered with carmeled sugar (*Kripik*); fried thin chips covered with chili sauce (*Kripik pedes*); starch dough, sliced, dried, and deep fried (*Krapuk*), fried thin chips (*Chip*); chili-flavored sauce (*Sambal*); and tomato-flavored sauce (*Saos*). Among the recommendations made by the researchers was a call for studies analyzing market information and governemnt policies on the importation of wheat, corn, and other agricultural commodities, as they affect development of sweet potato processing.

Processing

China. CIP's collaborative research with the Sichuan Academy of Agricultural Sciences (SAAS) on improving village-level processing of sweet potato has concentrated on Sichuan Province. This province has over 100 million inhabitants. Annual area planted in sweet potato in Sichuan is about 1.2 million ha., with a total production of over 20 million tons — higher than that of any other province in China, and representing about 15% of total sweet potato production worldwide.

Small-scale processing of sweet potato into starch and noodles is of considerable importance for income generation at the household and village levels in Sichuan. Three different methods for starch extraction have been identified: the natural precipitation method, the "sour liquid" method, and the water-through-precipitation method. Typical recovery rates of sun-dried starch for these three methods are 16%-18%, 17%-20%, and 12%-14%, respectively. Detailed processing procedures for each method have been described by the SAAS research team. The team also has identified various types of improved equipment for starch and noodle processing elsewhere in China. This equipment is currently being evaluated in several villages in Sichuan Province.

Utilization of residues from starch processing for pig feed is also of considerable importance in China. Recent field work in Sichuan by Chinese researchers, with backstopping from scientists from CIP and the Natural Resources Institute in the United Kingdom, found that residues are fed directly to pigs or after fermentation at the household level. Sometimes residues are dried or mixed with other fodder such as corn stalks and rice husks. Consequently, future studies at SAAS will evaluate the use of residues for pig feed. The field work also noted that industrial processing of sweet potato into products such as citric acid, calcium citrate, monosodium glutamate, glucose syrup, and organic solvents is of decreasing importance. There is a small, but increasing, market for snack products such as chips and candy.

The Philippines. In a collaborative project with the Visayas State Agricultural College (VISCA), several newly developed sweet potato products were identified as having good market prospects. These products include flavored chips; dehydrated, ready-to-fry chips; a hot-cake mix containing sweet potato flour and milk powder; pure sweet potato powder; and, Cantonese noodles made from sweet potatoes. Pure sweet potato powder is used as the main ingredient in the formulation of instant soups and in the preparation of a traditional breakfast food. All products were consumer tested and received high acceptability scores.

A processing line for sweet potato chips was also completed. A prototype of a pedal-operated slicer with a capacity of 60-70 kg/hr of 1.5 mm thick slices was developed. It includes a horizontal-cutting blade assembly that is equipped with two blades, making possible the cutting of 2 slices per revolution of the pedal. This machine can also be used as a strip cutter when another type of blade assembly is used. For the peeling operation, a mechanical peeler was modified for adoption; it is basically a horizontally rotating carborandum-coated oil drum with provision for entry and discharge of sweet potato roots and water. The capacity is about 100 kg/hr of roots peeled in batches of 15 kg to 20 kg. A lorena stove was adopted for frying operations. The process line is being further developed by allowing potential users to provide feedback after a hands-on experience with the equipment. Development of other equipment such as a mixer for the flavored chips, a steamer for precooked powder processing, and a dryer will depend on users' needs.

Preparatory steps for technology transfer have been taken, including identification of cooperators. Simultaneously, research on existing and competing products is being carried out to determine marketing strategies for the products.

Thailand. In cooperation with the Institute of Food Research and Product Development, factors affecting recovery rates of starch extraction were studied in a range of varieties. Also, studies were made of the use of sweet potato flour and starch as an ingredient in processing of extruded snack products and noodles.

In a project with the Agro-Industry Section of the Department of Agriculture, a total of 33 commercial varieties and advanced clones were systematically evaluated for dry matter content; starch content; and acceptability after frying, boiling or steaming, and roasting. This information will be used to prepare a national sweet potato variety catalogue.

Peru. In CIP's breeding program, sweet potato clones were grown at 4 different sites and subsequently evaluated for processing characteristics such as high dry matter content and a low degree of darkening after processing into chips (Fig. 8-1). Two high-yielding clones with dry matter contents of 32% and 33%, were considered for pathogen cleanup to prepare them for future regional distribution.

Because of commercial interest in using sweet potato as an ingredient in baked goods, an M Sc. thesis has focused on a chemical and nutritional evaluation of sweet potato clones for use in breadmaking. A total of 444 sweet potato clones were analyzed for reducing sugars and 25 clones were selected. These clones had less than 1% of reducing sugar content (dry weight basis), more than 7% of total protein (dry weight basis), and a dry matter content greater than 35% (Fig. 8-2). Of these 25 clones, all but 3 were sweet-tasting after cooking. Next, sweet potato bread was made by replacing 30% of the wheat flour (on a fresh weight basis) with ground, raw sweet potato roots from these clones. The resulting bread was found, by a taste panel, to have a good appearance, color, flavor, and texture. The level of sweetness of the clone had no effect on the acceptability of the sweet potato bread. Nutritive values of the sweet potato bread were determined in trials, and compared with wheat bread. From a nutritional point of view, sweet potato bread was shown to be comparable to bread made from 100% wheat flour.

Through a contract with the Ministry of Agriculture's Office of Agricultural Economics, a rapid appraisal was made of sweet potato bread in Lima. Results of that appraisal indicate that the price of imported wheat and the price/availability of locally produced sweet potatoes strongly influence the production of sweet potato bread. Estimates of the production costs show that despite the high price of sweet potatoes (November is a period of

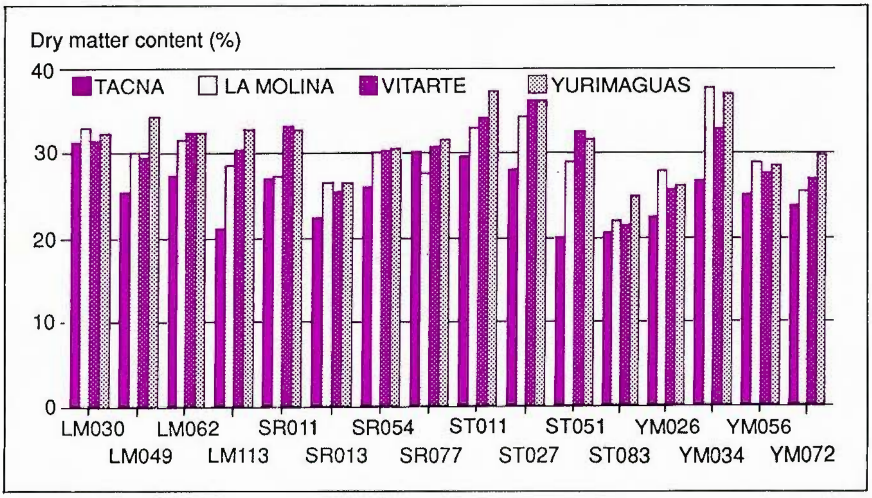
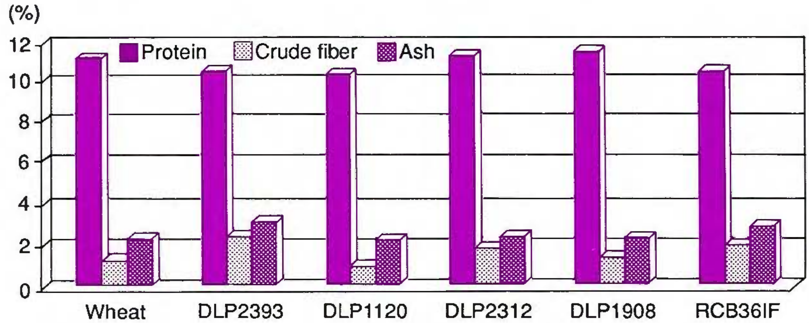


Figure 8-1. Peru: Dry matter content of 16 sweet potato clones in four locations.

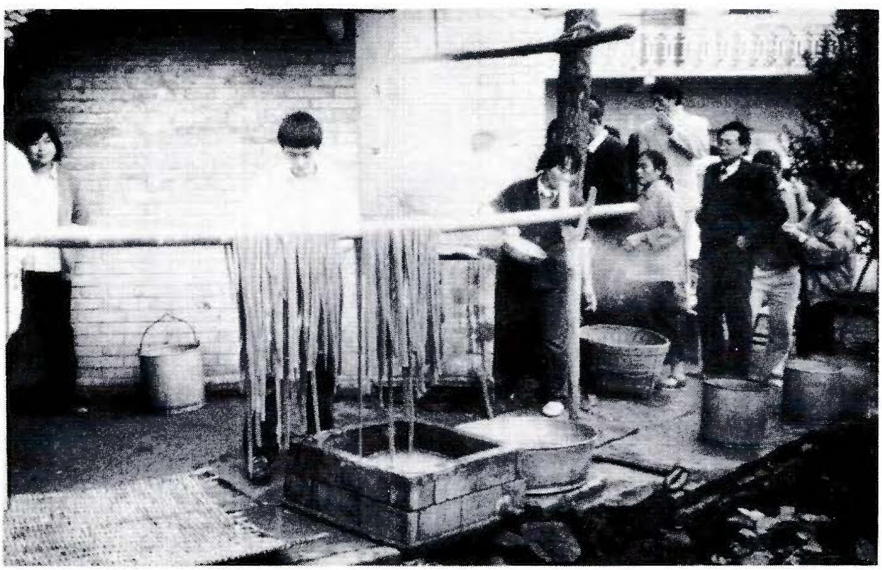


Source: Cárdenas, H. 1991. Nutrition/Chemical Evaluation of the Cultivars of Sweet Potato *Ipomoea Batatas* (L.) Lam. of the CIP Germplasm Collection for Use in Breadmaking. M.Sc., Univ. Agraria La Molina, Peru.

Figure 8-2. Peru: Biochemical analysis of wheat bread versus sweet potato bread.

reasonably high sweet potato prices), sweet potato bread cost less to produce than did bread from 100% wheat flour (Table 8-7). More detailed research on this topic is planned for next year.

Need for market/technology assessment. Preliminary results of all the baseline research conducted on sweet potatoes (e.g. in China, Indonesia, Vietnam, the Philippines, Peru, and Argentina)



Sweet potato noodles drying at Sichuan Province, China.

Table 8-7. Peru: Costs of production for sweet potato vs. wheat flour bread in Lima.[a]

	Sweet potato			Wheat flour		
	Unit (kg)	Costs (US$)	% Costs	Unit (kg)	Costs (US$)	% Costs
Wheat flour	37.3	20.35	53.0	5.00	27.27	67.8
Grated sweet potato	12.71	3.25	8.5	—	—	—
Sugar	0.8	0.53	1.4	0.94	0.62	1.5
Salt	0.63	0.50	1.3	0.68	0.54	1.3
Yeast	0.96	3.64	9.5	0.83	3.15	7.8
Margarine	1.95	1.91	5.0	0.41	0.40	0.9
Dough enhancer	0.43	1.54	4.0	0.43	1.54	3.8
Electricity and water	—	2.15	5.6	—	2.15	5.3
Labor	—	1.13	3.0	—	1.13	2.8
Administrative costs (e.g. Mgt., tel., depreciation, etc.)	—	3.41	8.9	—	3.41	8.5
Total	54.77	38.41	100.0[b]	53.29	40.21	100.0[b]
Cost per unit of bread		0.021			0.022	

Source: Cavero, et al. 1990. Estudio sobre producción y consumo de pan de camote (draft). Instituto Nacional de Investigación Agraria y Agro-industrial (INIAA). Lima.

[a] To produce 1,846 units of bread each weighing 32.5 gr., November, 1990.

[b] May not total to 100 due to rounding.

point to the need for a concerted, collaborative effort by CIP and national programs to carefully study the marketing prospects for processed sweet potato products. Such studies can better identify those commodities that stand the best chance of commercial success and help prioritize those technologies that offer the greatest potential for impact. Efforts to organize such assessments are currently being given top priority.

Potato production at 3 months after transplanting high-quality TPS of Serrana x LT-7 in Jinotega, Nicaragua (1500 m).

Thrust IX

Seed Technology

Thrust Profile: 1991

Substantial advances have been made in potato and sweet potato propagation appropriate to developing country conditions. Several genetic materials suitable to specific requirements for propagating potatoes using true potato seed (TPS) were identified and distributed for evaluation in different countries. Also, promising methods for increasing the efficiency of producing TPS in tropical areas were evaluated under short-day and high-temperature environments. Practical and accurate testing procedures were developed to determine seed quality characteristics of selected TPS progenies. Potential for extensive farmer adoption of TPS has also been developed in some Latin American countries. New alternatives were identified for increasing the efficiency of traditional seed tuber propagation schemes, and studies continued on the effects of environmental factors on the sweet potato flowering process. Findings will facilitate hybridization activities and the development of new genetic materials with improved adaptation. Rapid multiplication techniques adapted from the potato have shown their potential for use in sweet potato propagation.

Identification of Improved TPS Materials

Peru. The TPS progeny evaluation program concentrated on the implementation of a systematic procedure for developing advanced progenies with improved characteristics. At Lima, new hybrid combinations produced under field conditions with artificial light in successive seasons, as well as seed of other selected hybrids from CIP's regional program, were evaluated for seedling tuber production in nursery

Table 9-1. Characteristics of 35 progenies selected from a group of 50 advanced progenies evaluated in nursery beds. Lima.

Progeny	Vigor	Vegetation uniformity	Tuber color	Tuber shape	Earliness	Yield kg/m^2	Yield No./m^2
Atzimba x DTO-28	3.0	2.7	7.0	5.0	2.0	5.97	609
Serrana x LT-7	4.0	4.3	8.0	5.3	2.3	7.27	639
Atlantic x LT-7	4.7	4.3	9.0	5.3	2.3	5.13	694
Atzimba x AVRDC	4.3	4.3	7.3	5.3	3.7	7.53	873
Atzimba x TS-2	4.7	4.0	9.0	6.0	2.3	5.60	659
Atzimba x TS-3	4.3	4.3	9.0	6.0	2.3	5.51	720
Atzimba x 4.1DI	4.3	4.7	7.3	7.0	4.7	8.83	724
Atzimba x 104.12LB	5.0	4.0	7.0	6.0	4.0	9.66	880
Atzimba x Katahdin	3.0	3.3	8.3	6.0	1.0	5.24	737
Serrana x AVRDC	3.0	3.0	7.0	6.0	3.7	6.52	608
Serrana x TS-2	3.0	3.0	8.7	6.0	2.3	5.85	470
Serrana x Katahdin	3.0	4.0	9.0	7.0	2.7	5.03	461
Serrana x TS-3	3.7	3.7	9.0	5.7	2.3	6.00	510
CFK.69.1 x AVRDC	4.3	4.0	8.3	5.7	3.0	6.23	627
CFK.69.1 x TS-3	2.7	3.0	9.0	6.0	2.7	6.18	640
CFK.69.1 x 104.12 LB	3.7	3.3	7.0	6.0	4.3	9.78	705
CFK.69.1 x 4.1 DI	3.7	3.7	7.0	5.7	4.3	8.46	598
I-1035 x AVRDC	3.3	3.3	8.0	6.0	2.3	5.67	592
I-1035 x Katahdin	3.0	3.0	9.0	6.0	2.7	4.89	454
I-1035 x R 128.6	3.3	3.7	7.0	5.7	4.0	5.97	499
LT-8 x LT-7	5.0	4.7	9.0	6.0	2.3	5.79	642
LT-8 x 104.12 LB	4.7	4.0	7.0	6.0	2.7	7.50	663
LT-9 x TS-3	4.3	4.0	9.0	7.0	1.7	5.25	582
LT-9 x 104.12 LB	4.0	4.3	7.0	6.0	2.3	6.75	534
B71-240.2 x AVRDC	3.0	3.0	9.0	6.0	3.0	5.61	757
B71-240.2 x LT-7	4.3	4.3	9.0	6.0	3.0	5.60	752
MF-I x Kat.	2.3	3.3	9.0	5.7	2.7	5.62	524
MF-I x TS-3	2.7	3.3	9.0	6.0	2.0	7.13	687
MF-I x 104.12 LB	4.0	3.7	7.0	5.7	4.7	9.71	685
LT-9 x AVRDC	4.7	4.3	9.0	5.7	2.0	6.54	655
B71-240.2 x Katahdin	2.0	2.0	9.0	6.0	2.0	4.73	552
Atlantic x AVRDC	3.7	3.7	9.0	6.0	1.3	5.52	544
Atlantic x Katahdin	2.7	2.7	9.0	6.0	2.0	4.59	453
Serrana x 104.12 LB	3.7	3.7	7.0	6.0	3.3	7.56	547
Atlantic x TS-2	4.3	3.7	9.0	5.3	2.7	5.22	459
DLS $_{0.05}$	1.0	1.0	0.4	0.6	1.4	1.4	138
CV %	18.1	18.2	3.4	6.2	29.5	12.6	13.4

1. Vigor and uniformity: 1= poor; 5= excellent.
2. Color and uniformity of tubers: 1= poor; 9= excellent.
3. Earliness: 1= very early; 5= very late.
4. Number of tubers 1 g.

Harvest of 3rd-generation seedling tubers of open-pollinated TPS of the clone 7XY.1 produced in Nicaragua.

beds. Similar evaluations were made at San Ramon and Lima for production of consumer potatoes, using seedling tubers and seedling transplants. Thirty-five hybrids were selected for tuber characteristics (color, shape, earliness, uniformity) from a total of 50 grown in seedling tuber production beds in late 1989 (Table 9-1). Seed of the better hybrids is being produced in larger quantities for distribution to various countries for further evaluation.

In an experiment conducted in Huancayo, four generations of planting materials originating from TPS, using a set of 14 progenies, the progeny x generation interaction was not significant, indicating yield stability up to four generations. These findings suggest the capacity of TPS-derived plants of segregating populations to compensate for potential yield reductions due to build-up of tuber-born diseases after successive field exposure (Table 9-2).

A group of 32 progenies were also evaluated for their adaptation in the contrasting environments conditions of San Ramon and Huancayo. Progenies of LT-8

Table 9-2. Total and marketable yield of potatoes from TPS seedling tubers up to fourth generations. Averages for 14 progenies. Huancayo.

	Yield (t/ha)	
Generation[a]	Total	% Mktble.
First	25.9	69.2
Second	41.3	83.2
Third	42.0	84.0
Fourth	41.0	83.8
$LSD_{0.05}$	7.3	6.5
CV (%)	12.2	5.0

[a]First generation by transplanting seedlings into field, second to fourth by planting tubers kept from previous growing season.

x LT-7 and Atzimba x DTO-28 showed adaptation to the warm climate of San Ramon (Table 9-3). Both parents of the former cross normally set fruits abundantly under warm climates, which is an added favorable characteristic. For the cooler environments of Huancayo, the progenies AL-204 x 4.1 DI and AL-204 x 104.12 LB were the best performers with yields of 34.3 t/ha and 33.8 t/ha, respectively and

Table 9-3. Total and marketable yield of selected progenies transplanted to the field under two contrasting environments, Huancayo and San Ramon.

	Huancayo		San Ramon	
Progeny	Total (t/ha)	%	Total (t/ha)	%
Atzimba x R128.6	32.15	67.8	16.75	69.5
Atzimba x DtO-28	13.75	55.4	20.27	73.7
Atzimba x 4.1 DI	33.26	74.6	17.86	68.4
Atzimba x 104.12 LB	40.80	62.3	18.31	72.3
Atzimba x 7 XY.1	21.24	53.4	15.90	68.8
Atzimba x 377964.5	19.31	67.1	21.69	77.5
Serrana x R128.6	26.30	74.2	16.40	84.1
Serrana x 4.1 DI	31.53	82.1	12.18	86.2
CFK.69.1 x R128.6	31.41	76.8	16.50	73.6
CFK.69.1 x 4.1 DI	24.74	79.2	15.41	67.2
CFK.69.1 x 104.12 LB	41.08	75.1	22.09	63.7
79 G8.7 x R128.6	27.66	77.0	10.00	69.4
79 G8.7 x 4.1DI	22.97	82.9	10.14	66.4
79 G8.7 x 104.12 LB	32.73	79.2	15.14	70.8
I-931 x R128.6	32.15	76.0	14.01	67.2
I-931 x 4.1 DI	28.57	72.2	14.29	63.8
I-931 x 104.12 DI	32.15	62.5	17.96	70.7
AL-204 x R128.6	30.30	82.4	11.36	84.7
AL-204 x 4.1 DI	34.33	85.5	14.63	70.0
AL-204 x 104.12 LB	33.84	81.6	14.77	69.6
377891.19 x 104.12 LB	29.06	61.4	16.07	72.5
377891.19 x R 128.6	26.80	70.0	12.49	79.3
LT-8 x 104.12 LB	30.38	70.5	14.65	71.8
LT-8 x R 128.6	26.06	65.8	13.99	51.9
LT-8 x 4.1 DI	17.62	73.0	13.21	86.0
LT-8 x LT-7	8.36	62.6	17.45	72.2
80N.37.11 x R128.6	34.21	63.2	9.28	70.3
80N37.11 x 104.12 LB	38.20	57.1	10.39	49.1
I-822 x 104.12 LB	23.58	54.8	9.14	59.8
79 D10.9 x 4.1 DI	14.77	62.0	8.44	70.4
79 D10.9 x 104.12 LB	22.02	58.9	8.60	60.1
79 D10.9 x R 128.6	31.40	72.4	5.82	68.2
Average	27.90	70.0	14.22	70.3
$SLD_{0.05}$	6.5	10.3	5.5	13.8
CV %	14.6	9.2	24.2	12.2

marketable tubers rainging from 81% to 85%.

China. A large TPS breeding and progeny evaluation program gave promising results at trials in Wumeng and Bashang. The best families were 377964.5 x XY-13, LT-9 x XY-9. The families were outstanding in tuber shape, and had high tuberization compared to progenies tested before. In the Ninglan county, Yunnan, 70 ha were grown with transplants of Mira (OP) and about 6000 ha were planted with TPS derived tubers.

India. Advanced TPS progenies from CIP's Region VI program were evaluated in Modipuram, Deesa, and Agartala, for their performance in various forms of TPS utilization (Table 9-4). For seedling tuber production, eight TPS families (HPS-I/67, HPS-II/13, HPS-II/67, HPS-2/13, HPS-7/13, HPS-7/67, HPS-25/13 and HPS-25/67) were evaluated by direct seeding in nursery beds. All families had mean tuber yields over 5 kg/m^2. HPS-7/13 gave the highest yield of 6.2 kg/m^2. Seedling tuber number/m^2 ranged from 516 to 919. At Modipuram, seedling tubers of seven TPS families graded in four sizes, as well as seed tuber of variety Kufri Bahar, were evaluated in the field for commercial potato production. Mean tuber yield of the crop from seedling tubers ranged from 28.7 to 34.2 t/ha, the seed-tuber plantings yielded 30.8 t/ha. Results indicate that seedling tubers of some of the TPS families (e.g., HPS-I/13), had better yielding potential than did clonal seed tubers of the commercial variety. To assess yield stability of seedling tubers after consecutive field multiplication, a field trial was conducted using 60-80 gr tubers of the C_1, C_2, C_3, and C_4 generations of HPS-I/13. Mean tuber yield ranged from 27.0 (C_1) to 26.7 (C_4) t/ha, with 69% marketable tubers in C_1 and over 83% in C_2, C_3, and C_4. No differences in yields were found, suggesting that seedling tubers can be used successfully for several consecutive seasons without yield reductions.

Africa. TPS hybrids from CIP, tested for adaptation and yield in Agadir, **Morocco**; at Kalengyere and Kachwekano, in **Uganda**, and at Kafr-El-Zayat, in **Egypt,** showed excellent plant stands, plant growth, and high yields in all locations. Additionally, on-farm trials were conducted in several of those locations to confirm the research results and to study farmers' reactions.

In **Uganda**, TPS transplants showed better tuber characters and general late blight resistance than did the local control transplants. All the progenies displayed good plant vigor, with leaf area index

Table 9-4. Comparative performance of TPS families for seedling tuber production in Autumm (A) and Spring (S) seasons.

	Yield (kg/m^2)		Tuber No./m^2		Average tuber Wt.	
TPS families	A	S	A	S	A	S
HPS-II/13	5.09	2.61	626	598	8.1	4.3
HPS-2/13	6.19	2.84	569	540	11.0	5.3
HPS-7/67	5.87	2.67	919	516	6.4	5.2
HPS-25/13	5.05	2.75	631	591	8.2	4.7
HPS-25/67	5.21	2.96	696	712	7.5	4.2
LSD (P=0.05)	1.42	0.90	181	169	1.4	0.7

ranging from of 3.5 to 4. In one location mean yield ranged from 36.8 to 49.9 t/ha, as compared to 35.4 to 54.7 t/ha yields of two improved check varieties raised traditionally. Even higher yields were obtained in a second location, where mean yield of TPS progenies was 96% higher than that of the mean yield of two imroved varieties.

Improving TPS Production Efficiency

Chile. In Osorno, a total of 14.4 kg of disease-free TPS hybrid of four progenies were produced through a CIP contract with the National Research Institute, INIA. Various new seed production techniques were investigated. Planting at proper dates to maximize flowering was shown to be a good method for improving the efficiency of hybrid TPS production. Late maturing genotypes such as R128.6, Serrana, and Atzimba showed decreased flowering duration and intensity when planted after Nov. 1 in southern Chile (Fig. 9-1). Using pollen from two clones that carry an embryo-spot marker gene, flowers of 3 mother-plant varieties were pollinated one day before anthesis. A small proportion of selfing was obtained in one of the mother plant varieties (I-1035), but in none of the others, when not emasculated prior to hybridization.

Several techniques for improving pollination efficiency, such as the use of pollen dilutions, pollen storage, pollen application methods, and others were developed through collaborative projects with INIA, and were subsequently used in commercial TPS production. Pollen viability for the clone LT-7 was tested after storing for 4, 9, 14, and 19 days at two temperatures, -15° C and +5° C. The tests were made either immediately, or at 2 or 4 hours after storage. Pollen of LT-7 remained viable up to 9 days when stored at -15° C days, but only up to 4 days when stored at +5° C.

Peru. Use of male sterility has been proposed to produce hybrid TPS from open pollinated parental lines. The segregation for tetrad-sterile types was evaluated in Lima by analyzing the progenies of crosses between clones that

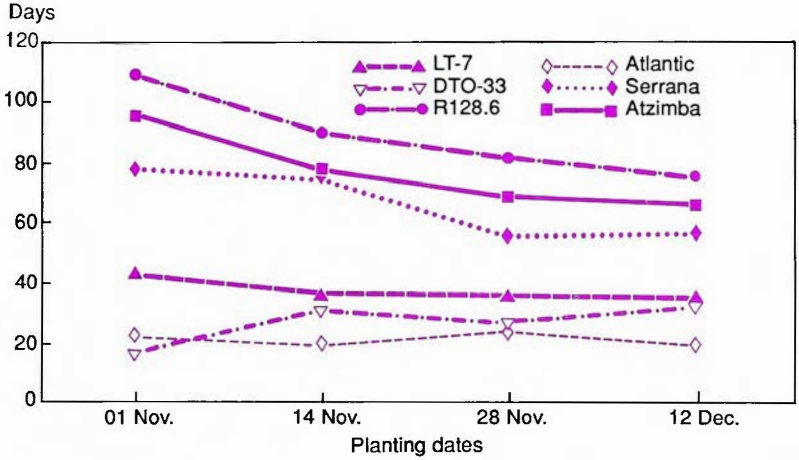


Figure 9-1. Flowering period of six progenitors used for hybrid TPS production as affeected by planting at different dates.

had [Tr^s] plasmon (Hermsen 50.3, Y-245.7, C.136 LM86-B and C.662 LM-86B) and one clone coming from protoplast fusion (Gal 1) as female parents. Irrespective of the source of tetrad male sterility, the segregation for this character was 100%, indicating that the female parents contain the Tr nuclear gene in a triplex or quadruplex state (Table 9-5).

In many tropical countries, there is an increasing farmers' demand for quality TPS. Countries in Asia, Africa and Central America have expressed their difficulties in meeting this demand due to unfavorable climatic conditions for TPS production. However, collaborative projects with national programs to identify suitable parental materials and cultural practices for efficient TPS production in tropical areas produced promising results. In Lima, Peru, using a night-break of three hours, a total of 2.7 kg of TPS were produced from 36 hybrids which were grown in potted plants in the field. The three most productive crosses were CKF69.1 XV-2, I-1035 x 104.12 LB, and Maine 28 x TPS-13, which yielded 11.9, 7.2, and 5.3 g/plant, respectively. The percentage of berry-set in those three crosses ranged from 72.0 to 90.1%. The productivity values of the most efficient combinations resembled closely those normally achieved in southern Chile in large scale hybrid TPS production with selected crosses, indicating the potential that can be achieved with better adapted parents grown under suitable growing conditions.

The use of shade to reduce the adverse effects of high temperature was studied during the summer season in Lima. Plants of four TPS progenitors grown at 50% of full sunlight produced fewer flowers in all cases, although flower duration was extended by about 20%. However, except for one parent clone (AVRDC), more pollen with equal viability was obtained from shaded plants than from those exposed to full sunshine. Fruit setting in crosses using Serrana as female parent was favored by practices that reduce heat stress. In crosses involving Serrana and two male parents, berry-set generally increased when the plants were grown under shade. A completely opposite response was obtained when LT-7 was used as a female parent. In San Ramon, covering the plants for six hours during the hottest part of the day (with a net that intercepted 47% of solar radiation for either the whole growth cycle or from flower initiation), reduced flowering and fruit setting, as compared to the unshaded control plants. This effect was similar in both well watered and drought stressed plants. However, pollen produc-

Table 9-5. Determination of tetrad type male sterility by stained pollen.

	Pollen Stainability Observed number		Expected	
Ratios progeny	Fertile	Sterile	Fertile	Sterile
Hermsen 50.3 x LT-7	0	18	0	1
Hermsen 50.3 x 7XY.1	0	12	0	1
Y-245.7 x LT-7	0	9	0	1
Y-245.7 x 7XY.1	0	25	0	1
C.662 LM86-B x C.342 LM86-B	0	33	0	1
C.136 LM86-B x C.614 LM86-B	0	15	0	1
GAL 1 x 7XY.1	0	8	0	1

tion and viability was improved when the plants were shaded starting at flower initiation.

Indonesia. In West Java, at Tangkuban Prahu, 7°S, 1400 m, the clone Atzimba was used as the female parent and R128.6 and DTO-28 as the male parents to investigate the potential of TPS production. Flowering was generally poor and yields of pollen were low due to short day-length (hours), high rainfall and frequent winds. Pollination after a night's rain required approximately four times as much pollen as that following a dry night.

Development of Seed Quality Procedures

Since different TPS genotypes exibit variable dormancy levels during the seed storage period, a practical seed testing method was developed to predict seed vigor potential at planting. A high level of field applicability for early seedling performance was obtained by using a germination rate criteria, which tests for the coefficient of velocity (CoV) of germination under laboratory conditions at extremely high temperature (27.5-40° C). This test is currently being used effectively at CIP for determining TPS of acceptable quality for exporting to the regions.

Peru. The commonly observed uneven germination of TPS under tropical environments had been traditionally remedied by gibberellic acid (GA) treatment. However, it has been repeatedly demonstrated that young TPS seedlings that are induced to germinate with GA develop sub-optimally. Previous research had suggested that soaking in salt solutions for 5 days followed by drying, or seed priming, improved seedling vigor only in non-dormant seed. However, newly-harvested TPS germinated at high temperature (27-40° C) more than twice as fast as GA-treated seed and the untreated control, when soaked at -1.0 MPa for longer periods than previously used (15 vs. 5 days). Increasing the osmotic concentration from -1.0 to -1.5 MPa, however, produced a sub-optimal response. In sufficiently nondormant TPS (6 months-old), the optimum duration and osmotic concentration of the seed priming treatment was found to differ depending on the progeny. Prolonged (15 days) priming was detrimental in Atzimba X7XY.1, because the seed germinated during priming; while priming for 5 days at -1.0 MPa was optimum for increasing germination at high temperature. Seedling fresh weight per plant increased about 400% with this treatment compared to that in GA-treated seed. In TPS of Serrana x LT-7, seed vigor was likewise greatly improved with a 10-day soaking at -1.0 MPa, as with a 5-day treatment at -1.5 MPa. The optimum conditions for priming TPS vary according to the genotype, probably in relation to its seed dormancy state. As dormancy decreases, the optimum duration for priming also decreases. Seed priming is an effective treatment for TPS, provided the seed is planted soon after treatment, because the priming effect is lost in storage at mild temperatures.

To improve the selection process for adaptation to tropical environments, seed quality is an important characteristic to be considered in a TPS trials. Seedling vigor, measured by the time required for TPS to reach transplant size, would affect yields in trials where all seed lots are transplanted at the same time. For example, the progeny of Atlantic x LT-7 has been identified to have superior seed vigor because the seedlings are usually ready for transplanting at only 3 weeks after sowing. Nevertheless, when the seed has not been produced properly, or stored for a sufficiently long period, or is incorrectly handled, its performance can be significantly affected. Twenty advanced TPS progenies were tested for seedling emergence against controls (selected progenies) during the summer in Lima. Only 5 of the progenies had percentage of emergence and seedling dry weight levels comparable to the controls, while the seed of all of the other progenies performed poorly. Thus, for efficient testing of new TPS progenies breeders are advised to use only high-quality seed.

Chile. Several long-term storage experiments with TPS produced during 1990, were begun to determine the optimum seed-moisture content (dry weight basis) and temperature conditions required for conserving TPS quality (viability and seed vigor) in storage. A seed moisture range of 4 to 12.5% (dry weight basis) under 30; 15; and 5° C temperature environments were evaluated. Preliminary results at 4 months of storage showed that the emergence was 95% in all treatments, except when seed was stored at 30° C, at above 8% seed moisture content, when none of the seeds germinated. Since TPS technology is aimed at warm climate environments, the TPS should be dried sufficiently before storage.

Advances in the Adoption of TPS

Paraguay. The National Potato Program produced 870 kg of seedling-tubers of Serrana and Atlantic x LT-7 in seedbed nurseries at the Experimental Stations (IAN, CECA) and they were distributed to several institutions and farmers. An encouraging institutional development process is being catalyzed by the TPS program, involving various agricultural interests and farmers. The distribution of seedling-tubers from the Experiment Stations to potential users promoted the communication between researchers, extensionists, agronomic institutions and farmers.

Seedling tuber production in beds, Esteli, Nicaragua.

Nicaragua. Results of three years of TPS trials in selected farmers fields show that, for the areas between 900 m and 1400 m, hybrid and open-pollinated seed of selected clones are suitable for use in the production of seedling tubers in seed beds. An International TPS Course co-sponsored by PRECODEPA and CIP was conducted in the highlands of Nicaragua to share technology among national scientists of the Caribbean basin region. The TPS technology is being adopted rapidly in Nicaragua, and many small farmers are currently successfully producing and marketing potatoes grown from seedling tubers. To satisfy the rapidly increasing demand for TPS by small Nicaraguan farmers, CIP provided the Nicaraguan program with 3 kg of TPS hybrids with proven adaptation to local conditions. Motivated by the initial success of TPS in Nicaragua, researchers in Venezuela, Jamaica and other Caribbean islands have also started research activities on TPS use in close collaboration with CIP scientists.

Tunisia. Seedling tubers of 35 progenies from the international TPS trial, 12 hybrids (crosses selected by a research contract in Italy), and 2 OP progenies were produced in nursery beds. These will be evaluated for use in the late crop (September) and the early crop (November) at two different locations. On-farm research conducted in Egypt showed that seedling tubers outyielded the commercial variety in 6 of 15 comparisons. In 6 other cases, seedling tubers were produced equally well as the commercial varieties planted in the same field. In only three cases were the seedling tubers less productive than the commercial varieties. Farmers were positive about the use of seedling tubers and some private companies, the Extension Service, and the General Potato Growers Cooperative have begun to produce seedling tubers in limited quantities for distribution in the Nile Delta.

Seed-Tuber Propagation

Agro-economic studies

Results of several seed production system case studies conducted in the previous seasons were further documented. Case studies were published of the Philippines and Ecuador and the companion contract study of the seed systems in the U.K., Canada and the Netherlands. In Egypt, an agro-economic evaluation paper on the use of TPS was completed and a series of working papers were published. A new activity "Management Information Systems for Seed Potato Production and Distribution Programs," was initiated and will be part of the umbrella project for collaborative seed research in Ecuador.

Rapid multiplication techniques in basic seed production

Kenya. The use of rapid multiplication techniques for pre-basic seed production is being routinely used in the national program utilizing both sprout cuttings and small tubers to produce mother plantlets for cutting production. After the plantlets have reached the stage of 5 to 6 leaves, the apical and axillary shoots (measuring about 5 cm, with three leaves), are cut and rooted in sand. These younger cuttings yielded better than the cuttings obtained with the traditional stem-cutting technique. Only Kenya Baraka, a late maturing and very vigorous variety produced well with the traditional stem-cutting technique. Propagation was more rapid when the mother plants were grown either under extra-light conditions or with normal daylength. A glasshouse was equipped with 40-watt incandescent lamps and a timer to regulate light duration (four extra hours per day, for a total of 16 hours daylength).

Tissue culture work began in September, using in-vitro plantlets received from PQS Muguga that were remultiplied and cultured. Also, routine virus and PSTV tests were conducted on the mother plants and on samples taken on rooted cuttings.

At Tigoni, alternatives to the stem cutting technique have been successfully tested as well as the application of extra light to extend the number of hours under the normal photoperiod. As an alternative to stem cuttings, apical cuttings obtained from sprout cuttings and small tubers were utilized to produce disease-free mother plants. The use of aerial tubers as another alternative method for seed production is also being explored.

Cameroon. Aphid monitoring using yellow water traps continued in three locations of the NW Province of Cameroon. At Upper Farm (2000 m) there was a relatively low aphid population throughout the year, suggesting that this location is suitable for basic seed production. At Babungo (1000 m), a considerably greater aphid population was recorded. However, random samples of local cultivars taken from 10 farmers fields and at the Experiment Station surprisingly showed low levels of virus incidence.

Facilities for potato propagation were established by the project at the IRA Bambui Station, in Cameroon. In these facilities, 13 late blight clones sent from Lima were multiplied in the screenhouse using sprout cuttings and apical stem cuttings.

Uganda. At the highland Crop Research Institute, Kalengyere (2500 m), a three-stage program was implemented to produce basic seed. The initial elite stocks were produced using two locally developed schemes. In 1991, the program is expected to generate about 100,000 virus-free tubers from around 20,000 stem cuttings. Studies on the dynamics of aphid populations as well as incidence of soil borne diseases and pests continued. Preliminary information on appearance of aphids and their population build-up indicates that aphids appeared near the end of April, with the cessation of rains and increase of temperatures, and peaked during the months from June to July. Thereafter, aphid number declined sharply. There were few aphids during September to March.

Colombia. The production of prebasic seed of the Colombian cultivars ICA-Purace, Parda Pastusa, Monserrate, Capiro, ICA-Nariño, ICA-Guantiva and ICA-San Jorge was initiated using in vitro plants as well as mother plants and stems cuttings. The cv. Andinita was also propagated. Virus tests using Elisa technique conducted on 21 samples of different categories of seed tubers from the highlands of Colombia, showed a very low virus incidence, especially with PVS in seed obtained from farmers. These results confirm previous information that tuber-seed (certified or not) produced at 3000 m above sea level or higher are of good quality. Support continued for the Antisera Production project in Colombia for the member countries of the PRACIPA network.

Venezuela. An aphid trapping and identification study (M.Sc. Thesis) was continued to monitor spread and population dynamics of important virus vector species.

Paraguay. Research on tuber-seed production were conducted at the Experiment Stations at Caacupe and N. Talavera. Studies were made of micropropagation and rapid multiplication to refine the technology for producing potato seed-tubers of high-quality. About 6000 high-quality seed tubers of four commercial varieties were produced at the Caacupe Station.

Peru. Through a collaborative effort of the National Agricultural Research Institute (INIAA), the Universities, and the non-governmental organization Arariwa, 1,208 t of basic seed were produced for participants in the national system for basic seed production. Seed research activities in Peru concentrated on four areas: selection of improved genetic materials, seed production agronomy, micropropagation efficiency, and virus spread studies in seed fields.

Bolivia. A prebasic seed program of PROINPA was started in March, 1990. During the first year, rapid multiplication techniques were used in the greenhouse to multiply nine native varieties that had been cleaned-up at CIP. The rapid multiplication technique was used on plants derived from in vitro plantlets and from first generation tuberlets produced in the greenhouse.

Jamaica. Tissue-cultured plantlets of the three potato cultivars were micropropagated and transferred to an insect-proof screenhouse. Virus testing showed a relatively low virus contamination (1%). Aphid population in the field was also monitored.

China. In the Yunnan Province, three new basic seed units with adequate equipment and personnel for tissue culture and rapid propagation work were inaugurated and will be used to produce basic and elite seed. In 1990, a total of 100,000 seed tubers of improved cultivars were produced and stored, and 55,000 minitubers were expected to be harvested. Meristem culture after thermotherapy was used to eliminate virus pathogens from the most common local varieties, Mira and Purple Skin. More than 400 in vitro plantlets have passed PVX, PVY and PLRV detection tests by ELISA and will be used for rapid propagation. In the Guangdong Province, large scale production of in vitro tubers continued at the Zhongshan Biotechnical Factory. Technical conditions such as temperature, light intensity and contamination control have been improved. It is expected that the goal of the program to produce one million micro-tubers will be reached in 1991.

Surveys on the occurence of virus diseases and its influences on yield were conducted in Benguet, the Philippines, and Yunnan and Sichuan, China. The survey in the Philippines was conducted on 63 farms at an altitude of 2000-2300 masl. Visual symptoms were noted and leaf samples were tested thru ELISA test. Data showed that some farmers had kept their Granola seeds for 12 years. The most prevalent viruses were PVX, PVS, and the mixture of PVX and PVS. PVY was not observed, and 50% of the farms were found to be virus free. In China, the survey was conducted on 157 farms in four cities/counties of Yunnan and three counties of Sichuan. Viruses PLRV and PVY were widespread in Yunnan; PVS and PVM in Wenchuan; and PVY and PLRV in Liangshan and Wanxian Region of Sichuan. Local clones from Yunnan were mostly infected with PVS and PLRV.

Development of Sweet Potato Propagation Methods

Environmental effects on flowering

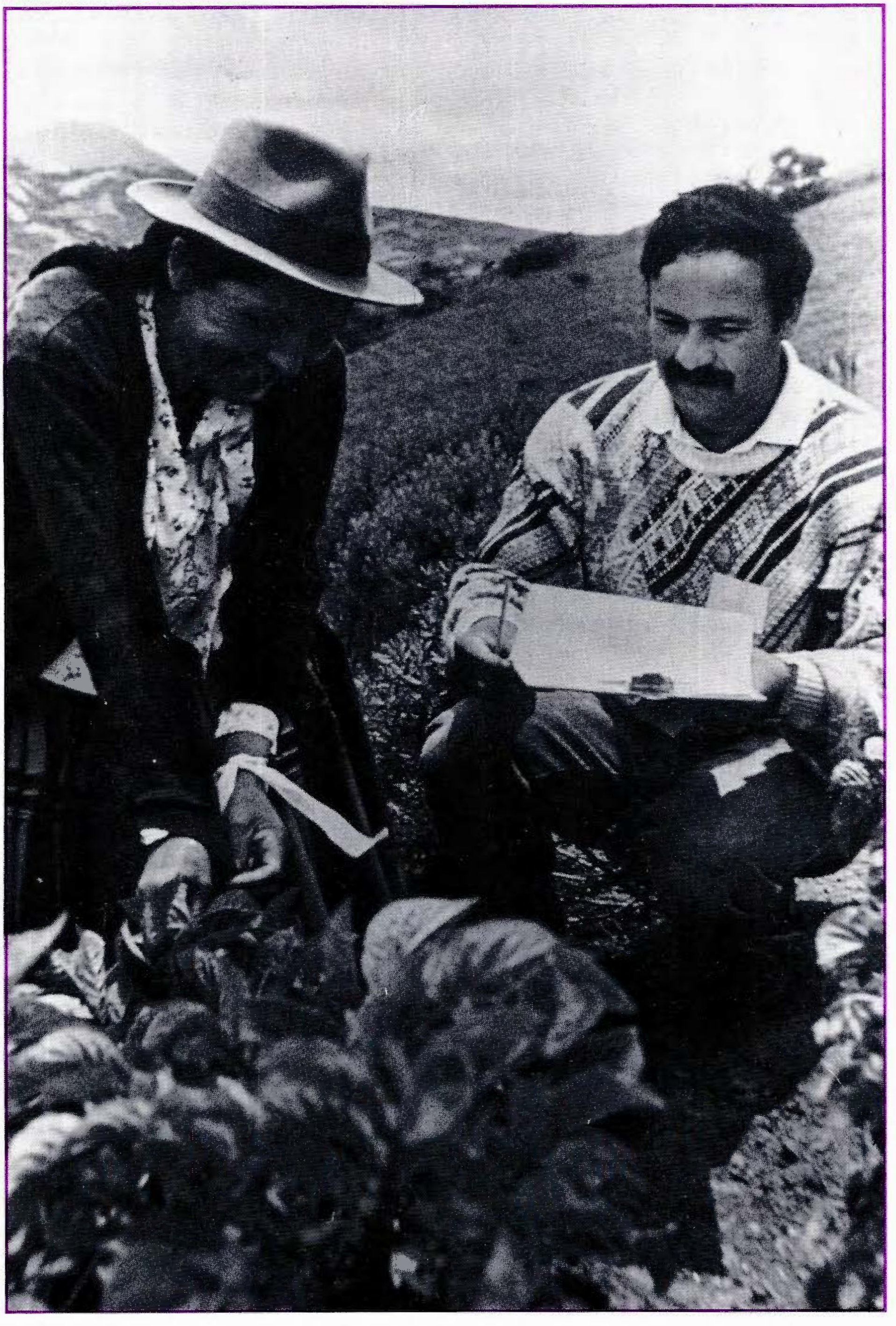
Peru. Experiments were conducted in Lima, San Ramon, Tumbes and Cajamarca, which collectively represent a wide range of photoperiods. The developmental responses of selected sweet potato cultivars under natural field conditions were evaluated at all locations. These evaluations were complemented by an experiment under controlled photoperiod and light conditions. These involved the use of filtered red, far-red and blue light, as well as incandescent (high levels of red) and fluorescent lamps (high levels of far-red light). Although sweet potato is usually considered a short-day plant, the results of these preliminary experiments indicate that cultivars may have short-day, long-day, day-neutral, and intermediate-day responses.

Multiplication methods for sweet potatoes

The Philippines. The possibility of using rapid multiplication techniques for sweet potato propagation is being explored. The study aims to develop a package of technology for the use of single-node cuttings (SNC's) for sweet potato production and to assess the influence of several factors on rooting, growth, and yield, both in the nursery and field. Thirty-nine clones were evaluated using SNC's.

Kenya. At the Mtwapa Research Station, located in the coastal region, 25 cm apical cuttings obtained from the nursery and from multiplication fields were used to evalate some agronomic practices related to plant establishment, growth and yield of sweet potato. Also, at Mtwapa, several practices were investigated for improving sweet potato propagation efficiency. The removal of leaves on the apical cuttings (leaving only the young leaflets on the top) provided for more marketable roots/hill, gross yield, and marketable yield of the var. IITA 222/77. This variety performed better than did the local variety Mtwapa 8, both in terms of marketability and gross yield. Similarly, earlier canopy development was promoted, producing a full canopy 43 days after planting when expanded leaves were not removed from cuttings at planting time. The var. IITA222/77 covered the soil more quickly, and produced more roots along the trailing vines as compared to the local variety. IITA 222/77 can thus be harvested by "priming" or harvesting only the large roots, with the smaller ones harvested as they enlarge. However, the root skin appears to be delicate and sensitive to bruising during harvest and afterward.

Facilities have been installed at Muguga Plant Pathology Section to clean up all the Kenyan germplasm to be used for evaluation trials and propagation. Thermotherapy is being used to produce the first clean plantlets through meristem-tip culture. These facilities could be used in the future for potato and sweet potato germplasm coming from the other programs of the Region.



Farmers' evaluations are important part of potato research in Bolivia.

Thrust X

Food Systems Research

Thrust Profile: 1991

THRUST ACTIVITIES had two major focuses 1) research on needs and impact assessment, especially through food systems characterizations, marketing, demand, and utilization studies, and 2) strengthening of national research capacity through formal training courses, workshops, and on-the-job training in collaborative research. Thrust X also shares research findings through books, reports, conference papers, and learning materials.

Needs assessment for sweet potato was a major focus and findings indicate the overwhelming importance of sweet potato in China and, to a considerably lesser extent, in other Asian countries. Agroecological data show that the subtropical belt stretching from northern India to southern and central China is the most important sweet potato-producing area, where the crop is grown in summer or autumn. Large amounts of sweet potato are also grown as an important summer crop in temperate environments in China. Sweet potato is also grown extensively in the hot humid tropics of southeast Asia and Oceania and in the sub-humid savanna climates of east and southern Africa. Sweet potato adapts better to elevated areas, and it is probable that more accurate data will reveal the importance of the mid-elevation tropical environment.

Although sweet potato is widely adapted to different environments, three major food systems are associated with the crop 1) extensive, rainfed, fallow systems in which sweet potato is grown as a co-staple or seasonal staple and is marketed on a small scale; 2) intensive systems, often with use of irrigation, in which sweet potato is an important cash crop and is marketed in large urban centers; and 3) home garden systems in which sweet potato is one of several crops grown on a small-scale for household consumption. The global survey of constraints highlights the need to develop alternative markets and uses for sweet potato, if these systems are to expand production. Country-specific case studies on sweet potato marketing and demand in Argentina and the Philippines indicate the need for processing research to generate additional demand for this commodity.

Needs assessment work also continued for potato. An analysis of time-series statistics for the last three decades points to the impressive growth in output in Asia, which produces over 75% of the potatoes grown in developing countries. The constraints survey ranked planting material, marketing and demand, and control of viruses as the highest priorities.

At the country level, seed-oriented potato research in Bolivia concentrated on characterizing variety use and production practices, and especially on understanding farmer seed management and replenishment, as a basis for developing an appropriate seed production and distribution scheme. The Semilla e Investigacion en Papa (SEINPA) seed project in Peru focuses a major part of its effort on developing seed distribution systems in the northern and southern sierra.

Potato marketing studies emphasized the production of learning methods related to methodology. Two further case studies were carried out in Indonesia and the Dominican Republic. A synthesis of research findings for sub-Saharan Africa was also prepared.

The Thrust continued to give major attention to building national capacity in food systems research, both through formal workshops and courses, and through specially funded hands-on training and the networking activities of UPWARD and PRACIPA.

As available resources for investment in agricultural research become increasingly scarce and as the negative effects of agricultural intensification on natural resources become better understood, there is an increasing need for analysis of the ecologies and farming systems in which potato and sweet potato are grown, as well as of the wider food systems and the policy environment that strongly influence the outcome of technological change. Food systems characterization seeks to narrow this knowledge gap and to identify priority problems and research needs through the involvement of technology users in the diagnostic process.

Sweet Potato

Needs assessment and priority setting are particularly important for sweet potato, a crop that has received little systematic research attention as compared with most other major world food crops. Thus, thrust needs assesment studies emphasized sweet potato.

At the global level, Food and Agriculture Organization of the United Nations (FAO) statistics were used to identify trends in the location and evolution of production. A CIP-administered survey identified major constraints to increased output and utilization as well as major agroecological zones for sweet potato production in developing countries.

FAO statistics. Analysis of revised production data for the period 1961-88 showed that over 90% of global sweet potato production is in Asia, and over 80% in China alone. Seven of the ten largest sweet potato-producing countries are in Asia, and ten countries account for 98% of the increase in sweet potato production in developing countries over the last three decades.

These findings suggest that the demand for new sweet potato technologies is likely to be strongest in Asia, which is home to the vast majority of the producers and consumers of the commodities such technologies can produce.

Agroecological zones. Although diagnostic research efforts in sweet potato have began only recently, the agroecological distribution of the crop can be broadly characterized. Table 10-1 summarizes the crop distribution for the different continents, as located in eight agroecological zones based on the Köppen classification of climates. Since Chinese production dominates world production (about 80%), the distribution excluding China is also calculated.

When China data are included, production in the subtropical environment (Ca) is

Table 10-1. Percentage share of sweet potato production (1986-88) by agroecological zones.

Continent	Humid tropical lowlands AF + AM	Semi-arid tropical lowlands AW	Arid areas Bs+BW	Sub-tropical lowlands CA	Tropical highlands CB	Sub temperate D+DA+DB	Total (%)
Latin America	2	46	22	26	4	0	100
NaWa	0	0	100	0	0	0	100
Asia (excluding China)	50	20	0	22	2	7	100
Oceania	13	14	0	0	73	0	100
Sub Sahara Africa	9	60	0	0	32	0	100
Total developing	4	5	6	62	2	22	100
Total developing (excluding China)	28	37	3	14	15	1	100

extremely important, as it is with potato. Where potatoes are planted in the cool winter season, sweet potato is primarily a summer or autumn crop. An exception is the extreme south of China, where approximately 10% of China's sweet potatoes are planted during the autumn and winter seasons. Over 25% of China's sweet potato production has been provisionally identified as growing in the temperate zone, especially in the lower Yellow river valley in Shandong province.

If calculations exclude the China data, both the hot humid (Am + Af) and the semi-arid climates (Aw) become important: Am + Af in Southeast Asia, Aw in Africa. It is probable that these estimates for the humid and semi-arid tropics include some mid-elevation production areas. Sweet potatoes are often grown on higher ground, at altitudes between about 500 and 2000. This suggests that the Af, Am, and Aw zones may be somewhat overestimated, and that the highland category (Cb) is probably underestimated. The arid environments (BW and BS) are of limited importance for sweet potato.

CIP constraints survey. A team of social and biological scientists surveyed national program personnel to capitalize on the abundance of location-specific knowledge about agronomic, biological, and socioeconomic constraints to expanded sweet potato production and use. They were asked about the importance of 73 specific constraints grouped into 12 categories. During 1990, 20 surveys from 22 additional sites were incorporated into the existing database. As a result, the final sample consists of 70 completed surveys from 45 countries, representing 198 sites. According to FAO statistics, these countries account for 99% of the production of sweet potatoes in developing countries.

National program scientists ranked postharvest problems as the most important (Fig. 10-1). Marketing, demand, and environmental problems were seen as major constraints to expanded production of sweet potatoes. Varieties, fungal and bacterial diseases (with one notable exception), nematodes and insects were all considered of minor or no importance when considered as groups or as individual constraints. Planting material and storage were ranked as intermediately important.

Results of the constraints survey were presented and discussed in thrust meetings during 1990 to better integrate research

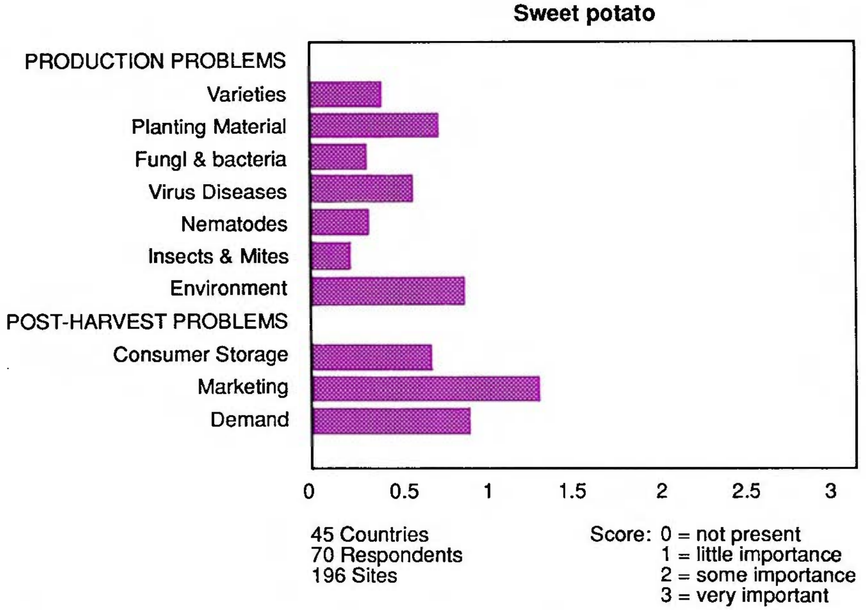


Figure 10-1. Perceptions by NARS scientists of constraints to sweet potato production and use (weighted by developing country production).

projects and priorities with the perceived needs of our partners in developing countries. Production statistics, agroecological data, and responses to the constraints survey are being integrated in further studies to obtain a clearer understanding of these needs.

Sweet Potato in Asian Food Systems

India. About 80% of Indian sweet potato production lies in the subtropical northern Indo-Gangetic plains (Ca climate). Sweet potato is usually grown as an irrigated, rainy season crop although tube wells are also used for irrigation. Planting is in June-July and harvesting occurs during November-December. In the majority of rotations, sweet potato is preceded by wheat or summer fodder crops and followed by wheat, sugar cane, or winter vegetables. The three important cultivars grown in the area are Dholi, Kali-Satha, and Mungia; the first two are early maturing (70-80 days) whereas Mungia matures in about 110-120 days.

Land preparation is done before the on-set of the monsoon rains. Some of the farmers apply nitrogen fertilizer at planting, but planting material is the most expensive input. Two hand weedings are generally necessary during the season. After harvesting, roots are cleaned, pruned, and graded. Almost all production is marketed both locally and in Delhi. Nevertheless, all farmers eat small quantities as snacks or vegetables.

Major production constraints identified by farmers were scarcity of planting material, high cost of vines for seed, insects, late maturity of varieties, weeds, and rats. Demand/marketing constraints included lack of processed products, limited availability, unstable prices, and flatulence/gastric problems associated with the crop.

The Asian ***UPWARD (User's Perspective with Agricultural Research and Development) Network.*** UPWARD research concentrated on three main areas 1) baseline studies of sweet potato; 2) sweet potato consumption, food habits, and nutrition; and 3) postharvest utilization and marketing.

Baseline studies attempted to understand sweet potato production locally or within the national food systems of different countries. Research projects were developed and funded for the Philippines, Nepal, Thailand, Sri Lanka, and Vietnam. Although Asia and the South Pacific show great diversity of sweet potato production systems, general patterns emerged. Three main Asia-wide systems have been identified 1) extensive, low-input production; 2) intensive, high input production; and 3) household gardening or specialized econiche production.

Sweet potato production cannot be fully separated from the rice-based food system within which sweet potatoes have a secondary, but integral role. The crop is rarely valued as a staple, however, except in remote, mountainous areas inhabited by tribal, unassimilated populations. Nevertheless, sweet potato has many functions, such as erosion control, marginal space utilization, secondary income for women, and as animal feed. It grows in many cropping systems (relay cropping, intercropping, mixed cropping, and backyard gardens).

The overwhelming farm-level constraint is the weevil (*Euscepes postfasciatus*). Although CIP and other agencies are investing heavily in breeding programs to develop natural resistance to the weevil, UPWARD research results indicate that farmers in Asia have already discovered ways to "live with the weevil," while obtaining satisfactory production levels (maximization of yields is rarely the major objective of sweet potato producers). Control methods include planting sweet potato on flooded lands, either after paddy or by specifically inundating an area to eliminate the pest; using early maturing varieties (e.g. 3 months at harvest) or harvesting the crop early and; using infested sweet potato roots for animal feed (mainly swine).

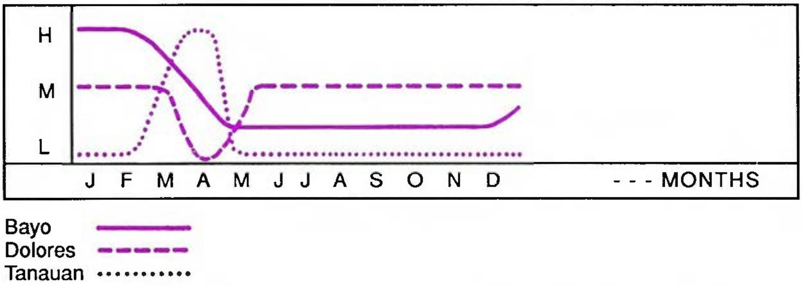
Fieldwork in the northern Philippines revealed that sweet potato is a "woman's crop"; that is, women are the primary producers and know more about all aspects of the crop than men do. Except for fencing of gardens, which is "men's work," most of the farming operations are performed by women. The crop is often planted in marginal microenvironments that cannot be used for other crops.

Comparative studies of consumption showed sweet potato has different dietary functions for different users' groups at different times of the year (Fig. 10-2). Such findings indicate that blanket generalizations about sweet potato consumption are oversimplified. In the diets of Filipinos, the sweet potato serves as 1) staple; 2) buffer or famine food; 3) secondary or seasonal energy source; and 4) diversification food and nutritional supplement.

In the Philippines, sweet potatoes are consumed as a staple only by cultural minorities located mainly in their ancestral lands in the northern islands. Sweet potato consumption contributed up to 80% of the annual food supply among the Ifugaos in the 1960s. Little is known about staple sweet potato consumption; however, it appears that as roads and market penetration expands, farmers and consumers shift to other crops, especially rice.

The reputation of sweet potato as a buffer food, particularly during Word War II, revived as a result of the 1990 Philip-

Relative frequency of sweet potato tuber consumption



High (H) implies sweet potato is consumed several times (up to 3) per day.
Medium (M) implies regular consumption several times per week.
Low (L) implies infrequent or no consumption.

Figure 10-2. Seasonality in frequency of sweet potato consumption in three Filipino villages.

pine earthquake. Supplies of rice from the lowlands were cut off, and when rice prices rose there was a corresponding increase in the area planted of sweet potato.

In Luzon, as in many parts of Asia, sweet potato is often planted after paddy as an off-season crop. During the sweet potato harvest period, consumption increases dramatically to nearly two servings per day. Nevertheless, the "snack" is probably the most common form of consumption of sweet potato in the Philippines. This use undermines somewhat the "inferior good" thesis, since sweet potato snacks are highly appreciated by all strata.

Post-production studies were a major part of all UPWARD baseline research in Thailand, the Philippines, Nepal, and Sri Lanka. In Indonesia, a special study on processing and marketing of sweet potato products was conducted by the Indonesian national program. The study revealed that more than 2000 tons of sweet potato were processed annually in west and central Java . At least 7 sweet potato products have been developed. The major constraint for agroindustrial processing was the lack of a secure supply of fresh, raw material.

Sweet Potato in African Food Systems

In characterization of sweet potato in African food systems, efforts were concentrated on two major areas 1) developing a systematized database on the crop, using FAO data sources, disaggregated national data sets, and "grey" literature from within the region; and 2) assisting researchers in conducting or supporting surveys of sweet potato farmers to better understand the production and utilization systems and the associated problems and research opportunities.

In Kenya a joint survey by national program and CIP personnel was completed and analyzed for 24 districts. Farmers were selected from a cross section of geographic regions and agroclimatic zones (Table 10-2). Sweet potatoes are grown in three broadly defined areas of Kenya, the most important being the densely populated, mid-elevation (1,300 m-1,900 m) region of western Kenya, up the slopes from Lake Victoria. The complexity of the agroecological zones indicated in Table 10-2 underlines the

Table 10-2. Kenya: Distribution of sample farmers by agroecological zone.

Description of agro-ecological zones	Percent of sample
Wet highlands 1,800 - 2,200/2,400 m	6.6
Drier highlands 1,800 - 2,200/2,400 m	3.8
Wet upper-middle elevation 1,300/1,500 - 1,800/1,900 m	37.0
Drier upper-middle elevation 1,300/1,500 - 1,800/1,900 m	15.4
Wet lower-middle elevations 800 - 1,300/1,500 m	14.9
Drier lower-middle elevations 800 - 1,300/1,500 m	11.6
Wet lowlands	0.0
Drier lowlands 0 - 800 m	11.5

difficulties encountered when using the "tropical highlands" category of the broader agroecological classification described earlier. The second most important area is the highlands of central Kenya, which are also densely populated. Sweet potatoes are grown both as food and animal forage. The third important area includes the semi-arid belts of central and coastal Kenya. Sweet potatoes are now a relatively minor crop in this region, but as population pressure increases, the government is interested in promoting food-security crops.

Although sweet potatoes are classified as a "subsistence crop" in Kenya, Figure 10-3 indicates that they are also an important source of cash income for many low-income rural families. The most common outlets are local retail markets, where women sell sweet potato to meet immediate needs. The crop is stored in the ground and can be harvested and sold frequently in small quantities over an extended period. Sales frequencies of once or twice a week are common.

The major constraints faced by farmers throughout the country are listed in Figure

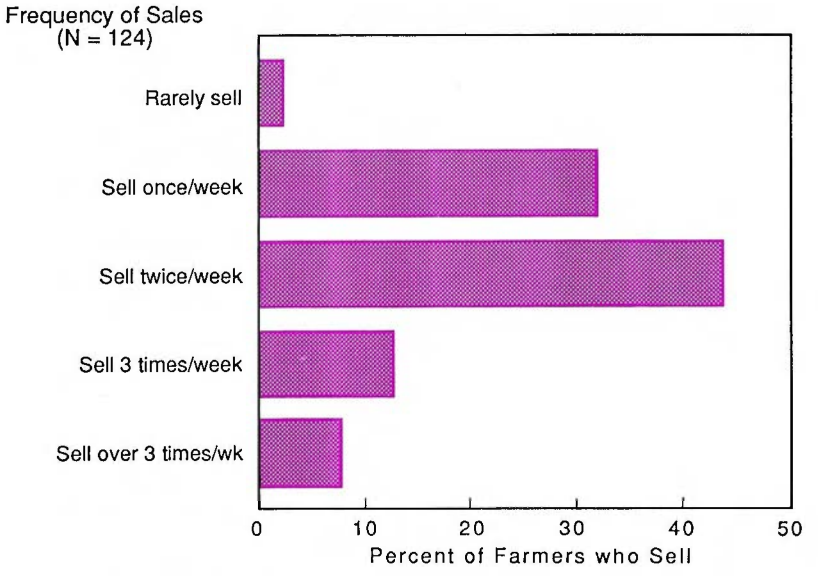


Figure 10-3. Kenya: Sweet potato marketing by farmers' frequency of sales.

10-4, which shows both the percent of the farmers reporting each problem and its average severity on a scale of 0 to 3. Disaggregation of this data shows that certain constraints are associated with different areas. Moles are a problem in cool, moist areas. In semi-arid zones, the big problems are drought, weevils, and shortage of planting material at the beginning of the dry season.

A wide diversity of landraces of sweet potatoes are grown by farmers in Kenya. Morphological descriptors were registered for 505 sweet potato varieties in farmers' fields and 220 varieties in collections at research stations, and a preliminary analysis was made. Most farmers grow 3 to 7 varieties, usually with all varieties in the same field. They grow red-skinned, white-fleshed, or white-skinned, white-fleshed varieties, and they prefer firm-fleshed, moderately sweet types.

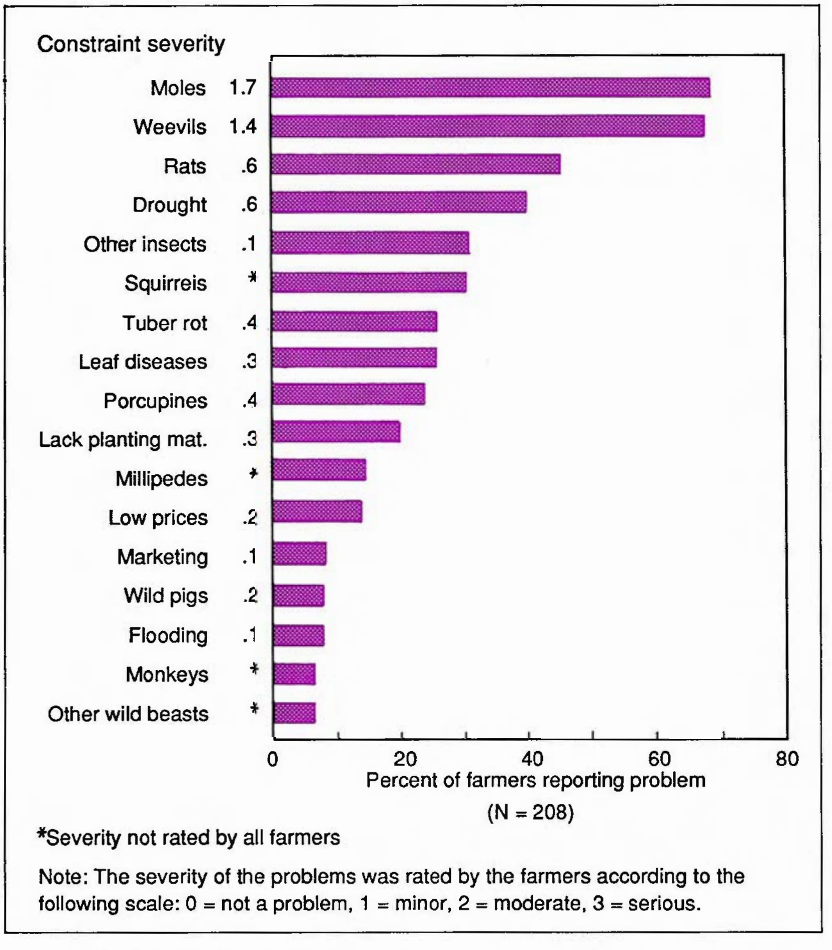


Figure 10-4. Kenya: Frequency and average severity of major constraints in sweet potato production.

Sweet Potato in Latin American and Caribbean Food Systems

Food-systems characterization of sweet potato and assessment of research needs over the past three years has provided an overview of the crop within Latin America and the Caribbean.

As shown in Table 10-1, lowland sub-humid tropics (Aw climate) is the most important environment for sweet potato in Latin America, accounting for approximately 46% of production. This environment includes much of northeastern Brazil, northern Paraguay, parts of Peru, and much of the Caribbean, and is characterized by the potential for year-round production. However, drought stress can be a problem where no irrigation is available during some parts of the year, and the cropping season is, therefore, restricted. Sweet potato weevil is prevalent, especially in the non-irrigated fallow systems.

Within these sub-humid conditions, sweet potato is grown in a range of cropping systems. These include low-input fallow systems (both monocropped in rotations and intercropped), and irrigated systems, as a filler crop on banks and in hedgerows. Sweet potato is also common in kitchen gardens, where it is planted together with a wide range of plant and tree crops; it is harvested as needed, with the same plant often continuing to produce for over two years.

The subtropics cover much of what is known as the southern cone of Latin America. An important system covering central Argentina and Uruguay can be termed a "temperate fallow system," which is determined by the cold winters that prevent year-round production in this area. A major disease problem associated with these conditions is black rot (*Plenodomus destruens*), which infects the sweet potato in nursery beds, in the growing crop, and postharvest storage.

Farmers report few problems with pests or diseases in arid climates, but lack of adequate irrigation can cause drought stress, especially at planting, and sometimes the soils in arid areas have very high salt concentrations, as on the coast of Peru.

Although sweet potato seems to be of very limited importance in the lowland humid tropics of the Amazon rainforest, it does have a role in the production systems of the southern Caribbean islands, which have the same type of environment.

Sweet potato has been found to be a highly versatile crop that adapts to different kinds of food systems. Sweet potato is found in three principal systems.

Metropolitan systems link commercial food producers in rural areas with large concentrations of urban consumers, whether direct consumers of the fresh product or processors of the crop. Examples include Buenos Aires, Montevideo, Asunción, and Lima, although sweet potato is not a general urban food staple in any of these areas. It may be a starchy staple for specific sectors of the urban population but usually it is a specialized food for use in a specific dish; for example, "puchero" in Argentina, and "cebiche" in Peru.

Local systems involve small-scale production of a mixture of food crops for household consumption and for irregular small-scale sales to local or sometimes regional markets. Examples include northern Paraguay and the mid-elevation environment of northern Peru, as well as many of the Caribbean islands.

Subsistence systems mainly involve very small-scale production of food crops in home gardens, to supplement the household diet. There is little or no marketing of the product although production may be distributed to relatives and neighbors.

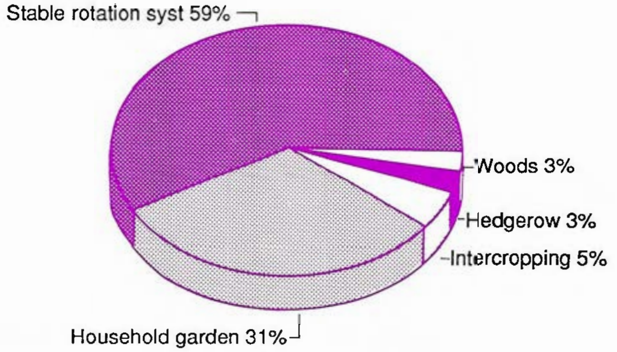
Argentina. In a survey of three regions of Argentina, needs identified at San Pedro and Cordoba included the need for detailed research on management of diseases in seedbeds and at transplanting. An on-farm research project involving farmer selection of healthy plants to harvest for seed has been prepared and awaits funding. The surveys suggested the general need for study of the incidence of fungal and bacterial diseases that occur in seed production and during germplasm conservation. Current conservation methods involve substantial losses, and alternative techniques are needed.

The survey in Tucumán highlighted the wealth of germplasm and germplasm knowledge among farmers in those regions more distant from the Buenos Aires market, and the importance of tapping that knowledge. In collaboration with national scientists and CIP's Genetic Resources Department, a small survey of farmer practices and of their knowledge was included with the normal passport data sheets in a germplasm collecting expedition in northern Argentina. Figure 10-5 shows the range of data collected on production systems and varietal characteristics.

Paraguay. SEAF extensionists and CIP scientists studied the socioeconomic importance of the sweet potato in the districts of Nueva Italia and Coronel Oviedo in 1988 and 1989, and this year they continued to study it in the departments of Presidente Hayes, Ñeembucu, Paraguari, and Concepción. The findings are being used to plan future sweet potato research.

Several general characteristics of sweet potato production and utilization in Paraguay have been identified:

- Sweet potato is consumed throughout the year (if available) in most Paraguayan households; however, consumption increases during the three-month summer period when manioc (the principal staple) production decreases. During the summer, consumers eat sweet potato much more regularly, often 3 to 4 times per week, replacing or supplementing manioc consumption. In the northwest (the "Chaco") sweet potato is a staple food.



Zone, Corrientes, Misiones, Chaco, Formosa

Figure 10-5. Sweet potato cropping systems, N.E. Argentina (%).

Sweet potato harvest in Central America.

- Most commercial production is centered around the capital city of Asunción, with smaller-scale local systems found near regional and local marketing centers.

- Sweet potato wholesale and retail prices are always higher than manioc prices. Highest sweet potato prices occur during the period of peak demand, in the off-season for manioc.

- Relatively few varieties of sweet potato are available for consumers to purchase. The most common variety marketed in Asunción is round, with white skin and flesh.

- Major problems included the instability of planting material supplies in some areas.

Peru. On the arid coast of Peru, research included farmer evaluation of sweet potato germplasm, in terms of foliage and roots. For farmers (mostly commercial) involved in the study, foliage is an important component of animal fodder; nevertheless, they generally gave more importance to root evaluation.

The degree of attention given to the foliage varies during the year; when foliage is abundant farmer-evaluation criteria are applied much more rigorously. Both leaves and shoots are considered in foliage evaluation. Bulk is obviously an important consideration, especially in the leaves which are more favored as fodder. But quality is also an important factor. Extreme hairiness in the leaves can make the foliage inedible for the cattle. Farmers gave little importance to fibrous or dry shoots which cattle tend to avoid. The results on foliage color were inconclusive. Some farmers suggested that cattle preferred to eat deep-green foliage, rather than foliage of other colors.

Criteria used by farmers in the evaluation of roots of different varieties fell into three groups: production, appearance and handling. The relative importance of these three groups is variable through the year. When the market is well supplied and prices fall, the appearance of the variety becomes very important. In times of scarcity, production counts more. But even when evaluating production, farmers did not simply count kilos. The number of roots per plant and the size of the roots were major criteria, though other aspects of production such as uniformity and earliness were also considered. Another important criterion that can eliminate a variety from adoption is rapid sprouting after harvesting. The apparently low number of observations for this criterion in Figure 10-6 is misleading, since only one of the clones used in the trials had this characteristic, and all but one of the farmers evaluating the clone commented negatively on it.

Key criteria when evaluating for appearance included skin color, flesh color, the form or shape of the root, and the external appearance (shininess, smoothness, undulations, pitted surface due to insect damage).

Although a few clones and varieties such as Mochero, ST87122, and Huarco were unanimously selected by the farmers, there were other differences among the varieties selected by the farmers from the different agroecological

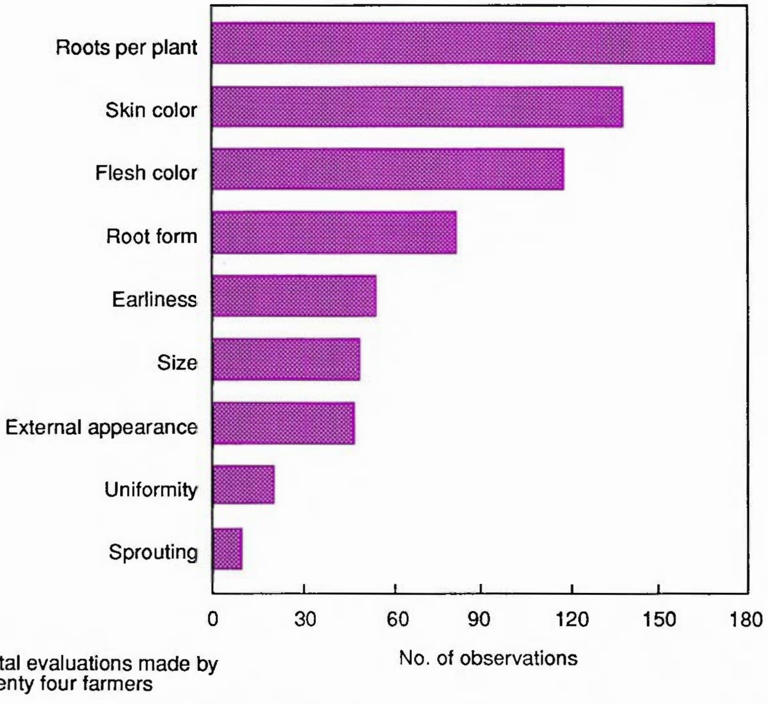


Figure 10-6. Frequency in use of different criteria during evaluations of sixteen clones/varieties by Cañete farmers.

zones of the valley where the trials were conducted (Table 10-3). Their choices reflect the different conditions in these zones and the distinct preferences noted among farmers. Some varieties selected (Tambeño) were not the highest yielders, but had other attractive characteristics, such as color and form. Farmers of the commercial areas, which include the central and saline zones, strongly preferred Jewel, a variety also grown in the United States. Jewel scored highly for shape, flesh and skin color, and was also one of the best yielders. Because of the selections by farmers in these trials, Jewel is to be the first officially released Peruvian sweet potato variety.

The Dominican Republic. To identify research needs, especially the characteristics and problems of sweet potato weevil, surveys were conducted in the important Dominican growing areas. More than 90% of the producers in the San Juan valley, (the second most important sweet potato-producing region in the Dominican Republic) have access to irrigated land and their sweet potato plots average 3 ha. In the rotation system, rice is often followed by sweet potatoes and then by red beans. These are the three most important crops economically for the San Juan farmers. Whereas rice and beans are also the most important subsistence crops, sweet potato is grown mainly as a low-cost cash crop.

Most farmers sell their product to the market in the capital city, either directly or via intermediaries. Nevertheless, about two-thirds of the farmers use some of the production as household food, and one-quarter of them use it for feed. An important alternative outlet is the export market, but only for specific varieties.

The sweet potato weevil, fluctuating prices, and unstable markets were identified as major problems by half the producers interviewed. Lack of irrigation water was another important problem.

Sweet Potato Marketing and Demand

Studies on sweet potato marketing and demand were the focus of contract research in Argentina, through the Institute of Economic and Rural Sociology (IES) of the National Institute for Agricultural Technology (INTA), and in the Philippines, through the International Food Policy Research Institute (IFPRI).

Table 10-3. Varieties preferred by farmers on the basis of evaluations in Cañete valley.

Varieties	Skin color	Flesh color	Form	Yield Total	s	Commercial	%	Zone[a]
Jewel	orange	orange	Elliptic	28.6	14.5	22.1	77.2	CS
Valdivia	dark purple	yellow	Round	27.2	7.4	22.6	83.0	S
Tambeño	dark purple	yellow	Round	11.0	3.0	8.0	72.7	S
Huarco	yellow	yellow	Round-elliptic	23.7	8.0	16.3	68.7	MCS
Kon-tiki	red	orange	Long-elliptic	27.5	8.5	20.2	73.4	MC
ST. 87122	cream	yellow	Round	23.8	10.5	16.1	67.6	MCS
Mochero	yellow	yellow	Oblong	28.7	10.1	20.4	71.1	MCS
LM. 88107	red	cream	Long-oblong	32.4	9.4	18.8	58.0	MCS
Jhonthan (central)	cream	orange	Round	24.8	11.0	21.0	84.6	MCS

[a] agroecological zone: C=central, S=saline, M=marginal

Argentina. Sweet potato production in Argentina has fluctuated drastically during the last three decades. Output stood at 388,000 t in 1961, rose to 479,000 t in 1973, fell to 246,000 t in 1980, rose again to 461,000 t in 1988, only to fall again to 311,000 t in 1989. Nearly all (99.8%) of sweet potato production is for sale in the domestic market; less than 0.5% is exported. Knowledge about the quantity of sweet potatoes utilized for processing and about the potential market for processed products is limited, as a result of the severe crisis that has affected the general economy for nearly a decade. Buenos Aires' central wholesale market handles roughly 60,000 t of sweet potatoes a year, with peak months from May to August and a drastic drop in supplies from November through January. Price movements largely reflect the availability of supplies, i.e. prices are lowest in months of abundance and highest in months of shortage. Most sweet potatoes are washed prior to arrival at the MCBA, and these roots receive prices 10% to 40% higher than unwashed roots and are particularly high in periods of abundant supply. Wholesale prices for sweet potato were generally higher than those for potatoes (16%) and carrots (17%) during 1985-88; however, on a cost per unit of protein and calories basis, sweet potatoes are cheaper than any other horticultural crop, e.g. potato, carrot, squash, cassava.

These findings suggest that lack of demand for sweet potatoes in Argentina represents a barrier to future expansion of the sub-sector. Current utilization is largely confined to human consumption, with little apparent industrial use; this is apparently because of the high price of sweet potatoes. According to wholesale prices in Buenos Aires, sweet potatoes are roughly 15%-20% more expensive than potatoes.

Better collection and diffusion of information is needed on area planted and prices in order to improve current marketing procedures, and to minimize annual fluctuations in production and in returns to growers and thus to reduce the economic risk associated with planting sweet potatoes. Improvements in storage and availability of planting material are also needed to enable growers to take advantage of well established, within-year fluctuations in sweet potato prices.

The Philippines. Sweet potato is an inexpensive source of diversification in the average Filipino diet. Rice is the basic staple food, and corn is the less expensive alternative. According to the First Nationwide Nutrition Survey of 1978, annual per capita sweet potato consumption was 6.2 kg among rural consumers and 3.3 kg among urban consumer. For the average consumer in the Philippines (rural and urban), sweet potatoes represent less than 1% of budget expenditures.

In studies using data from the nutrition survey to generate price and income elasticities for sweet potatoes, it was found that when the price of rice or vegetables goes up, people react by purchasing more sweet potatoes, i.e. cross-price elasticities are positive. Thus, as staple foods and vegetables become more expensive, people simply have to spend more money on sweet potatoes, a less preferred food. Higher incomes for Filipino consumers result in only minor increases in sweet potato consumption, e.g. a 1% increase in consumer income would result in a .01% increase in sweet potato consumption.

Although sweet potato consumption is not very sensitive to changes in income, it is sensitive to changes in the price of this commodity. Thus, a lower price for sweet potatoes would result in a more than equivalent rise in sweet potato consumption, and higher prices would lead to less consumption.

These findings suggest the need to develop alternative uses for sweet potato, if increases in production are to be properly absorbed by the market.

Sweet Potato Utilization

The book "Sweet Potato: an Untapped Food Resource," which is to be published by Cambridge University Press, is now in final draft form.

Potato

FAO Statistics. Needs-assessment research on the potato continued to refine knowledge about production patterns and trends, which complements FAO information about constraints to expanded output and use obtained in the constraints survey. Further work is under way to elaborate a typology of potato-producing countries, based on revised and extended FAO time-series data on production, area, and yields.

Analysis showed that 75% of the developing world's potatoes are produced in Asia; this figure is up from just under 70% in the early 1960s (Table 10-4). Asia accounted for about 80% of the increase in potato production and nearly 80% of the increase in area planted in developing countries from 1961-63 and 1986-88. Fifteen of the largest potato producing countries account for nearly 90% of the developing world's potatoes, and they account for practically all of the increase in production and area planted since 1963. Conversely, 99 developing countries produce few (less than 10,000t annually) or no potatoes. Potato production in sub-Saharan Africa expanded more rapidly than did that of any other food crop, but the sub-region's output remains less than 5% of the total for all developing regions (Table 10-5). Despite average yields that have more than doubled since the early 1960s, Latin America's share of developing-country potato production fell by nearly 50%.

Table 10-4. Potato production, area and yield in developing countries by regions, 1961-88.

	1986-88			Change (%)[a]								
	Production	Area	Yield	Production			Area			Yield		
	(000 t)	(000 ha)	(t/ha)	1	2	3	1	2	3	1	2	3
Africa[b]	5,967	704	8.4	74.8	86.5	226.2	85.3	60.1	196.8	-5.6	16.5	9.9
(Sub Saharan)[c]	2,387	444	5.3	70.2	47.5	151.1	81.6	52.9	177.7	-6.2	-3.5	-9.5
Asia[d]	53,049	4,345	12.2	90.2	39.8	166.0	40.3	35.1	89.6	35.5	3.4	40.2
(China)	27,043	2,529	10.6	99.8	4.8	109.5	41.9	24.2	76.3	40.8	-15.6	18.7
Latin America[e]	12,228	1,045	11.6	29.1	31.8	70.2	1.2	1.1	2.3	27.5	30.3	66.3
Total	71,245	6,095	11.6	74.1	41.3	146.0	32.0	29.9	71.6	31.8	8.7	43.3

Source: FAO Basic Data Unit, unpublished statistics.
[a] 1=(1973-75 vs 1961-63); 2=(1986-88 vs 1973-75); 3=(1986-88 vs 1961-63).
[b] Africa not including South Africa.
[c] Africa - [Morocco, Algeria, Tunisia, Egypt, Libya] - [South Africa].
[d] Asia - [Israel, Japan] + Oceania - [Australia, New Zealand].
[e] North and Central America + South America - [Canada, USA].

Table 10-5. Food crop production in sub-Saharan Africa, 1961-63 vs. 1986-88.

Crop	1986-88 Production (000 t)	Area (000 ha)	Yield (t/ha)	Increase[a] Production (%)	Area (%)	Yield (%)
Cassava	59,054	8,312	7.1	86.1	46.9	26.7
Yams	23,518	2,339	10.1	74.4	14.5	52.4
Maize	18,511	15,438	1.2	93.2	45.3	32.9
Sorghum	14,714	17,060	0.9	47.8	32.5	11.5
Millet	10,053	14,440	0.7	45.1	22.4	18.6
Rice paddy	7,618	4,997	1.5	120.8	81.7	21.5
Sweet potatoes	6,193	1,198	5.2	83.1	87.2	-2.1
Bananas	5,261	1,133	4.6	85.3	105.8	-10.0
Groundnuts in shell	4,353	5,717	0.8	-12.6	-0.7	-12.0
Potatoes	2,388	445	5.4	151.2	177.7	-9.6
Wheat	1,704	1,166	1.5	88.2	-1.3	90.8
Beans dry	1,641	2,520	0.7	73.3	61.8	7.1

Source: FAO Basic Data Unit, unpublished statistics.
[a]1961-63 vs 1986-88.

Constraints survey. During 1990, constraint data from nine additional surveys representing 29 sites, were incorporated into the existing database. According to FAO statistics, these countries account for 97% of the production of potato in developing countries. Problems of planting material, marketing, and viruses are the most important constraints to potato production (Table 10-6). These findings reconfirm results of earlier research that point to the high cost of seed as the most important component of total production costs for potatoes. To the extent that the weighted averages give more importance to countries that produce more potatoes, there is concern about marketing as a constraint. Such countries have large quantities of potatoes to sell and thus have more to be gained (or lost) by selling them. Similarly, virus diseases constitute more serious problems for them than for countries which produce fewer potatoes for sale. Interestingly, nematodes are considered to be only a minor constraint. With certain notable exceptions (e.g. aphids) insects and mites, the environment, and demand were also of lesser importance. These findings can serve as useful benchmark information for setting priorities for potato research.

Characterization of Potato Production in Bolivia

A baseline evaluation of potato production in central Bolivia helped identify research needs and priorities for the PROINPA project. The interdisciplinary diagnostic surveys used rapid rural research methods. Seven surveys were made in potato-producing zones in the central and eastern regions of the department of Cochabamba, and two each were made in Potosi and Chuquisaca during the 1989-1990 agricultural year.

In Cochabamba, the primary varieties cultivated were the andigena types: Waych'a, Imillia Blanca, and Qoyllu, The Dutch import *Tuberosum* was also common. Farmers generally produced their

Table 10-6. Constraints to potato production and use. 12 groups of constraints for developing countries; scores are per country (54 surveys, 53 countries, 156 sites).

	Simple average		Weighted average[a]	
	Mean	Std.Dev.	Mean	Std.Dev.
Production problems				
Varieties	0.5	0.5	0.9	0.6
Planting material	1.6	0.8	1.7	0.7
Bacterial diseases	1.1	0.7	0.9	0.5
Fungal diseases	1.0	0.5	0.9	0.4
Virus diseases	1.2	0.7	1.4	0.5
Nematodes	0.5	0.6	0.2	0.3
Insects and mites	0.7	0.4	0.6	0.4
Environment	0.7	0.4	0.6	0.3
Postharvest problems				
Seed storage	1.3	0.7	1.0	0.6
Consumer storage	1.1	0.8	0.9	0.6
Marketing	1.7	0.7	1.4	0.6
Demand	0.9	0.6	0.6	0.3

Score: 0 : Not present
1 : Little practical importance
2 : Somewhat important
3 : Very important

Women play a crucial role in the evaluation of potato production, harvesting, and marketing.

own seed, and preferred seed sizes ranging from 30 g to 60 g. Selection of seed was based on the quality of the potato eye, sprouts, and tuber size and form. Seed-to-yield ratios ranged from 1:0 to 1:30. Major production constraints were biophysical (drought, frost, hail) and economic (high cost of inputs, low quality of seed available in markets, low prices, and lack of technical assistance). At field sites, the primary observable problems were thrips, *Epitrex* spp., symptoms of *Phytophtora infestans*, and Saq'o (a physiological problem with no known causal agent). Nematodes, both *Globodera* and *Naccobus*, were often found.

In Potosi and Chuquisaca, the Sani Imilla variety was most commonly grown. Tractors are more widely used for soil preparation than in Cochabamba, where oxen are common. Climatic and economic factors were major problems cited by farmers. Major pests were similar to those cited in Cochabamba, but more verruga and *Rthizoctonia* were observed.

Seed marketing was studied at two agricultural markets in the traditional potato-growing areas of Rodeo and Colomi, Department of Cochabamba. In Rodeo, production and sales are mainly of the andigena types. Approximately 40% of the seed produced in the area is sold by "trusted" farmers at the farmgate at a higher price, rather than in the market.

The primary variety sold in the market at Colomi is Imilla Blanca, which originates from traditional seed-producing zones in Candelaria and Melga. In Colomi most seed is obtained through the market as there is little participation of intermediaries and not many farmgate sales.

During the major agricultural harvest of 1989-1990, potato yields were evaluated in the departments of Cochabamba, Chuquisaca, and Potosí. Empirical data on the production and utilization of potato were obtained to orient projects and direct the eventual transfer of technology. In joint work with national programs scientists, 568 farm families were interviewed and their crop yields sampled.

Despite drought conditions that forced early harvests in many of the production zones, yields were found to average 14 t/ha in Cochabamba, 8.2 t/ha in Potosi, and 8.8 t/ha in Chuquisaca. This compares with a range of about 4.5 t/ha to 6 t/ha for the three departments, as recorded in official statistics. High percentages (29%, 60%, 82%) of farmers interviewed were currently working with potato projects, which may explain this great difference. More than 90% of all farmers in each department had produced the seed of the predominant variety growing in their field for 2 years or more. The majority of farmers originally obtained this seed from relatives, neighbors or friends, and sold some of their production for consumption (62%, 57%, 69%) or as tuber seed (11%, 2%, 14%).

Basic Seed Distribution—Peru

The SEINPA project continues to give priority attention to seed distribution which is felt to be the key to a successful seed program. Commercial seed multiplication and distribution, is concentrated in the central highlands, where increased terrorist activity has forced the Association of Seed Growers to disband after three encouraging seasons of seed multiplication. Some multiplication of seed continues on an individual basis in the Mantaro Valley and a new association has been formed in Canta, a valley to the north of Lima.

Informal or traditional basic-seed multiplication and distribution is now concentrated in the northern and southern highlands. In Cajamarca, multiplication and distribution of basic seed is being carried out by provincial committees of the peasant self-defense groups ("rondas campesinas"). Both seed tubers and seed sprouts are being used by 35 committees in five provinces of the department. In Cuzco, committees have been formed to take charge of multiplication and distribution in two types of communities 1) communities that receive no external assistance, and are coordinated directly by the Program, and 2) communities that are linked to governmental or non-governmental development projects.

Potato Marketing and Demand

Methods of preparation and collection of marketing research data were given major emphasis during 1990. Case studies conducted under contract were completed in Indonesia, in collaboration with CGPRT, and in the Dominican Republic, through IICA.

Peru. A workshop on methods for marketing research was organized for Latin America at CIP-Lima, and was attended by 26 participants from national programs in 10 Latin American countries, as well as by participants from CIAT, CIMMYT, IFPRI, and IICA. The published proceedings will serve as a practitioner's guide to this type of research in the future.

Indonesia. Principal study findings were as follows:

Potato production increased from 70,000t to 420,000t between 1968 and 1987.

The bulk of production in Java is produced as a cash crop on highland farms with less than 1ha in potato, which supply major consumption centers and the processing industry; production on North

Potato marketing in Cusco, Peru, is a centuries-old tradition.

Sumatra has strong links to the export market.

Farmers generally sell potatoes (in the ground) to assembly traders who pay from 75% to 90% of the wholesale selling price; this finding and the tendency for prices in major markets to be highly correlated suggests a fairly efficient marketing system.

Potato is consumed as a vegetable in a variety of dishes and has become popular in the form of french fries and potato chips. Per capita consumption has increased from an estimated 0.5 kg in 1968 to approximately 2 kg in 1985. Estimated price and income elasticities for potato are 0.6 to 0.8, respectively, which suggests good prospects for an increase in consumption due to lower prices and/or higher incomes.

The study recommendations focus on the market implications of expanded mid-elevation production, e.g. quality of potatoes produced under these conditions; on the need for research on potatoes outside Java, particularly in North Sumatra; and on the need to assess the sustainability of highland production to meet the growing demand for potatoes.

The Dominican Republic. Major findings included the following:

Potato production rose from 7,700t in 1961 to 35,000t in 1973, fell to 11,000t in 1979, and then rose again to nearly 38,000t in 1987. These fluctuations reflect year-to-year retail price changes and instability in the supply (i.e. importation) of seed.

The bulk of potato production is transferred from growers' fields to the wholesale market in Santo Domingo, either by trucker/traders or growers themselves. The growers' share of the retail price increased from 52% in 1985 to 65% in 1987.

Per capita consumption has fluctuated from 4 kg. in 1967 to 1.8 kg. in 1979 to 3.4 kg. in 1987. However, it appears that potatoes are more widely available than in the past, in shops, hotels, restaurants, etc.

The study recommended 1) improvements in data management for the potato sector so that information about production and prices can be made available on a regular and more timely basis; and 2) increases in the production of certified seed and measures to strengthen seed marketing.

Burundi. In a 1983 follow-up study to field work on potato marketing findings included the following:

The major obstacle to increased potato output in Burundi is production capacity, rather than the market's ability to absorb surpluses. The principal production constraints are the shortage of improved quality seed at the farm level and the limited availability of chemical fertilizer and pesticide.

Rwanda. Table potatoes continue to be a minor share of the total volume of potatoes sold in Burundi. Given the precarious state of local food supplies, research should focus on increased domestic output. Fortifying the existing seed multiplication and distribution scheme is the most important step in that direction.

At the meeting of the African Potato Association in Mauritius in 1990, findings were presented from a synthesis of case studies and related research in Africa. These findings included the following:

Potato production and area planted increased faster than any other food crop in sub-Saharan Africa during the last 25 years (Table 10-4). Ninety percent of the total production is in eight countries.

Potato sales are an important source of cash income for African growers; nevertheless, the bulk of production typically is used for on-farm consumption and seed.

During 1986-88, 34 countries imported some 61,000t of potatoes annually with a total value of US$179 million. Of this total, two-thirds was imported by only 4 countries.

Growers receive about 41% of the retail price in the capital cities of Burundi, Madagascar, and Rwanda, but less than 10% in the capital of Zäire. These margins appear to reflect limited infrastructure, small volumes per transaction, and the risks associated with buying and selling a perishable product.

The report notes that the principal potato producing countries will require renewed efforts, if production is to keep pace with population. Such countries must develop minimum-input packages, because many farmers use few, if any, modern inputs. Policymakers should support improved marketing efforts by the private sector, and because potatoes are very much a luxury food, any reduction in price should lead to increased consumption.

PRACIPA Marketing Network in Latin America

Highlights of the following reports prepared by each of the participating countries include the following:

Bolivia. In the Cochabamba region, at least 14 institutions are engaged in the multiplication and distribution of seed potatoes. Prior to this project, nearly all were unaware of the scope (e.g. number of growers, quantities of seed), nature (e.g. types of potato varieties, quality of seed), and operating procedures (conditions for receiving seed to multiply, etc.) of their counterparts in this activity. This project has succeeded in documenting these and other facets of seed marketing in the Cochabamba region. It has identified practices that need improvement and sug-

Sweet potato marketing in Rwanda.

gested an orientation for these institutions to follow in the future, i.e. to produce according to user requirements, rather than simply trying to multiply what can be procured. It has also generated a methodology and developed a local capability to facilitate diffusion to other regions of the country.

The project has explored the workings of the informal seed marketing system that operates alongside the aforementioned institutions, and has collected data on varieties sold, volumes handled, and prices and place of origin for seed marketed through regional agricultural fairs. Information generated from this project should be of use to other countries in the region contemplating "an institutional approach" to overcoming seed distribution problems.

Colombia. Project work focused on rustic potato processing for human consumption in Pamplona (northeast Colombia) during 1987-88, and on simple processing for animal feed in Nariño (southwest Colombia) during 1988-89. Neither of these possibilities proved to be particularly attractive to growers, in large part because highly favorable prices for potatoes ruled out the need for interest in alternative outlets for the crop. In addition, unlike Bolivia or Peru, Colombia has no tradition of simple potato processing at the farm level. Hence, growers were curious, but cautious, about engaging in such activity.

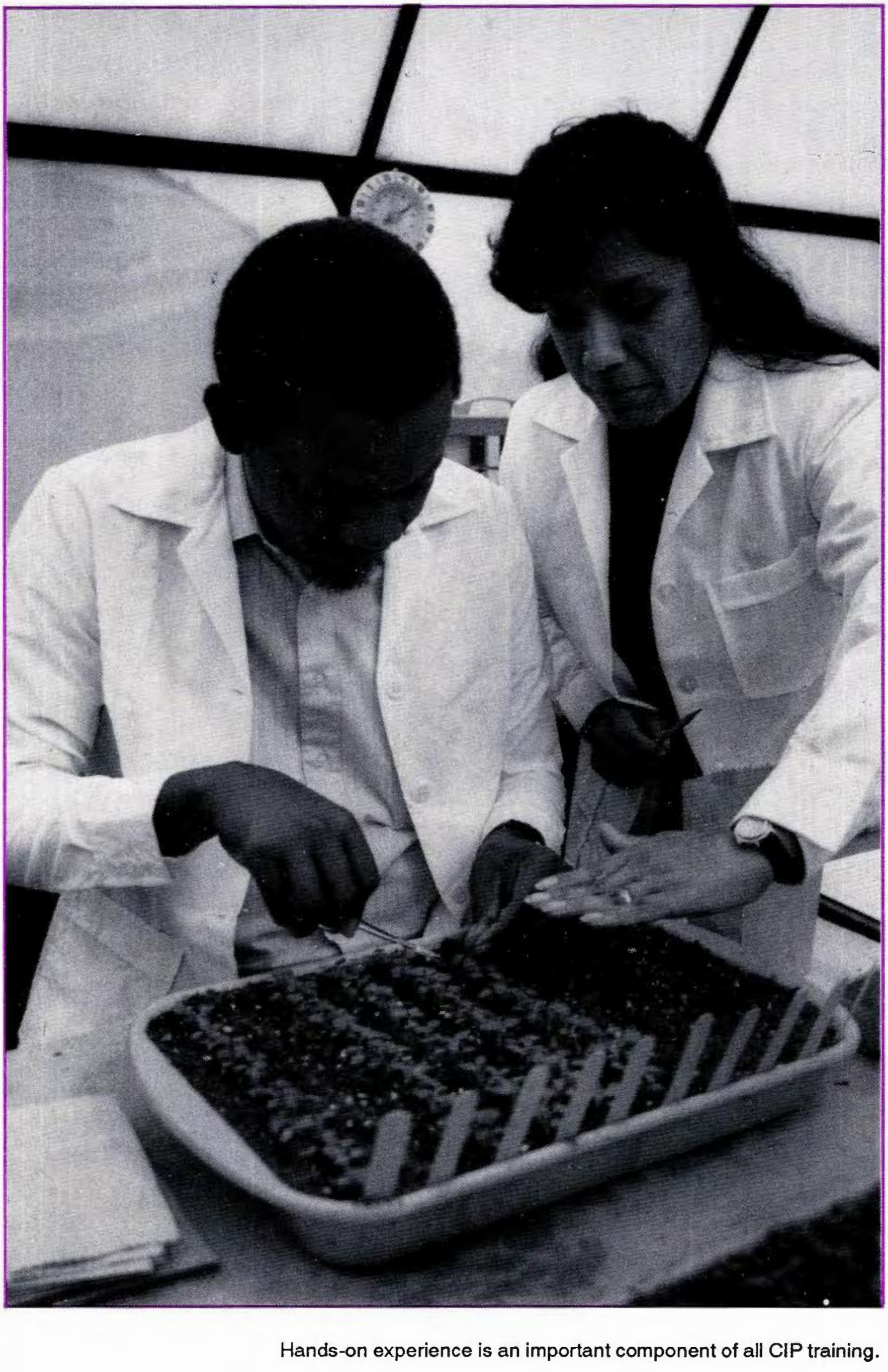
In 1990, attention turned to the requirements of the semi-industrial and industrial potato processing industry in Colombia and the preliminary findings were surprising: 1) processed potatoes account for 15%-18% of actual potato utilization in Colombia (some 350,000t/yr of fresh potatoes), not the 5% previously estimated; 2) the industry is growing rapidly; and 3) quality requirements appear to be considerably different from those envisioned by Instituto Colombiano Agropecuario (ICA) potato breeders. Results of this study will be available in 1991 and should prove instructive to other countries in Latin America interested in assessing the nature of the market for processed products.

Ecuador. The distribution scheme for improved quality seed was examined by this project through a series of structured questionnaires administered to multipliers, users, and non-users of such seed. Survey findings indicate that, contrary to widely held views, seed multipliers procure seed largely, if not exclusively, for use on their own farms. Hence, they operate more as final users than as multipliers or promoters of improved quality seed.

The existing system is deficient in that many non-users are unaware of where to buy such seed, or may not know that it is available. The varieties produced by the present system are often not those planted by the vast majority of small growers that the system is supposed to serve. As the first study of its kind on the seed situation in Ecuador, the results have proved useful for ongoing national program activities, as well as for seed projects now being designed.

Peru. Research has focused on the problem of market information as related to both table and seed potatoes. A collection and analysis system for market information has now been established and a market bulletin printed and distributed. In addition, a database on potatoes has been set up and a survey of growers' information requirements conducted in the central highlands and coast. The procedures put into place for this market information system have functioned reasonably well, despite difficult economic and social conditions that have prevented diffusion of the information to growers. The local program has benefitted from access to this information for reporting and planning purposes and the procedures seem readily adoptable by national programs that face less difficult circumstances.

Venezuela. Marketing of table potatoes in the Andean region of the country is a central focus for this project, and preliminary findings for the Merida region suggest a dual-track marketing system. One track serves larger, commercial growers, another caters to small, semi-subsistence producers. Whereas the commercial farmers benefit from participation in potato marketing both as growers and traders, smaller farmers benefit less because of lack of access to information, geographic isolation, and the limited bargaining power associated with the small volumes sold per grower. The draft report suggests that a regional, cooperatively owned, rural assembly center and an improved market information system might improve the situation of the smaller farmers.



Hands-on experience is an important component of all CIP training.

Training Department

TRAINING AT CIP is a cooperative effort between the Regional Program and the Research Program under the coordination of the Training Department. The training programs take the form of short regional courses, workshops, seminars, conferences, and in-country courses according to the needs of our research and development partners in more than 80 countries of the developing world. In 1990, the workplan consisted of numerous training activities on potato and sweet potato production and utilization and related specialized disciplines. The summary presented in Table T-1 contains information on the number of courses and participants classified by major training categories.

Table 1. Summary of CIP training activities in 1990.

	No. of participants	No. of countries represented	No. of courses/ workshops
Group training			
Specialized courses	226	42	16
Production courses	237	36	15
Workshops	429	59	13
Individual training at Lima-HQ	46	18	-
Total	938		

Training Activities: Potato

Seed Production Technology and Related Disciplines

During the last twenty years a major effort at CIP has been training in seed production technology to increase supply of quality seed to new production areas located in the tropics and subtropics. Seed production technology has been perhaps the area of most rapid development among CIP's research efforts. Tissue culture and rapid multiplication techniques have been readily assimilated into most basic seed programs of the NARS in the developing world, and modern methods for virus detection, monitoring, and eradication are widely utilized in many countries. In traditional potato growing areas, seed technology developed at CIP has been adapted to local conditions and feedback given to CIP scientists to refine the technologies. Thus, training in seed production technology has catalyzed exchange of information and methodologies between CIP scientists and trainees, with mutual benefits. Equally noteworthy is the horizontal exchange of knowledge on this subject that has occurred among members of collaborative research networks. Intensive interaction in seed production technology has been experienced among the countries of Programa Regional Cooperativo de Papa (PRECODEPA), Programa Andino Cooperativo de Investigación en Papa (PRACIPA), Southeast Asian Program for Potato Research and Development (SAPPRAD), and Programme Regional d'Amelioration de la Culture de Pomme de Terre en Afrique Centrale (PRAPAC) over the last ten years. In 1990 ten group-training activities on seed production were sponsored or organized by CIP. Regional courses on seed production were held in Regions I, III, VI, and VII. Also, in-country courses on the subject were organized in collaboration with national institutions in Regions III, VI, and VII. The following is a detailed account of group training activities in seed production including location, number of participants, and country of origin.

Chile. The IV International Course on Potato Seed Production and Storage, jointly organized by the Instituto de Investigaciones Agropecuarias (INIA) de Chile and CIP was held in Osorno, Chile. Course participants came from several countries in CIP's Regions I and II: Venezuela (2), Paraguay (1), Uruguay (1), Ecuador (2), Guatemala (1), Bolivia (1), Brazil (1), Argentina (1), the Dominican Republic (1), and Peru (1).

Course objectives were to a) identify and describe the major constraints in production, storage, and marketing of potato seed; b) study the scientific principles for production and storage of quality seed; c) identify and develop instruments and mechanisms for better communication among farmers, extensionists, and scientists; d) prepare research projects aimed at solving production, storage, and marketing problems at the farm level. The course consisted of lectures followed by practicals and field visits.

Rwanda and Kenya. Two regional Potato Seed Production courses were held in CIP's Region III. The course for francophone countries took place at Ruhengeri, Rwanda. Participants came from Burundi (4), Rwanda (7), Zäire (2), and Madagascar (3). The course was organized jointly by CIP and PRAPAC. An English version of this course was held in Nairobi, May 28 to June 6. Participants in this course came from Kenya, Tanzania, Uganda, Madagascar, Botswana, and Ethiopia. Both courses were sponsored by the CIP-UNDP Human Resources Development Project. Emphasis was given to discussing physiological and agronomic aspects of seed tuber production in lectures and field visits to seed farms. Greenhouse and laboratory sessions were designed to provide practical experience in RMT and pathogen detection and elimination techniques.

Burundi. An In-Country Seed Potato Production and Management course was held in Burundi. The course was designed to allow students to study all stages of a potato crop. Theoretical aspects of seed production and practicals on soil preparation, seed management, and planting were covered in September. Trainees attended field days at Mwokora and Munanira in November and returned to conduct harvesting, selection, and storage in January.

Uganda. An In-Country Potato Seed Pathology course was held at Kabale, Uganda from November 16 to 24. The course was attended by 22 participants from Uganda and was sponsored by United Nations Development Programme (UNDP).

A Seed Multiplication course was held at D.F.I. Kachwekano near Kabale, Uganda from June 18 to 23. The 25 participants included scientists, extension officers, and progressive farmers.

India. The X International Training Course on Potato Seed Production and Certification was held from November 23 to December 6 at the Central Potato Research Station, Modipuram, India, and was organized by Central Potato Research Institute (CPRI) Indian Council for Agricultural Research (ICAR) and CIP Region VI, with funding from UNDP.

Thailand. A Workshop on Seed Potato Production for Consumer and Processing Varieties was held at Chiang Mai, Thailand from January 19 to 21 and was attended by participants from Thailand (31), Japan (1), and Indonesia (1). The objectives were to : a) exchange experiences related to production and distribution of seed potatoes; b) identify needs for research and development; and c) discuss future plans and prospects.

An International Workshop of Storage of Seed and Ware Potatoes in Warm Climates held at Fang, Chiang Mai, Thailand was attended by participants from Nepal (3), Vietnam (2), Thailand (5), The Philippines (1), Iraq (1), and Malaysia (1). It was sponsored by CIP, SAPPRAD, and the Thailand Department of Agriculture. The objectives of this workshop were to a) provide background information on storage principles for seed and ware potatoes; b) exchange experiences related to seed and ware potato storage in warm climates; c) report results of ware potato storage trials in SAPPRAD countries, as defined during the 1989 storage workshop in Malaysia; and d) identify areas of priority research that might be tackled on a regional basis.

Indonesia. An In-Country Potato Seed Production course was held at Lembang Horticultural Research Institute (LEHRI), Lembang, Indonesia and was attended by 20 participants from Indonesia. This course was financed by United States Agency for International Development (USAID), organized by HARD/LEHRI, and administered by CIP.

China. A Workshop on the Potato Germplasm and Seed Production in Southern China took place in Zhongshan, Guangdong province, and was attended by 14 participants from China.

Potato production with true potato seed (TPS) continues to be one of the most challenging areas of research at CIP. Although research is still in progress to refine TPS technology, several countries have requested that their scientists be trained by CIP to enable them to undertake research in this innovative technology.

Nicaragua. In response to this demand, an international course on the Use of TPS in Potato Production was sponsored by CIP/PRECODEPA and organized by the Nicaraguan national potato program. The course took place at Esteli on the premises of the MAG and was attended by participants from El Salvador (1), Nicaragua (2), the Dominican Republic (1), Haiti (2), and Cuba (1). The main objective was to extend TPS technology to PRECODEPA member countries. Discussions during the course centered on the Nicaraguan experiences in using TPS for production of seed tubers, production of open-pollinated TPS, and seed extraction and storage techniques. The major aspects of TPS production and use of TPS as an alternative propagation method to seed tuber production were discussed.

Theory and methodology sessions were complemented by field demonstrations and other hands-on activities. Field trips were organized to various experimental and growers' fields to see TPS technology in situ.

Ecuador. A Workshop on Methodologies for Agronomic and Socioeconomic Research in Production and Distribution of Potato Seed was held in Quito, Ecuador. This meeting was attended by participants from Bolivia (5), Ecuador (4), Colombia (1), Chile (2), Brazil (1), Argentina (1), Peru (3), and CIP (8). Workshop objectives were to a) define appropriate methodologies for research on seed production and distribution; b) review the agronomic, phytosanitary, and socioeconomic factors related to production and distribution of potato seed; and c) guide Latin American scientists in the improvement of their seed production programs. The written contributions of the participants were edited and published in a document entitled "Metodologías de Investigación en Tubérculo-Semilla de Papa."

Seed quality depends largely on the ability to slow the dissemination of virus and virus-like diseases in the basic seed stocks. Basic and advanced training given by the virology section of the Pathology Department have markedly contributed to building up NARS' capabilities in both field-level and laboratory virology techniques.

Peru. The Practical Virology Course was held at CIP's headquarters in Lima, Peru. Participants came from Bolivia (2), Paraguay (1), Guatemala (1), Tanzania (1), Cameroon (1), Jamaica (1), and Peru (2). This two-week training activity is offered annually to teach basic virology techniques to national program researchers from Regions I and II.

The second Advanced Virology Course was also held in Lima. Trainees came from Uruguay (1), Argentina (2), Chile (2), and Costa Rica (2). This course is designed for scientists actively involved in virus research and in identification or preparation of antisera for virus detection. The full course lasted six weeks, although in the future, it may be taken by modules according to individual needs.

Kenya. Training in virology has also been conducted at regional locations. A Tissue Culture/Virology course was held in Nairobi, Kenya. It was attended by 5 participants from Kenya and Tanzania.

Rwanda. A Tissue Culture and Virology course was held at Ruhengeri, Rwanda. It was attended by participants from Burundi (2), Rwanda (11), Uganda (2), and Zaïre (1).

India. An International Field-Level Virology course held at Shimla, India was attended by participants from Bangladesh (2), Nepal (2), Bhutan (1), Sri Lanka (3), India (4), and Iran (2). The course was jointly organized by CPRI and CIP. The course was designed to provide potato scientists directly engaged in seed potato production with the latest technological developments for identification, testing, and eradication of virus diseases from potato fields.

Tissue culture and rapid multiplication techniques have become basic tools of breeders and seed specialists. Most of CIP's seed production courses normally include lectures and practicals on those techniques.

Burundi. An In-Country course on In Vitro and Rapid Multiplication Techniques for Potatoes held in Burundi was attended by five national scientists.

Germplasm Management

In working toward the achievement of one of its most fundamental goals, CIP is devoted to strengthening NARS' ability to manage germplasm of potato and sweet potato. This requires the mastering of various technologies to properly handle germplasm, in the form of seed or vegetative propagules; to maintain and multiply it free of pathogens; and to utilize it in their breeding programs. In 1990 courses on this subject were held in Regions III, VII, and VIII.

Rwanda. A Potato Germplasm Management Course was held at Ruhengeri, Rwanda. It was attended by participants from Burundi, Rwanda, Uganda, and Zaïre. The course dealt with general aspects of germplasm management. Objectives were to enable national potato programs of participating countries to receive potato germplasm, to study and select those clones resistant to diseases and adapted to their own environments, and to produce a good quality potato according to their own standards. Since the two major constraints to potato production in the countries of the PRAPAC are late blight and bacterial wilt, the course gave special emphasis to management of those diseases.

Mongolia. A Potato Germplasm Training course was held at Hohhot, Wumeng, Inner Mongolia and Datong, Shanxi province. It was the second training course on potato germplasm conducted by CIP's Region VIII. Sixteen participants from Inner Mongolia, Shanxi, and Hebei provinces attended the course. Objectives were to improve evaluation of new advanced selections for productivity, late blight, and drought resistance. The course also covered the areas of drought tolerance physiology, virus detection, and bio-statistics. Lectures combined with practical field experience led to a better understanding of the subject matter and facilitated the learning process for the trainees.

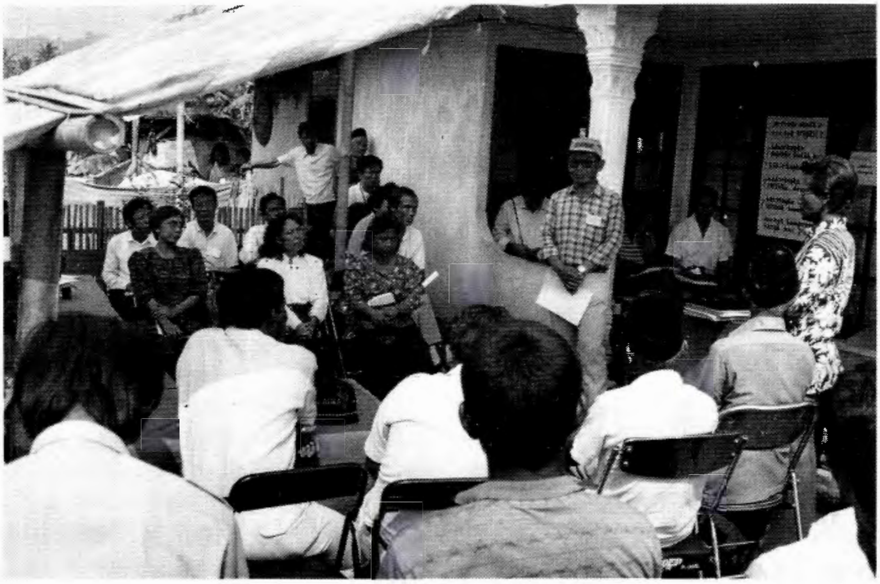
On-Farm Research and Field-Level Diagnostic Skills

The Philippines. A Workshop on Research Diagnostic Tools for Farm and Household Analysis: Hands-on Training of Trainers, was held at Los Baños, Philippines and was attended by participants from India (4), Thailand (3), Sri Lanka (3), and the Philippines (18). The course was hosted and organized by CIP-UPWARD (User's Perspective with Agricultural Research and Development), a social science network which focuses on the potato and the sweet potato in Asia. Funding was provided by UPWARD and the UNDP Human Resources Development Project and was jointly executed by CIP, CIAT, and IITA. Workshop objectives were to a) expose the participants to conventional and nonconventional user-sensitive research approaches for farm and household analysis; b) give the participants an opportunity to work in interdisciplinary teams and use newly acquired skills in formulating practical recommendations for a problem related to agricultural production of root crops; and c) enable the participants to reinforce their learning experience by conducting a training course in their respective regions.

Invited speakers provided relevant information on user-sensitive research approaches. Because the training was conceptualized as a "field school," the participants were sent to the field to try the various methods and to give feedback afterwards on the advantages and disadvantages of the methods used.

Classroom interaction provided a forum for the exchange of ideas and relevant information gathered in the field. The participants were able to share their observations and exchange field notes and opinions. Working in interdisciplinary teams, participants were able to submit a group report on the different aspects of agricultural production of root crops.

A planning workshop for UPWARD was organized by CIP with funding from The Dutch Government. The meeting was held at Baguio City, Philippines. Participants came from Indonesia (6), The



A communication training course in Indonesia involved trainees from China, Vietnam, Indonesia, and participants from local institutions.

Philippines (19), Sri Lanka (3), Thailand (5), CIP (10), and guests and observers from several international organizations related to agricultural development.

Production

Tanzania. An In-Country Potato Production and Postharvest course was held in Mbeya, Tanzania. The course was attended by 20 participants from Tanzania.

In-country courses on Potato Production were held in Tunisia and Morocco. Potato workers from the national programs of Tunisia (25) and Morocco (20) were exposed to lectures and field visits related to all aspects of modern potato production technology. CIP provided financial assistance, training materials, and one instructor. National institutions were responsible for organizing the course and providing instructors.

Mali. An In-Country Potato Production course held at Segou, Mali was attended by 20 participants from Mali. The course was sponsored by UNDP.

Cameroon. A regional course on Potato Production, Storage, and Processing for West and Central Africa was organized by IRA and CIP's regional office at Bamenda. The course brought together participants from Nigeria (2), Ghana (1), Mali (1), West Africa (1), and Cameroon (13). Financial assistance for the course was provided by FAO, UNDP, and the World Bank.

Togo. An In-Country Potato Production course held in Togo was attended by 16 participants. Among them were 10 representatives of farmers' groups, four extensionists, one agronomy consultant, and one agronomy student, all from Togo. This course was organized by the Institute de Plantes à Tubercules (INPT) in collaboration with CIP and with financial assistance from UNDP.

India. The XIX International Course on Methods in Potato Production was held at Central Potato Research Institute (CPRI), Shimla, India, from June 1 to 30, and was attended by 14 participants from Nepal (2), Bangladesh (1), Bhutan (1), Sri Lanka (1), and India (9). The course was sponsored by CIP/UNDP.

Two regional workshops addressed the problems of production and development of the potato in Regions IV and VII.

Spain. A workshop on The Potato in the Mediterranean Region was sponsored by the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM)) and CIP. It was held at the I.A.M. Zaragoza, Spain. Scientists from nine Mediterranean countries and three international organizations attended the meeting, where a three-year work program was developed to study potato adaptation, potato tuber moth, and seed technologies.

A Potato Workshop for the South Pacific was also held at Zaragoza with the participants from the Sweet Potato Workshop.

Objectives were to determine progress in germplasm evaluation, agronomy research, and seed production/storage since 1988.

Pest and Disease Control

Costa Rica. CIP scientists participated as instructors in a PRECODEPA-sponsored course on Pathology of Potato Production in Costa Rica. Course participants (12) were from Cuba, Mexico, Panama, Nicaragua, Honduras, Haiti, El Salvador, the Dominican Republic, Costa Rica, and Guatemala.

India. A Workshop on Integrated Pest and Disease Management of Root and Tuber Crops was held in Bhubaneswar, India, jointly sponsored by CIP, IITA, CIAT, and ICAR/CTCRI.

It was attended by participants from national programs working on root and tuber crops from China (3), Indonesia (2), the Philippines (4), Thailand (2), Vietnam (2), Nepal (1), Sri Lanka (2), India (3), and Bangladesh (2). The workshop aimed to establish the state of the art on Integrated Pest Management (IPM) research at the international centers and national programs dealing with root and tuber crops and; develop modalities and plans for setting up to an Asian Country Network for research, technology transfer, and manpower development in the field of integrated pest and disease management.

Postharvest Technology

Courses and workshops on storage, and processing, and marketing of ware and seed potatoes were held in 1990.

Peru. A Latin American Workshop on Methodologies for Agricultural Marketing Research took place in Lima, Peru. The workshop brought together participants from 11 Latin American countries and CIP: Colombia (3), Bolivia (3), Guatemala (1), Ecuador (2), Venezuela (1), Uruguay (1), Mexico (1), Chile (2), Brazil (1), Argentina (1), and Peru (8). There were also two participants from outside Latin America, one from the USA and one from West India. The purpose of the workshop was to respond to repeated requests from biological scientists and administrators from CIP and its national program partners of Latin America, for methodologies in marketing research.

Mauritius. A Workshop on the Production, Postharvest Technology, and Utilization of Potato in the Warm Tropics was sponsored and organized jointly by the

Mauritius Sugar Industry Research Institute (MSIRI), CIP, and the African Potato Association (APA) within the Triennial Asian Potato Association Meeting and Conference in Mauritius. The meeting was attended by 136 participants, mostly from Africa.

A Workshop on Seed Potato Production for Consumer and Processing Varieties was held at Chiang Mai, Thailand and was attended by participants from Thailand (31), Japan (1) and Indonesia (1).

Objectives were to a) exchange experiences related to production and distribution of seed potatoes; b) identify needs for research and development; and c) discuss future plans and prospects.

Training and Communication Skills

Guatemala. A course on Potato Research and Communication Methodologies was held in Guatemala. The course was organized jointly by the Instituto de Ciencia y Tecnología (ICTA), CIP, and PRECODEPA. Course participants came from Nicaragua (1), Mexico (2), Guatemala (3), Honduras (1), the Dominican Republic (2), Cuba (1), El Salvador (2), Costa Rica (1), and Haiti (1). Course topics included planning design and analysis of experimental work as well as techniques for presentation and communication of experimental results.

Nigeria. A Training and Communications Workshop was conducted by the Institute of Agricultural Research and Training at Ibadan, Nigeria, with support from IITA, CIP, and CIAT. This workshop was part of a joint effort by the three international centers that work on root and tuber crops to develop and support training and communications activities in national programs. Funding was provided by UNDP through an inter-center project on human resources development for generation and transfer of root and tuber crops technology. Participants came from Tanzania (2), Sierra Leone (2), Guinea (2), Malawi (1), Kenya (1), and Nigeria (9).

Indonesia. Under the auspices of UNDP, the three international centers that work with root and tuber crops organized the Asian Workshop on Training and Communication Skills in Bogor, Indonesia. The meeting was hosted by the Central Research Institute for Food Crops (CRIFC) and was attended by 18 participants from Vietnam, China, and the Philippines. General objectives of this workshop were to 1) enable specialists in root and tuber crops to organize training activities to meet their needs; 2) include social science components in their training programs; and 3) improve communication with peers and farmers.

Training Activities: Sweet Potato

Argentina. The II International Course on Sweet Potato Production was held at the San Pedro Experimental Station, Argentina. The course was coordinated by the Instituto Nacional de Tecnología Agropecuaria (INTA) and CIP. Course participants came from Argentina (4), Bolivia (1), Brazil (2), Colombia (1), Ecuador (1), Guatemala (1), Mexico (1), Paraguay (1), Peru (1), the Dominican Republic (1), Uruguay (2), and Venezuela (1). Course objectives were to enable participants to a) assess farmer-level limiting factors and potentials for sweet potato production; b) understand the scientific principles of sweet potato production; c) develop research projects; and d) enhance communication skills among researchers and extensionists.

An In-Country Course on Sweet Potato Production held in Tucuman, Argentina was sponsored by CIP. The course, organized by INTA, was offered to 16 participants from Argentina, one from Uruguay, and one from Paraguay.

Tanzania. An In-Country Sweet Potato Development Workshop was held in Morogoro, Tanzania. The workshop was attended by 19 participants from Tanzania. It was sponsored by UNDP.

Egypt. An In-Country Sweet Potato Production course was held in Egypt. It was sponsored by the UNDP Project.

India. The Second International Training Course on Sweet Potato Production was held at CTCRI, Trivandrum, India. This course was jointly sponsored by the Indian Council of Agricultural Research (ICAR) and CIP within their agreement to collaborate in sweet potato research and training activities.

Vietnam. The In-Country Sweet Potato Production course was held at Danang, Vietnam. A total of 16 participants from major sweet potato growing areas attended. The course dealt with on-farm research. Emphasis on field work included farmer surveys for diagnosing constraints, experimental design, and field testing. The experience was a completely new research approach for Vietnamese scientists used to the classical extension models.

Two additional regional workshops related to research and development of sweet potatoes in Regions III and VII were organized in 1990.

Kenya. A workshop on Sweet Potatoes in the Food Systems of Eastern and Southern Africa was held at Nairobi. It brought together researchers in several disciplines from Nigeria (1), Burundi (1), Ethiopia (1), Kenya (3), Uganda (3), and Tanzania (3).

The workshop was designed to define key research questions about sweet potatoes in food systems, to discuss methodologies appropriate to these questions, and to set

A regional course in Potato Production, Storage, and Processing held in Cameroon brought together trainees from five African countries.

priorities, both for individual national programs and for the interchange of information at the regional level. It will be followed up with support to strengthen existing research or to establish new projects by next year.

Tonga. A Sweet Potato Workshop for the South Pacific was held at the Institute for Rural Development, USP, Tongatapu, Tonga and was attended by participants from Australia (1), the Cook Islands (1), Fiji (4), Polynesia (1), Indonesia (1), Kiribati (1), New Caledonia (1), Papua N. Guinea (2), the Philippines (2), the Solomon Islands (1), Banatow (2), West Samse (3), and Tonga (3). The objectives were to a) determine existing genetic resources in national collections and in farmers' fields of major South Pacific sweet potato producing countries; b) discuss germplasm cleanup (virus eradication) and in vitro germplasm management; c) determine priorities for future germplasm exchange utilization, with due consideration to quality and disease and pest resistance.

China. An In-Country Potato and Sweet Potato Virus Detection course was held in Xuzhou, China at the Sweet Potato Research Center. The course was attended by 25 Chinese virologists, breeders, and agronomists from universities and research institutes in 13 provinces. CIP and Chinese scientists shared experiences in lectures and practicals. For practical work trainees were required to bring samples collected in their own provinces to be analyzed during the course. It was determined that sweet potato feathery mottle virus (SPFMV) was the most frequently found sweet potato virus disease in Beijing, Jiangsu, Sichuan, and Shandong provinces. This combined training-virus survey was found to be an efficient method of utilizing scarce resources.

Germplasm Management

The Philippines. A Workshop on Sweet Potato Germplasm Utilization held at Los Baños, Laguna, Philippines was attended by participants from China (5), India (1), Austria (1), Indonesia (1), Japan (1), Malaysia (1), the Philippines (5), Vietnam (4), and Western Samoa (1). It was sponsored by CIP and Philippine Council for Agriculture and Resources Research and Development (PCARRD). The objectives were to discuss germplasm collection, cleanup, and exchange procedures; and to develop suitable breeding strategies for meeting national needs. At the end of the workshop participants prepared a list of recommendations on 1) germplasm collection, characterization and exchange, 2) breeding strategies, and 3) screening methods.

On-Farm Research and Field-Level Diagnostic Skills

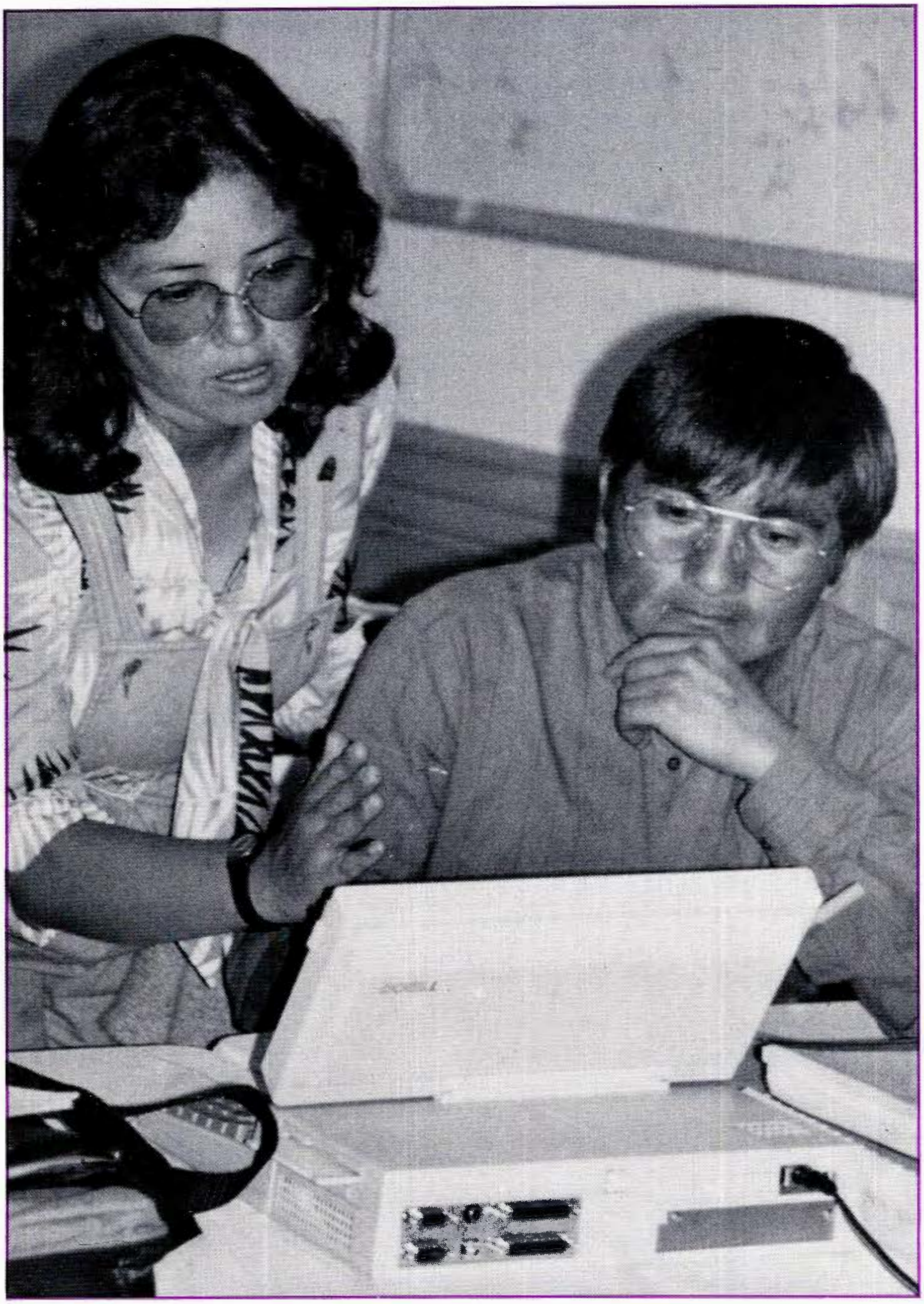
Peru. An On-Farm Research Course took place in Cañete, Peru. The course was attended by participants from Bolivia (2), Argentina (1), Paraguay (1), Uruguay (1), Peru (1), and Brazil (1). The objectives were to train research scientists in planning, designing, and executing research in farmers' fields on constraints to sweet potato production and utilization; and to develop the participatory research skills of research scientists in order to introduce the users' perspective into their research and development programs.

Biotechnology

Cuba. An International Course on Production, Biotechnology, and Pest Control in Sweet Potatoes took place in La Habana and Santa Clara, Cuba. The course was organized by CIP's Regional Office in the Dominican Republic in coordination with the Instituto Nacional de Investigaciones en Viandas Tropicales (INIVIT) from Cuba and was sponsored by FAO. It was attended by participants from Nicaragua (1), the Dominican Republic (2), Costa Rica (2), Guatemala (1), Cuba (4), Mexico (1), Ecuador (1), Venezuela (1), and Haiti (1). The venue was at the Genetic Engineering and Biotechnology Center of La Habana and the Experimental Center of INIVIT in Santa Clara. The course was designed to provide trainees with the latest developments in biotechnology for sweet potato production and to stimulate exchange of knowledge among participants.

Advanced Degree Training

During 1990 CIP gave funding and logistical support to 116 students from the NARS of the developing world, who were working toward bachelor's (33), M.Sc (53) and Ph.D (25) degrees in agricultural sciences and related disciplines. The majority of them came from Latin America (70) because of the large involvement of Peruvian students in research projects at CIP Lima headquarters. Thirty-four students were from Asian countries and eight from Africa. Most of the academic training in Peru is carried out in collaboration with the National Agrarian University. Training toward the doctoral level is normally undertaken at universities in the USA or Europe. Degree training provides students with an opportunity to actively participate in CIP's research program and also helps them to develop technical and managerial skills. Thesis research topics are normally selected in response to actual research needs in the students' own country. Graduates from the academic degree program frequently conduct research in partnership with CIP. Many of them also become research leaders and top managers within their institutions. The benefits of the program are therefore far-reaching in terms of institutional development.



National program staff received training to integrate statistical analysis and communication of research results at Cochabamba, Bolivia.

Information Sciences Department

The Information Sciences Department, created in 1989, has been consolidated this year to integrate information functions and resources at CIP, and to respond to the emerging communication challenges of the Center's continuing decentralization strategy. This year has also been marked by an intensive effort to develop the components of the strategic plan that deal with the information functions at CIP. New facilities were made available this year for the Department, which now includes the Information, Communication, Computer, Statistics, and Public Awareness units. The main activities and achievements in each area are described below.

Information Unit

Information Unit staff carried out the following activites in 1990:

- Provided special technical assistance to help in the implementation and development of the National Potato Program Library in Bolivia, and CIP's Library in Region V, Cameroon.
- Produced an audiovisual about CIP information services in Spanish, English, and French, in order to make CIP information services known to a large audience, which includes trainees and visitors to the Center.
- Made the Potato Network Database operational and integrated all information on individuals and institutions working with potato or sweet potato around the world. It includes the Center's mailing list, as well as data about CIP trainees.
- Strengthened the exchange of information among potato and sweet potato researchers from developing countries. To achieve this objective, a database on Publishing Procedures of Agricultural Journals was completed. To date, this database includes more than 180 journals.
- Entered, to date, a total of 35,600 references into the CIP Bibliographic Database of which 27,200 items are on potatoes and 2,800 on sweet potatoes and 5,600 publications on general topics.
- Made 892 retrospective computer searches of the CIP, AGRIS, and CABI bibliographic databases for CIP and national program staff.
- Designed over 400 SDI profiles for CIP and National Agricultural Research System (NARS) users. Special emphasis was given to increasing the support to users in Africa. The individual nature of the SDI service was highly valued by researchers receiving this type of service, as is evident in the evaluations conducted periodically.
- Continued to distribute specialized bibliographies to CIP staff, NARS, and agricultural libraries. Two projects which began in 1990 were 1) a bibliography on potato and sweet potato publications by Peruvian authors and coauthors that were published in collaboration with CIP; and 2) a bibliography on the potato in Africa.
- Continued to distribute to all national programs and agricultural libraries the accession list, a monthly publication listing all new documents received by the CIP library.
- Signed an agreement with UNESCO for obtaining and using the MICRO-ISIS

software. This software, which is specially conceived for management of bibliographic databases in PCs will permit information from CIP's bibliographic database to be transferred in diskettes and will permit the development of small bibliographic databases in regional offices.

- Participated in a joint IARC Project, coordinated by ISNAR, which aims to NARS with publications and information produced by the international agricultural research centers. This joint venture is an example of the kind of cooperative activities which may lead to closer links between NARS and IARCs.
- Collaborated in the development of the brochure "CGIAR Information Resources in Latin America," coordinated and produced by CIMMYT. This brochure describes the information services of Centro Internacional de la Papa (CIP), Centro Internacional de Agricultura Tropical (CIAT), and CIMMYT and has been published in English, Spanish, and French.

Communication Unit (CU)

In 1990, this unit's staff:

- Conducted a UNDP-funded regional workshop on training and communication skills in Indonesia. Seventeen participants from China, Vietnam, and Indonesia attended. A similar UNDP-funded workshop organized by the International Institute of Tropical Agriculture (Nigeria)(IITA) was held in Ibadan, Nigeria. Participants from five African nations attended.
- Printed 14 books and booklets, with 4,600 copies in English, and 5,150 in Spanish. In addition, the CIP Circular was produced, with 10,230 copies in English, 6,680 in Spanish, and 2,000 in French.
- Translated thirty-nine CIP documents into Spanish, French, and English.
- Provided support to headquarters and regional staff in writing and editing of scientific articles and documents, as well as in art, photography, and other audiovisual needs.
- Spearheaded CIP's participation in several events, such as the Andean Crops Exposition coordinated by the Andean Pact, and the II International Exhibition of Potato Varieties, held in France, where Peru won an award. In addition, several poster presentations were produced for CIP's participation in congresses.
- Provided support for video recording of experiments, particularly in genetics, entomology, and postharvest technology. Three videotape programs were produced: "The Use of Sweet Potato in Breadmaking", "IPM of Andean Potato Weevil", and "The New Canchan Potato Variety" (in Spanish).
- Helped organize the "Asociación Latinoamericana de la Papa" (ALAP) congress in Lima.
- Supported the PROINPA (Bolivia) Project, in editing and printing.
- Served as consultant to the Swiss Pakistan Potato Program in their publication of CIP Technical Information Bulletins (TIBs) in Urdu.
- Conducted an intensive on-the-job training to upgrade CIP communications staff on desktop publishing capabilities.

- Collaborated with the "Comité Français contre la Faim" and French Channel 3 in the production of two video programs on CIP and on potato in the Andes for broadcasting in Europe. Over 1,000,000 persons viewed the programs in France alone.

Computer Unit

This year the Computer Unit was reorganized and incorporated three computer specialists from the Information Unit. The physical facilities of the Unit were rebuilt to accomodate additional services. Staff activities in 1990 included the following:

- Delineated three functional areas: 1) VAX and hardware management, 2) Systems development, and 3) PC management.

- Worked, with this unit's Computer Committee, to propose standards and policies required for CIP. A computer bulletin was initiated to share information on computer skills and services within the Center, including regional offices.

- Provided CIP staff with training on word processing, database management, spreadsheets, and other software.

- Organized the area of systems development with initial focus on motor pool, security, personnel, and potato network information systems. Systems programming and database administration using System 1032 was given at different levels. Intensive support was given to the tissue culture database. A PC version of the CIP Bibliographic Database was developed using MICRO-ISIS, for management of subsets of the database to regional offices.

- Installed a headquarters-wide Ethernet network that will permit the interconnection of PCs and terminals through the VAX system.

- Installed new PCs at CIP. Use of PC's has increased substantially, and the center now has over 100 PC compatibles to support basic research and administrative information processing and management.

- Supported increased use of electronic mail. This year has seen a great increase in this service, both for headquarters and regional offices. Telexes and faxes are now sent regularly through electronic mail, thereby increasing efficiency and reducing costs.

- Conducted successful trials to communicate with PERUNET, the Peruvian telecommunications system. This will

Advanced electronic tools play a crucial role in CIP's information and communication services.

allow CIP's computer system to be on-line for regional and national program access.

Statistics Unit

The Statistics Unit carried out the following activities in 1990:

- Provided training in experimental statistics and statistical software to scientists associated with PRECODEPA.
- Offered short training courses on SAS/BASE, SAS/STAT, SAS/FSP, and SAS/GRAPH to CIP scientific staff.
- Developed statistical programs to process augmented designs in Randomized Complete Blocks and Latin Square for evaluating areas infested with *Phytophthora infestants.*
- Developed training documents on the most frequently used experimental designs, including statistical software for general use at CIP.
- A staff member of the unit received intensive training on online information processing in Japan.

Public Awareness Unit

The Public Awareness Committee, formed in 1989, developed an operational plan to respond to the communications needs of internal and external audiences including NARS, donors, and the international scientific community.

Various public awareness actions were undertaken, particularly in coordination with the CGIAR Public Awareness Association, chaired by CIP's Director General.

List of Abbreviations and Acronyms

AGRIS	International Information System for Agricultural Sciences and Technology (Italy)
a.i.	active ingredient
AID	Agency for International Development
ALAP	Asociación Latinoamericana de Papa
AMV	alfalfa mosaic virus
ANOVA	analysis of variance
APLV	Andean potato latent virus
APMV	Andean potato mottle virus
ARARI	Aegean Regional Research Institute (Turkey)
AUDPCs	Disease Progress curves
avg	average
AVRDC	Asian Vegetable Research & Development Center (Taiwan)
BARI	Bangladesh Agricultural Research Institute
bp	base pairs
BPI	Bureau of Plant Industries (Philippines)
BW	bacterial wilt
CAAS	Chinese Academy for Agricultural Sciences
CABI	Commonwealth Agricultural Bureau International (CAB International)
CaMV	Cauliflower Mosaic Virus
CGA	general combining ability
CGIAR	Consultative Group on International Agricultural Research
CGPRT	Coarse Grains, Pulses, Roots and Tuber Crops Centre
CIAAB	Centro de Investigaciones Agricolas "A-Boerger" (Uruguay)
CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CICA	Centro de Investigacion de Cultivos Andinos
CICIU	Centro de Introduccion y Cria de Insectos Utiles
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CIP	Centro Internacional de la Papa (Peru)
CIPC	isopropyl-N-3-chlorophenyl-carbamate
CLD	chlorotic leaf distortion
cm	centimeter
CMS	cytoplasmic male sterility
CMV	Cucumber mosaic virus
CNPH	Centro Nacional de Pesquisa de Hortaliças (Brazil)
COTESU	Cooperación Técnica Suiza
CPB	Colorado Potato Beetle
CPRI	Central Potato Research Institute (India)
cv	coefficient of variation
cv.	cultivar

d	day
DAP	days after planting
DAS-ELISA	Double-antibody sandwich enzyme linked inmunosorbent assay
DIECA	Diethy Idithiocarbamic Acid
DLS	diffused-light store
DMRT	Duncan's multiple range test
DNA	deoxyribonucleic acid
EB	early blight
EBN	endosperm balance number
EC	Evaporative Cooling
EDTA	ethylenediaminetetraacetic acid
ELISA	enzyme-linked immunosorbent assay
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria (Brazil)
ENEA	Comitate Nazionale per la ricerca e per lo sviluppo dell Energia Nucleare e delle Energie Alternative
ERSO	Consorzio "Mario Neri" (Italy)
FAO	Food and Agriculture Organization of the United Nations
FDR	first division restitution
FONAIAP	Fondo Nacional de Investigaciones Agropecuarias (Venezuela)
FRKN	False root knot nematode
g	gram
GA	gibberellic acid
GAAS	Guandong Academy of Agricultural Sciences
GCA	General Combining Ability
GTZ	Gesellschaft für Technische Zusammenarbeit
GUS	B-glucuronidase gene
GV	Granulosis Virus
H	Hybrid
h	hour
ha	hectare
hrp	hypersensitive response
HSVd	Hop stunt viroid
IAO	Istituto Agronomico per l'Oltremase, Italy
IBPGR	International Board for Plant Genetic Resources
IBTA	Instituto Boliviano de Tecnologia Agropecuaria
ICA	Instituto Colombiano Agropecuario (Colombia)
ICAR	Indian Council for Agricultural Research
ICRISAT	International Crop Research Institute for Semi-Arid Tropics
ICTA	Instituto de Ciencia y Tecnologia Agricolas (Guatemala)
IDEAS	The Venezuelan International Institute of Higher Studies
IDRC	International Development Research Centre (Canada)
IES	Institute of Economic and Rural Sociology
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture (Nigeria)
ILBRT	International Late Blight Resistance Trial

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 Investigación y Promoción Agropecuaria (Peru)
INIVIT	National Institute for Research in Tropical Roots and Tubers (Cuba)
INPT	Institut National de la Pomme de Terre (Togo)
INRA	Institut National de la Recherche Agricole (Senegal)
INRAT	Institut National de la Recherche Agronomique de la Tunisie
INTA	Instituto Nacional de Tecnologia Agropecuaria (Argentina)
IPO	Research Institute for Plant Protection (Netherlands)
IPM	Integrated Pest Management
ISABU	Institut des Sciences Agronomiques du Burundi
JICA	Japan International Cooperation Agency
kb	kilobar
L	liter
LAR	leaf area ratio
lat.	latitude
LB	late blight
LEHRI	Lembang Horticultural Research Institute (Indonesia)
LER	land equivalent ratio
long.	longitude
LSD	least significant difference
LUE	light use efficiency
m	meter
MA	monoclonal antibody
MBN	*Meloidogyne* bacterial wilt nematode resistant material
MDH	Malate dehy drogenase
meq	milliequivalent
min	minute
MJ	megajoule
ml	milliliter
mm	millimeter
mo	month
MT	Mean overtime
NAR	net assimilation rate
NARS	National Agricultural Research Systems
NASH	nucleic acid spot hybridization test
NCM	nitrocellulose membranes
NCSU	North Carolina State University
ND	not determined

nm	nanometer
ns	not significant
NS	not studied
NSAC	Nova Scotia Agricultural College
NVS	Naturally ventilated store
OP	open-pollinated
PBI	Plant Breeding Institute (UK)
PCARRD	Philippine Council for Agriculture and Resources Research and Development
PCN	potato cyst nematode
PGDH	Phosphoglucodehidrogenase
PGI	Phosphoglucoisomerase
PGM	Phosphoglucomutase
PGPR	Plant-growth promoting Rhizobacteria
PIPA	Programa de Investigación en Papa (Peru)
PL	Pectate lyase
PLRV	potato leafroll virus
PME	Pectin methyl esterase
PNAP	Programme National de l'Amelioration de la Pomme de Terre (Rwanda)
ppm	parts per million
PRACIPA	Programa Andino Cooperativo de Investigación en Papa (Andean region)
PRAPAC	Programme Regional d'Amelioration de la Culture de Pomme de Terre en Afrique Centrale (Central Africa)
PRECODEPA	Programa Regional Cooperativo de Papa (Central America-Caribbean)
PRI	Plant Research Institute
PROCIANDINO	Programa Cooperativo de Investigación Agrícola para la Subregion Andina
PROCIPA	Programa Cooperativo de Investigaciones en Papa (southeast region of South America)
PSTV	potato spindle tuber viroid
PTM	potato tuber moth
PTV	Peru tomato virus
PVA	potato virus A
PVM	potato virus M
PVS	potato virus S
PVT	potato virus T
PVV	potato virus V
PVX	potato virus X
PVY	potato virus Y
RCB	randomized complete block design
RFLP	Restriction Fragment Length Polymorphism
RGTC	relative growth rate

RH	relative humidity
RICA	Red Interamericana de Comunicadores Agricolas
RKN	root-knot nematode
RLER	relative leaf expansion rate
RNA	ribonucleic acid
SAAS	Sichuan Academy of Agricultural Sciences
SAPPRAD	Southeast Asian Program for Potato Research and Development
SCRI	Scottish Crops Research Institute (Scotland)
SD	standard deviation
SDH	Shikimic acid dehydrogenase
SDI	Selective dissemination of information
SEAG	Servicio de Extension Agricola y Ganadera
sec	second
SED	standard error or difference
SEINPA	Semilla e Investigacion en Papa (Peru)
SEM	Scanning Electron Microscopy
SLA	special leaf area
SNC	single node
SOTEC	Society for the Development of Appropriate Technology
SP	Sweet Potato
SPCV	sweet potato caulimo-like virus
SPFMV	sweet potato feathery mottle virus
SPLV	sweet potato latent virus
SPMMV	sweet potato mild mottle virus
SPW	Sweet potato weevil
t	ton
TIB	Technical Information Bulletins
TPS	true potato seed
TSV	Tobacco streak virus
UNA	Universidad Nacional Agraria - La Molina (Peru)
UNCP	Universidad Nacional del Centro del Peru
UNDP	United Nations Development Programme
UPLB	University of the Philippines - Los Baños
UPWARD	User's Perspective with Agricultural Research and Development
USAID	United States Agency for International Development
var.	variety
VISCA	Visayas State Agricultural College
vol	volume
vs.	versus
WI	Wound-inducible
wk	week
wt	weight
WUE	water use efficiency
XSPRC	Xushou Sweet Potato Research Center
yr	year

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Research and Consultancy Contracts in 1991

Thrust I
Collection, Maintenance, and Utilization of Unexploited Genetic Resources

Departmental Projects

1. Biosystematic Studies of Selected Wild Species and Their Utilization in Breeding. **Genetic Resources.** *P. Schmiediche/C. Ochoa*

2. The Maintenance, Documentation, Distribution, and Evaluation of Potato and Sweet Potato Germplasm. **Genetic Resources.** *Z. Huaman*

3. Germplasm Enhancement Through the Use of Haploids and 2n Gametes. **Genetic Resources.** *K. Watanabe*

4. Ploidy Manipulations for Exploitation and Enhancement of Sweet Potato Germplasm. **Genetic Resources.** *G. Orjeda/P. Schmiediche/E. Carey/J. Dodds*

5. Collection of Sweet Potato Genetic Resources and Sweet Potato Germplasm Enhancement. **Genetic Resources.** *F. de la Puente/Z. Huaman*

6. Exploitation of *S. acaule, S. stoloniferum* and other polyploid species. **Genetic Resources.** *K. Wanatabe*

7. In Vitro Potato and Sweet Potato Germplasm Collection. Introduction, Maintenance, and Analysis. **Genetic Resources.** *R. Lizarraga/J. Dodds*

8. Use of Innovative Tissue Culture Techniques to Improve Potato Germplasm. **Genetic Resources.** *J. Dodds*

9. Germplasm Exploration, Conservation, and Utilization of Several Underutilized Andean Tuber Crops. **Special Project (GTZ).** *M. Hermann (P. Schmiediche)*

Collaborative Projects

10. Collection and Characterization of Sweet Potato Germplasm in Argentina. **Region I.** *A. Boy, P. Bianchini, M. Lenskak* (INTA, Argentina)/*F. De la Puente.*

11. Characterization of Sweet Potato Germplasm in the Dominican Republic. **Region II.** *O. Malamud, P. Gomez* (CESDA)/*Z. Huaman*

12. Collection, Characterization, and Preliminary Evaluation of Sweet Potato Germplasm. **Region II.** *M. M. Rao, O. Malamud* (CARDI)/*E. Carey, Z. Huaman*

13. Collection of *Ipomoea batatas* Germplasm in Irian Jaya, Indonesia. **Region VII.** *P. Vander Zaag, M. Potts, R. Rhoades* (CRIFC)/*Z. Huaman, F. De la Puente, Il Gin Mok*

14. Production of Potato Plants Resistant to *Erwinia* by Genetic Manipulation by *Agrobacterium*. **Region I.** *P. Oliger /J. Dodds*

Contract Projects

15. Ente Nazionale de Energie Alternative (ENEA), *Italy.* "Development of Potato Germplasm Resistant to Insect Pests by Means of Conventional Innovative Breeding Technologies." **Special Project.** *A. Sonnino, L. Bacchetta*

16. Universita Degli Studi Della Tuscia Viterbo, *Italy*. "Use of Genetic Engineering Methods to Confer Fungal Disease Resistance to Potatoes." **Special Project.** *C. Di Pace*

17. Universita di Napoli, *Italy*. "In Vitro Selection of Potato Mutant Tolerant to Abiotic Stress." **Special Project.** *L. Monti*

18. Transfer of Genes and Organelles by Electroporation. **Special Project.** *D. Aviv/E. Galun* (Israel)

19. Characterization of Organelle Genomes as a Tool in Germplasm Characterization. **Special Project.** *E. Galun* (Israel)

20. Instituto Nacional de Investigaciones Agropecuarias (INIAP), *Ecuador*. "Maintenance of the Potato Germplasm In Vitro Collection". **Region I.** *G. Garcia/J. Dodds*

21. Zuzhou Institute of Sweet Potato (ZISP), *China*. "Evaluation of a Sweet Potato Germplasm Collection". **Genetic Resources.** *Sheng Jialian*

22. Guangdong Academy of Agricultural Sciences (GAAS), *China*. "Evaluation of Sweet Potato Germplasm in the Warm Tropics". **Genetic Resources.** *Feng Zu-Xia*

23. Maintenance of In Vitro Sweet Potato Germplasm in Venezuela. **Genetic Resources.** L. Villegas (IDEAS, Venezuela)/*J. Dodds*

24. University of Wisconsin, Madison, *U.S.A.* "Potato Breeding Methods with Species, Haploids, and 2n Gametes." **Genetic Resources.** *S. J. Peloquin*

25. Louisiana State University (LSU), *U.S.A.* "The Use of *Agrobacterium* Plasmid Vectors to Antibacterial, Anti-insect, and Frost-Resistant Genes into Potato Plants." **Physiology.** *J.M. Jaynes*

Thesis Projects

26. The Utilization of Wild Potato Species of the Series *acaulia* and *etuberosa* as Sources of Resistance to Potato Leaf Roll Virus (PLRV) and Potato Spindle Tuber Viroid (PSTVd). UNA, Peru. **Genetic Resources.** *C. Arbizu (P. Schmiediche)* (Terminated)

27. Crossability between *Ipomoea* species of Section Batatas. UNA, Peru. **Genetic Resources.** *J. Diaz (F. De la Puente)*

28. Production of Synthetic 6x Clones of *Ipomoea trifida*. UNA, Peru. **Genetic Resources.** *R. Freyre (M. Iwanaga)* (Terminated)

Thrust II Production and Distribution of Breeding Material

Departmental Projects

29. Adaptation and Utilization of Potato and Sweet Potato Populations in Breeding. **Breeding & Genetics.** *H. Mendoza*

30. Breeding and Selection of Potato Clones with Disease Resistances and Other Appropriate Horticultural Characteristics. **Breeding & Genetics.** *H. M. Kidane-Mariam*

31. Breeding, Selection, and Distribution of Appropriate TPS Progenies and/or Parental Lines in East and Southern

Africa. **Breeding & Genetics.** *H. M. Kidane-Mariam*

32. Evaluation and Utilization of Potato Germplasm for Adaptation to Warm Climates. **Breeding & Genetics.** *E. Chujoy*

33. Development of Improved Sweet Potato Germplasm for Warm and Cool Tropics of Southeast Asia. **Breeding & Genetics.** *E. Chujoy*

34. Development of True Potato Seed (TPS) Parental Lines and Progenies for Agronomical and Reproductive Characters. **Breeding & Genetics.** *A. Golmirzaie*

35. Breeding Sweet Potato Populations Having Short Duration and High Stable Yields for Tropical and Subtropical Regions of South Asia. **Breeding & Genetics.** *T. R. Dayal*

36. Sweet Potato Populations for Hot, Humid Environments. **Breeding & Genetics.** *E. Carey*

37. Maintenance and Multiplication of Pathogen-Free Seed; Production of Low Virus Seed. **Support.** *J. E. Bryan*

38. Socioeconomics of Germplasm Evaluation. **Social Science.** *G. Prain*

39. Development of Sweet Potato and Potato Germplasm for Resistance to Diseases and Insect Pests in Southeast Asia. **Breeding & Genetics.** *Il Gin Mok*

Collaborative Projects

40. Evaluation of Advanced Genetic Materials with Resistance to Late Blight, Bacterial Wilt, Storability and Adaptation. **Special Project** *A. Rubirigi* (ISABU, Burundi)/*J. Rueda*

41. Selection of Potato Cultivars with Late Blight Resistance, Adaptation and Quality. **Special Project.** *B. Tuku* (IAR, Ethiopia)/*P. Callejas*

42. Production, Evaluation, and Utilization of Region I Potato Germplasm in Colombia. *I. Valbuena* (ICA, Colombia)/*O. Hidalgo*

43. Evaluation of Germplasm and Selection for Region I Cyst Nematode Resistance. *R. Eguiguren* (INIAP, Ecuador)/*O. Hidalgo*

44. Evaluation of Advanced Potato Breeding Material in Ecuador. **Region I.** *H. Andrade* (INIAP, Ecuador)/*O. Hidalgo*

45. Evaluation of Advanced Potato Breeding Region I Material in Venezuela. *R.L. Palencia* (FONAIAP, Venezuela)/*O. Hidalgo*

46. Evaluation of Advanced Potato Breeding Material in Peru. **Region I.** *A. Hidalgo* (INIAA, Peru)/*O. Hidalgo*

47. Evaluation of Advanced Potato Breeding Material in Chile. **Region I.** *J. Kalazich* (INIA, Chile)/CIP Breeders

48. Evaluation of Advanced Potato Breeding Material in Argentina. **Region I.** *A. Mendiburu* (INTA, Argentina)/CIP Breeders

49. Evaluation of Advanced Potato Breeding Material in Uruguay. **Region I.** *F. Vilaro* (CIAAB, Uruguay) /CIP Breeders

50. Evaluation of Advanced Potato Breeding Material in Paraguay. **Region I.** *A. López* (Min. of Agriculture, Paraguay) /CIP Breeders

51. Evaluation of Advanced Potato Breeding Material in Brazil. **Region I.** *J. Buso* (CNPH/EMBRAPA, Brazil) /CIP Breeders

52. Evaluation of Cultivated Sweet Potato Germplasm in Paraguay. **Region I.** *M.* Cardoso (Min. of Agriculture, Paraguay)/*A. Strohmenger*

53. Collaboration with National Programs in the Evaluation and Selection of TPS Progenies and Superior Clones. **Region III.** National Breeders of East and Southern African Countries/*H.M. Kidane-Mariam*

54. Introduction, Maintenance and Distribution of Potato Advanced Genetic Materials. **Region III.** *C. Carli/H.M.Kidane-Mariam/S. Nganga*

55. Evaluation of Advanced Potato Genetic Materials with Emphasis on Virus Resistance. **Region IV.** *M. Fahem* (CPRA, Tunisia)/*R. Cortbaoui*

56. Evaluation of Advanced Potato Genetic Materials in Egypt. **Region IV.** *L. Anrity* (Min. of Agriculture, Egypt)/*R. El Bedewy*

57. Evaluation of Advanced Potato Genetic Materials for Cameroon and Neighboring Countries with Emphasis on Disease Resistance. **Region V.** National Breeders of West and Central Africa/*C. Martin*

58. Introduction, Evaluation, and Multiplication of Sweet Potato Germplasm. **Region V.** IRA Scientists/*C. Martin*

59. Breeding for TPS Parental Lines. **Region VI.** *M. Upadhya/K.C. Thakur*

60. Introduction, Screening, Multiplication, and Redistribution of Potato and Sweet Potato Germplasm. **Region VII.** Countries/*P. Vander Zaag/E. Chujoy*

61. Evaluation of TPS Progenies and Production of Hybrid Seed. **Region VII.** National Scientists (LEHRI, Indonesia)/*M. Potts*

62. Introduction and Utilization of Potato Germplasm. **Region VIII.** National Scientists of China (CAAS, China)/*S. Bofu*

63. Development of Improved TPS Progenies for Various Environments of China. **Region VIII.** National Scientists of China (CAAS, China)/*S. Bofu*

64. Evaluation of Sweet Potato *Ipomoea batatas* Clones in Different Areas of Peru. **Breeding & Genetics.** *H. Goyas/ E .Carey/O. Hidalgo*

Contract Projects

65. Consorzio "Mario Neri", ERSO, Imola, *Italy*. "Selection of Potato Clones with High Starch Content." **Special Project.** *F. Concilio/F. Cioni*

66. Cornell University, Ithaca, *U.S.A.* "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*

67. North Carolina State University, *U.S.A.* "Breeding and Adaptation of Cultivated Diploid Potato Species." **Breeding and Genetics.** *W. W. Collins*

68. Instituto Nacional de Tecnologia Agropecuaria (INTA), Balcarce, *Argentina.* "The Utilization of Increased Genetic Variability in the Potato

Breeding Program." **Breeding and Genetics.** *A. Mendiburu*

69. Agriculture *Canada.* "The Nutritional and Chipping Evaluation of Selected Parental Clones in Peru, the Philippines, and Canada." **Breeding and Genetics.** *T. R. Tarn*

70. Universidad de Tacna, *Peru.* "Evaluation of Sweet Potato Germplasm for Tolerance to Certain Abiotic Stresses under Arid Conditions." **Breeding and Genetics.** *N. Arevalo*

71. Instituto Nacional de Investigación Agraria y Agroindustrial (INIAA), *Peru.* "Evaluation of CIP Advanced Clones for the National Potato Program of Peru." **Breeding and Genetics.** *A. Hidalgo*

72. North Carolina State University, *U.S.A.* "Breeding Yielding, Early, and Disease Resistant Sweet Potatoes with Enhanced Food Quality and Nutritional Value." **Breeding and Genetics.** *W. W. Collins*

73. Centro de Investigaciones Agricolas, "A. Boerger" (CIAAB), *Uruguay.* Consultancy on Sweet Potato Breeding. **Region I.** *F. Vilaro*

74. Aegean Regional Agricultural Research Institute (AARI), *Turkey.* "Potato Germplasm Evaluation and Multiplication." **Region IV.** *N. Kuzman*

75. Germplasm Evaluation with Emphasis on Earliness and Virus Resistance. **Region IV.** AARI, *Turkey*

Thesis Projects

76. Inheritance of Earliness in Autotetraploid Potatoes. UNA, Peru. **Breeding and Genetics.** *L. Calua (H. Mendoza)*

77. Inheritance of Earliness, Yield, and Dry Matter Content in Sweet Potatoes. UNA, Peru. **Breeding and Genetics.** *L. Díaz (H. Mendoza)*

78. Inheritance of Quality Factors in Autotetraploid Potatoes. UNA, Peru. **Breeding and Genetics.** *E. Hernández (H. Mendoza)* (Terminated)

79. Comparison of Methods for Selection for General Combining Ability for Yield. UNA, Peru. **Breeding and Genetics.** *J. L. Marca (H. Mendoza)*

80. Quantitative Variation in Potato Breeding. UNA, Peru. **Breeding and Genetics.** *J. Tenorio (A. Golmirzaie)*

81. Components of Genetic Variance for Various Traits in Advance Populations of Autotetraploid Potatoes. UNA, Peru. **Breeding and Genetics.** *N. Zuñiga (H. Mendoza)* (Terminated)

Thrust III Control of Bacterial and Fungal Diseases

Departamental Project

82. Integrated Control of Bacterial Wilt. **Pathology.** *J. Elphinstone* (Terminated)

83. Soil borne Diseases. **Pathology.** *H. Torres*

84. Ecology and Taxonomy of *Pseudomonas solanacearum.* **Pathology.** *H. El-Nashaar.*

85. Fungal and Bacterial Diseases of Sweet Potato in Peru. **Pathology.** *P. Aley*

86. Identification, Physiology, Pathogenicity, and Control of *Alternaria* spp.

Associated with Early Blight. **Pathology.** *H. Torres*

87. Evaluation for Horizontal Resistance to *Phytophthora infestans* in Rwanda. **Pathology.** *L. Skoglund/P. Tegera*

88. Study of *Phytophthora infestans* Isolates in Kenya and Rwanda. **Pathology.** *L. Skoglund/M. Mibey/P. Tegera*

89. Breeding for Early Blight Resistance. **Breeding and Genetics.** *H. Mendoza*

90. International Testing of Late Blight-Resistant Clones. **Breeding and Genetics.** *J. Landeo/G. Forbes*

91. Breeding for Late Blight Resistance with Populations A and B. **Breeding and Genetics.** *J. Landeo*

92. Breeding for Resistance to Bacterial Wilt. **Genetic Resources.** *P. Schmiediche*

93. Development of Improved Native Potato Germplasm. I. Selecting Resistance to *Erwinia* spp. **Genetic Resouces.** *Z. Huaman*

Collaborative Projects

94. Instituto Nacional de Investigaciones Agropecuarias (INIAP), *Ecuador.* "Etiology and Control of Common Rust and *Rosellinia* Black Rot of Potato in Ecuador." **Region I.** *E. Mora/L. Ayala/R. Eguiguren/O. Hidalgo* (Terminated)

95. Integrated Control of Bacterial Wilt. **Special Project.** *A. Autrique* (ISABU, Burundi)/*J. Rueda*

96. Management of Bacterial Wilt. **Region III.** *A. O. Michieka* (NAL, Kenya)/*L. Skoglund*

97. Etiology and Epidemiology of Bacterial and Fungal Pathogens Affecting Sweet Potato in Kenya. **Region III.** *R. W. Gatumbi (NAL, Kenya)/L. Skoglund*

98. *Erwinia* Disease in Different Phases of the Tunisian Potato Seed Program. **Region IV.** *M. Mahjoub* (ESH, Tunisia)/*R. Cortbaoui*

99. Selection of Advanced Clones for Resistance to Late Blight, Combined with Earliness. **Region VII.** *E. Badol* (NPRCRTC, the Philippines)/*E. Chujoy*

100. Managing Bacterial Wilt Through Resistant Germplasm and Appropriate Farming Systems. **Region VII.** *N. Balanay* (Min. of Agriculture, the Philippines)/*P. Vander Zaag*

101. Control of Bacterial Wilt on Potatoes. **Region VIII.** *H. Liyuan* (CAAS, China)/*B. Song*

102. Est. Exp. Agr. INTA - San Pedro, *Argentina.* "Survey and Control of Diseases of Sweet Potato in Argentina." **Region I.** *I. de Mitidieri/M. Scandiani*

Contract Projects

103. University of Wisconsin, *U.S.A.* "Fundamental Research to Develop Control Measures for Bacterial Pathogens of the Potato." **Pathology.** *L. Sequeira*

104. Universidad Nacional de Huanuco, *Peru.* "Development of Potato Varieties with Resistance to Diseases and Adaptation to Ecological Zones of the Department of Huanuco." **Pathology.** *E. Torres Vera*

105. Consultative Contract, *Peru.* "Early Blight of Potatoes: Specialization on *Alternaria* spp." *T. Ames de Icochea*

106. Gilat Regional Experimental Station, *Israel.* "*Verticillium* Wilt and Early Blight Tolerance of Potato in Hot

Climates." **Pathology**. *A. Nachmias* (Terminated)

107. Scottish Crop Research Institute, *Scotland*. "Development and Standardization of Effective Screening Procedures to Determine Resistance of Potato to Blackleg and Soft Rot (*Erwinia* spp.)." **Pathology**. *M. Perombelon*

108. Universidad Austral, *Chile*. "Biological Control of Bacterial Wilt in Chile." **Region I.** *L. Ciampi*

109. Centro Nacional de Pesquisas de Hortaliças (CNPH/EMBRAPA), *Brazil*. "Evaluation of Potato Germplasm for Resistance to *Alternaria*, PVX and PVY in Brazil." **Region I.** *F. Reifschneider*

110. Instituto Colombiano Agropecuario, (ICA), Rionegro, *Colombia*. "Evaluation of Genetic Material from CIP for Resistance to Late Blight and Bacterial Wilt." **Region I.** *P. L. Gomez/J.L. Zapata/O. Trillos*

111. Centro de Investigaciones Agricolas "A. Boerger" (CIAAB), *Uruguay*. "Selection of Clones with Resistance to *Alternaria* and Earliness in a Virus-Resistant Population." **Region I.** *F. Vilaro/C. Crisci*

112. Centro Nacional de Pesquisas de Hortalicas (CNPH/EMBRAPA), *Brazil*. "Potato Germplasm Evaluation for Resistance to Bacterial Wilt." **Region I.** *C. A. Lopes*.

113. Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP), *Mexico*. "Selection of Resistance to Late Blight of Potato." **Region II.** *M. Villarreal*

114. Louisiana State University (LSU), *U.S.A*. "Etiology of Sweet Potato Chlorotic Leaf Distortion." **Pathology**. *C. A. Clark/R. A. Valverde/D. R. La Bonte*

Thesis Projects

115. Serological Detection of *Erwinia carotovora*. UNA, Peru. **Pathology**. *C. Corredor* (*J. Elphinstone*) (Terminated)

116. Characterization, Compatibility, and Incompatibility Reaction of Differentials to *Phytophthora infestans*. UNA, Peru. **Pathology**. *W. Galindez* (*G. Forbes*)

117. Sources of Resistance to Early Blight in CIP's Germplasm Collection. UNA, Peru. **Pathology**. *A. Palomino* (*V. Otazu*) (Terminated)

118. Identification of Native and Introduced Hosts of *Pseudomonas solanacearum* in Peru. UNA, Peru. **Pathology**. *B. Paz* (*E. French*) (Terminated)

119. Inventory of Pests and Diseases Affecting Sweet Potato Production. UNA, Peru. **Pathology**. *O. Quincho* (*J. Elphinstone*)

120. Interaction between *Erwinia carotovora* var. *caratovora* and *Fusarium* spp. Affecting Potatoes in Peru. UNA, Peru. **Pathology**. *H. Silva* (*E. French*). (Terminated)

121. Pathogenic Variation in *Pseudomonas solanacearum*. UNA, *Peru*. **Pathology**. *J. Marin* (*H. El-Nashaar*)

122. Comparison of Methods to Uniformly Infest Fields with *Pseudomonas solanacearum*. UNCP, Huancayo,

Peru. **Pathology**. *E. Ponce* (*H. El-Nashaar/V. Otazu*) (Terminated)

123. Detection and Quantification of Pectolytic *Erwinias* in Tuber Seed and Their Effect on Disease Incidence in Different Environments. UNA, *Peru*. **Pathology**. *A. Villantoy* (*H. El-Nashaar/E. French*)

124. Inventory of Pests and Diseases that Affect Sweet Potato Production in the Warm Climate of San Ramon. UNCP, Huancayo, *Peru*. **Pathology**. *O. Quincho* (*V. Otazu*) (Terminated)

125. Development and Standardization of Effective Screening Procedures to Determine Resistance to Blackleg and Soft Rot. UNA, *Peru*. **Pathology**. *L. Gutarra* (*H. El-Nashaar*)

126. Inheritance of Horizontal Resistance to Late Blight in *S. tuberosum* spp. *andigena*. UNA, *Peru*. **Breeding and Genetics**. *M. Gastelo* (*J. Landeo*) **(Terminated)**

127. Biological Control of Bacterial Wilt. UPLB, the *Philippines*. **Region VII**. *Hongqi Zeng (P. Vander Zaag)*

128. Recurrent Selection for Late Blight Resistance. UPLB, *The Philippines*. **Region VII**. *Dao Huy Chein* (*E. Chujoy*)

129. 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. **Breeding and Genetics**. *R. Anguiz* (*H. Mendoza*)

130. Inheritance of Horizontal Resistance to Late Blight *Phytophthora infestans* in Advanced Potato Hybrids. **Breeding and Genetics**. *E. Roncal*. (*J. Landeo*)

Thrust IV Control of Virus And Virus-like Diseases

Departmental Projects

131. Antiserum Production and Improvement of Serological Techniques for Virus Detection. **Pathology**. *V. Flores/L. Salazar*

132. Identification and Characterization of Sweet Potato Viruses. **Pathology**. *S. Fuentes/L. Salazar*

133. Mechanism of Resistance and Variability of Potato Leaf Roll Virus (PLRV). **Pathology**. *U. Jayasinghe*

134. Studies on Potato Virus X and Y. **Pathology**. *E. N. Fernandez-Northcote*

135. Molecular Analysis of Genetic Resistance to Viruses. **Pathology**. *M. Querci*

136. Development of Molecular Probes for the Identification of Pathogens. **Pathology**. *M. Querci*

137. Identification of Sweet Potato White Fly-borne Viruses. **Pathology**. *M. Nakano*

138. In Vitro Eradication of Sweet Potato Viruses and Viroids. **Physiology**. *J. Dodds*

139. Characteristics of the Transmission of Potato Viruses and Viroids Through TPS. **Physiology**. *P. Malagamba/C. Barrera*

140. Genetic Studies and Breeding of Virus and Viroid Resistance. **Breeding and Genetics**. *H. Mendoza*

141. Search for Genes for Resistance to Viruses in wild-*Solanum* Tuberiferous species. **Genetic Resources**. *C. Lizarraga/A. Salas/L. Salazar*

142. Breeding for Resistance to PLRV Combined with Immunities to PVX. **Breeding and Genetics**. *A. Brandolini/H. Mendoza/L. Salazar/U. Jayasinghe*

Collaborative Projects

143. Effect of Potato Virus S on Growth, Yield, and Late Blight. **Special Project**. *M. Goethals* (ISABU, Burundi)/*J. Rueda*

144. Development and Utilization of Virus Detection Techniques. **Region VIII**. *Z. Heling* (University of Inner Mongolia, China)/*S. Bofu*

145. Studies on Yellow Vein Virus. **Region I**. *A. Saldarriaga* (UNM, Colombia)/*O. Hidalgo*

146. Test Application of Modern Technology for Detection of Potato Pathogens. **Region I**. *A. M. Escarra* (Argentina)/*L. Salazar*

147. Resistance to Potato Viruses in *Solanum Brevidens*. **Pathology**. *J. Valkonen* (Univ. Helsinki)/*L. Salazar, K. Watanabe, J. Dodds, E. Pehu, R. Gibson*

148. CNPH/EMBRAPA, *Brazil*. "Evaluation of Clones for PLRV Resistance, Immunity to PVY and PVX and Adaptation to the Center West Region of Brazil." **Region I**. *J. A. Buso*

149. Survey of Virus Diseases and Evaluation of Yield Losses by Viruses in Sweet Potato in Argentina-Socioeconomic Importance. **Region I**. *Sergio F. Nome/L. Salazar*

Contract Projects

150. Virus Diseases of Sweet Potatoes. **Special Project**. *G. Loebenstein/H.J. Vetten (Israel/Germany)*

151. Scottish Crop Research Institute, *Scotland*. "Resistance to Potato Leafroll Virus." **Pathology** *B. D. Harrison*

152. North Carolina State University, *U.S.A*. "The Accumulation of Sweet Potato Feathery Mottle Virus, dsRNA and Selected Viral Proteins in Sweet Potatoes." **Pathology**. *J. Moyer*

153. Instytut Ziemniaka/Institute for Potato Research, *Poland*. "Breeding Potatoes Resistant to the Potato Leaf Roll Virus, PLRV." **Pathology**. *K. M. Swiezynski*

154. North Carolina State University, *U.S.A*. "Development of Virus Testing Procedures for Sweet Potatoes." **Pathology**. *J. Moyer*

155. Centro de Investigaciones Agricolas "A. Boerger" (CIAAB), *Uruguay*. "Evaluation of Genetic Material for Resistance to PVX and PLRV Under Field Conditions." **Region I**. *C. Crisci/F. Vilaro*

Thesis Projects

156. Studies on the Mechanisms of Resistance of Potatoes to Viruses: Determining the Factor that Confers Extreme Resistance to Potato Virus X in Potato. UNA, *Peru*. **Pathology**. *S. Vega*, (*M. Querci/L. Salazar*) **(Terminated)**

157. Combination of PVX and PVY Immunity with High Resistance to *Phytophthora infestans* in Potato Clones. UNA, *Peru*. **Pathology**. *J. L. Zapata* (*E. N. Fernandez-Northcote*)

158. Efficiency of PLRV Transmission by Different Species of Aphids. UNA, *Peru*. **Pathology**. *G. Brignetti* (*U. Jayasinghe*)

159. Identification of Viroids in Sweet Potatoes. UNA, *Peru.* **Pathology**. *A. Hurtado* (*L. Salazar*)

160. Viroid Detection Using Wide-spectrum Nucleic Acid Probes. UNA, *Peru.* **Pathology**. *C. Lizarraga* (*L. Salazar*)

161. Genome Structure and Expression of Sweet Potato Feathery Mottle Virus. University of Birmingham, *Great Britain.* **Pathology**. *J. Nakashima* (*R. Wood*)

162. Determining the Segregation Pattern of the Gene for Immunity to Potato Virus Y (PVY). **Breeding and Genetics**. *N. Hernandez* (*H. Mendoza/L. Salazar*) **(Terminated)**

163. Studies on the Heredity of the Resistance to Sweet Potato Feathery Mottle Virus. **Breeding and Genetics.** *E. Mihovilovich* (*H. Mendoza/L. Salazar*)

Thrust V Integrated Pest Management

Departmental Projects

164. Screening for and Utilization of Resistance to Root Knot Nematodes Species. **Nematology and Entomology**. *P. Jatala*

165. Components of Integrated Root Knot Management and Interrelationships of this Nematode with Other Organisms. **Nematology and Entomology**. *P. Jatala*

166. Development of IPM Strategies Against the Sweet Potato Weevils and their Socioeconomic Implications. **Nematology and Entomology**. *H. Kokubu/A. Swindale*

167. Management of Potato and Sweet Potato Insect and Mite Pests of Global and Regional Entomological Importance. **Nematology and Entomology.** *K. V. Raman*

168. Integrated Control of Potato Cyst Nematode. **Nematology and Entomology.** *M. Canto*

169. Management of Potato and Sweet Potato Insect Pests of Importance in Region I. **Nematology & Entomology.** *L. Valencia*

170. Agricultural Chemical Use and Sustainability of Andean Potato Production. **Social Science.** *C. Crissman/J. Antle/S. Capalbo*

171. Development of Mass Production Methods for *Beauveria* sp. Parasitic to the Andean Potato Weevil and the West Indian Sweet Potato Weevil. **Pathology.** *H. Torres*

172. Breeding for Resistance to Insect Pests (Potato Tuber Moth, Leaf Miner Flies and Aphids) of Potato. **Breeding and Genetic**. *A. Golmirzaie/K.V. Raman*

Collaborative Projects

173. Integrated Control of Root Knot Nematode. **Special Project.** *M. Goethals* (ISABU, Burundi)/*D. Berrios*

174. Integrated Management of Tuber Moth in Burundi. **Special Project.** *Z. Nzoyihera* (ISABU, Burundi)/*D. Berrios*

175. Integrated Management of Potato Tuber Moth and Aphids in Ethiopia. **Special Project**. *B. Tuku* (IAR, Ethiopia)/*P. Callejas* **(Terminated)**

176. Integrated Pest Management for Sweet Potato in Burundi. **Special Project.** *J. Sakubu/A. Autrique* (ISABU, Burundi)/*D. Berrios*

177. Ecology and Control of the Andean Weevil. **Region I.** *H. Calvache* (ICA, Colombia)/*L. Valencia*

178. Biological Control of Potato Tuber Moth. **Region I.** *A. Lopez* (ICA, Colombia)/*L. Valencia* (Terminated)

179. Biological Control of Potato Tuber Moth in Venezuela. **Region I.** *J. Rincon* (FONAIAP, Venezuela)/L. Valencia (Terminated)

180. Integrated Control of Andean Weevil in Venezuela. **Region I.** *F. Torres* (FONAIAP, Venezuela)/*L. Valencia*

181. The Design and Execution of an Integrated Control Program for Andean Potato Weevil in Huatata, Chinchero, Peru. **Region I.** *E. Yabar* (INIAA, Peru)/*J. Alcazar*

182. Integrated Control of Sweet Potato Insect Pests in Argentina. **Region I.** *H. Bimboni, D. Ruberti* (INTA)/ *K. V. Raman*

183. Evaluation of Sweet Potato Germplasm for Resistance to Sweet Potato Weevil in Central America and the Caribbean. **Region II.** National Scientists of the Region/*H. Kokubu, E. Carey, O. Malamud*

184. Integrated Management of Sweet Potato Weevils in the Caribbean. **Region II.** *J. Reid, M. Alam* (CARDI)/*H. Kokubu, O. Malamud*

185. Evaluation of Trap Types with Sex Pheromones of *Cylas* spp. **Region II.** *P. Gomez, V. Escarraman* (CESDA) /O. *Malamud, H. Kokubu, O. Malamud*

186. Agronomical Practices to Control Sweet Potato Weevil. **Region II.** National Scientists of the Dominican Republic and Haiti/*O. Malamud*

187. IPM for Sweet Potato Pests in Kenya. **Region III.** National Scientists/*N. Smit*

188. IPM for Potato Pests in Kenya. **Region III.** National Scientists/*N. Smit*

189. Integrated Control of Potato Tuber Moth in Egypt. **Region IV.** *S. Doss* (Min. of Agriculture, Egypt)/*R. El-Bedewy*

190. The Integrated Control of the Potato Tuber Moth in Tunisia: Farmers' Fields and Storage. **Region IV.** *H. Ben Salah, K. Lebdi* (INRAT)/*O. Roux*

191. Population Dynamics of the Potato Tuber Moth: Optimizing IPM Strategy in Field and Storage. **Region IV.** *H. Ben Salah, R. Ben Amor, K. Lebdi* (INRAT)/*O. Roux*

192. The Integrated Control of the Potato Tuber Moth in Tunisia: Evaluation and Refinements of Treatment Components and Techniques. **Region IV.** *H. Ben Salah/K. Lebali* (INRAT)/*O. Roux*

193. Integrated Management of Sweet Potato Weevil (*Cylas formicarius*). **Region VII.** *D. Amalin* (VISCA, the Philippines)/*P. Vander Zaag*

Contract Projects

194. University of the Philippines, Los Baños (UPLB), *The Philippines*. "Integrated Control of Weeds and Nematodes by the Use of Biological Control Agents and Solarization."

Nematology and Entomology. *R. Davide (Terminated)*

195. North Carolina State University, *U.S.A.* "Evaluation of Potato Lines for Resistance to the Major Species and Races of Root Knot Nematodes (*Meloidogyne* spp.)." **Nematology and Entomology**. *J. N. Sasser* **(Terminated)**

196. Universidad Nacional Agraria, *Peru.* "Evaluation of Resistant Clones to Potato Cyst Nematode in Peru." **Nematology and Entomology**. *R. Egusquiza/M. Canto/J. Landeo*

197. Universidad Nacional Agraria, *Peru.* Consultancy on "Biological and Selective Chemical Control of Potatoes and Sweet Potato Insect Pests." **Nematology and Entomology**. *J. Sarmiento/* Colleagues

198. Centro de Cria de Insectos Utiles (CICIU), *Peru.* "Biological Control of Major Potato and Sweet Potato Pests." **Nematology and Entomology**. *L. Valdivieso/M. Whu*

199. Instituto Nacional de Investigaciones Agropecuarias (INIAP), *Ecuador.* "Evaluation of Resistant Clones to the Potato Cyst Nematode (*Globodera* spp.) in Ecuador." **Region I.** *R. Eguiguren/J. Revelo*

200. The Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), *The Philippines.* "Management of Thrips and Mites Attacking Potato in the Lowlands." **Region VII.** *E. N. Bernardo.* **(Terminated)**

201. Mississippi State University, *U.S.A.* "Development of Host-plant Resistance to the Sweet Potato Weevil *Cylas formicarius elegantulus*." **Breeding and Genetics**. *P. G. Thompson/J. C. Schneider*

202. University of Florida, *U.S.A.* **Region II.** "Use of Sex Pheromone and Entomopathogenic Nematodes for Control of the Sweet Potato Weevil, *Cylas formicarius* (Fabricius)." R. K. Jansson

Thesis Projects

203. Extraction and Inoculation Methods of *Nacobbus aberrans* and its Interaction with *Globodera pallida.* UNA, *Peru.* **Nematology and Entomology** *J. Arcos (P. Jatala/M. Canto)* **(Terminated)**

204. Effect of Glandular Trichomes on Leaf Miner Fly (*Lyriomyza huidobrensis*) Damage in Potatoes. UNA, *Peru.* **Nematology and Entomology** *G. Hospina (K.V. Raman)* (Terminated)

205. Detection and Evaluation of *Granulosis Virus* (GV) for Potato Tuber Moth (PTM) *Phthorimaea operculella* Control. UNA, *Peru.* **Nematology and Entomology**. *H. Leal* (*K. V. Raman*) (Terminated)

206. Reaction of Potato Clones to *Pratylenchus* spp. from Umari, Huanuco. UNA, *Peru.* **Nematology and Entomology**. *Z. Nicolas (P. Jatala/M. Canto)* (Terminated)

207. Determination of Some Components for an Integrated Control of *Pratylenchus flakkensis.* UNA, *Peru.* **Nematology and Entomology**. *S. Jaime* (*M. Canto*) (Terminated)

208. Life Cycle of the Central American Potato Moth *Scrobipalpopsis solanivora* (Povolny) and Studies on Monitoring Field Populations.

Nematology and Entomology. *F. Torres* (*L. Valencia*) (Terminated)

209. Biochemical Differences in the Genera of *Globodera, Meloidogyne*, and New Nematode Attacking Potatoes. *A. Mayorga (P. Jatala)* (Terminated)

210. Histopathological Changes Caused by a New Nematode Attacking Potatoes. **Nematology and Entomology.** *R. Haddad*, (*P. Jatala*) (Terminated)

211. Evaluation of Sweet Potato Cultivars to *Euscepes postfasciatus* Fairmaire. **Nematology and Entomology.** *J. Sarmiento* (*K. V. Raman/M. Palacios*)

212. Reaction of 15 Plant Specie to *Nacobbus aberrans* Populations from the Americas (Thorne, 1935; Thorne & Allen, 1944) **Nematology and Entomology.** *T. Boluarte* (*P. Jatala*)

213. Evaluation of Potato Cyst Nematode Reproduction *Globodera pallida* (Stone Behrins 1975) in the Pot Test. **Nematology and Entomology.** *C. Posadas* (*M. Canto*)

Thrust VI Warm-Climate Potato and Sweet Potato Production

Departmental Projects

214. Improving Efficiency of Fertilizer, Water, and Light Use in Non Traditional Warm Potato-Growing Areas. **Physiology.** *D. Midmore* (Terminated)

215. Evaluation of Genotypic Responses to Water Stress and Improvements to Water Use Efficiency by Potatoes and Sweet Potatoes for Warm Climates. **Physiology.** *I. Ekanayake.* (Terminated)

216. In Vitro Screening of Sweet Potatoes to Saline and Osmotic Stress Conditions. **Physiology.** *I. Ekanayake* (Terminated)

217. Potato Production in the Cropping Systems of the Warm Climate Zone of Asia. **Physiology.** *M. Potts.*

218. Potato Production in Lowland Caribbean Environments. **Physiology.** *F. Payton*

219. Adaptation and Utilization of Potato Populations for the Hot Tropics. **Breeding and Genetics.** *H. Mendoza*

220. Intercropping with Sweet Potato, Improvement of Crop Productivity in Sub-Optimal Environments. **Physiology** *A. Oswald/D. Midmore/J. Roca/ E. Carey*

Collaborative Projects

221. Sustainable Potato Production in Dominican Republic. **Region II.** National Scientists/*F. Payton*

222. Improvement of Sweet Potato in Egypt. **Region IV.** *S. Doss* (Ministry of Agriculture, Egypt)/*R. El-Bedewy*

223. Cropping Systems and Intercropping. **Region IV.** *R. Cortbaoui*

224. True Potato Seed Hybrid Families in Different Agroecological Zones of *India*. **Region VI.** National Scientists of CPRI, India/*M. Upadhya*

225. True Potato Seed on Farm Trials in India. **Region VI.** National Scientists of CPRI, India/*M. Upadhya*

226. Use of Plant Growth Substances in Improving Quality and Quantity of Potato Yield. **Region V.** National Scientists of CPRI, India/*M. Upadhya*

227. Agronomic Evaluation of Selected Sweet potatoes. **Region VI.** *T. Dayal*

228. Tuber Seed Production and Storage for Warm Climates in Asia. **Region VII.** National Scientists of CPRI, India/*M. Upadhya*

229. Agronomic and Physiological Studies on Sweet Potato in Warm Climates: the Philippines and Vietnam. **Region VII.** *H. Taja* (Institute of Biology, Philippines)/*N. Van Uyan* (HCMC, Vietnam)/*P. Vander Zaag*

230. Intercropping Studies on Potato with Maize and Other Annual Crops. **Region VIII.** *L. Jiemin* (S. China Potato Research Center)/*B. Song*

231. Sustainable Sweet Potato Cropping Systems on Upland Eroded Soils. **Region VIII.** *S. Bofu*

232. Effects of Potassium Nitrate in the Production and Processing of the Potato. **Region II.** *S. Villagarcia/F. Payton*

Contract Projects

233. UNA, *Peru.* "Soil Management, Fertilizers and Mineral Nutrition of the Potato and Sweet Potato Under Adverse Conditions of Soil and Climate." **Physiology.** *S. Villagarcia*

234. Scottish Crop Research Institute, *Scotland.* "Drought Tolerance in Potatoes." **Physiology.** *P. Waister*

235. Instituto Nacional de Tecnología Agropecuaria (INTA), *Argentina.* Consultancy on Sweet Potato Production and Utilization. **Region I.** *A. Boy*

236. Mauritius Sugar Industry Research Institute (MSIRI), Nairobi, *Kenya.* "Development of Potato Varieties for Lowland Tropical Conditions." **Region III.** *N. Govinden*

Thesis Projects

237. Effect of Nitrogen Fertilizer and Inoculation with *Azospirillum* on Yield and Nitrogen Content of Two Sweet Potato Varieties. **Physiology.** UNA, *Peru. M. Julca (P. Malagamba)*

238. Management of Sweet Potato Planting Material. UNA, *Peru.* **Physiology.** *F. Wizman (P. Malagamba)*

239. Irrigation Requirements for Sweet Potato. **Physiology.** *E. Rios (D. Midmore)*

Thrust VII Cool-Climate Potato and Sweet Potato Production

Departmental Projects

240. Breeding for Resistance to Frost, Drought, Wide Adaptability, and Other Major Virus and Pest Diseases of Highlands and Cool Environments. **Breeding and Genetics.** *J. Landeo*

241. Genotypic Response to Water Stress and Low Fertilization Input in Cool Environments. **Physiology.** *D. Midmore* (Terminated)

242. Evaluation and Selection of Sweet Potatoes in Cool Environments. **Breeding and Genetics.** *J. Landeo*

Collaborative Projects

243. On-Farm Trials to Introduce Cultivars to Improve Potato Production in Burundi. **Special Project.** *CH. Muvira, Z. Nzoyihera* (ISABU, Burundi)/*C. Turner* **(Terminated)**

244. Yield Improvements Through Agronomic Practices. **Special Project.** *CH. Muvira, Z. Nzoyihera* (ISABU, Burundi)/*D. Berrios*

245. Potato Production from True Seed: Progenies and Agronomy. **Special Project.** *B. Tuku* (IRA, Ethiopia)/*P. Callejas* (Terminated)

246. Management of Cultural Practices to Reduce Potato Damage Caused by *Nacobbus aberrans* in Bolivia. **Special Project.** *J. Franco*/Bolivian National Scientists

247. Genetic Control of False Root Knot Nematode, Frost, and Black Wart by the Use of Resistant Varieties in Bolivia. **Special Project.** *N. Estrada*/Bolivian National Scientists

248. Ecophysiology of Potato Production in the Southern Region of Chile. **Region I.** *J. S. Rojas* (INIA, Chile) /*D. Midmore*/*P. Malagamba*

249. Adaptive Research to Grow Potatoes in Arid and Saline Soils under Irrigation During the Cool Season in Mexico. **Region II.** *M. Villarreal* (INIA), Private Researchers/*O. Malamud*

250. Agronomy of Potato Production in Cameroon and Other Countries with Similar Agroecological Conditions. **Region V.** *D. Nyualem* (IRA, Cameroon)/*T. Gass, C. Martin* .

Contract Projects

251. Instituto de Investigaciones Agropecuarias (INIA), *Chile.* "Selection of Potato Genetic Materials Adapted to Suboptimal Temperatures." **Region I.** *J. S. Rojas*

Thesis Projects

252. Determination of Type of Gene Action in the Control of Frost Resistance. **Breeding and Genetics.** UNA, *Peru. V. Huanco* (*J. Landeo*) (Terminated)

253. Techniques to Select Potato Genotypes with an Efficient Use of Nitrogen Fertilizer. **Physiology.** UNA, *Peru. S. Sarapura* (*D. Midmore*) (Terminated)

254. Study of the Inheritance of Frost Tolerance in Native Potato Clones of *S. tubersoum*, ssp. *andigena* from Bolivia. **PROINPA/IBTA.** *E. Carrasco* (*J. Landeo*)

Thrust VIII Postharvest Technology

Departmental Projects

255. Low-Cost Storage of Consumer Potatoes. **Physiology.** *S. Wiersema*

256. Simple Processing for Low-income Groups. **Physiology.** *S. Wiersema.* (Terminated)

257. Physiological Aspects of Seed and Ware Potato Storage. **Physiology.** *S. Wiersema* **(Terminated)**

258. Integrated Control of Postharvest Losses During Tropical Potato Storage. **Pathology.** *J. Elphinstone.* (Terminated)

259. Breeding Potatoes for Processing in Tropical Countries. **Breeding and Genetics.** *H. Mendoza*

260. Socioeconomics of Potato and Sweet Potato Processing. **Social Science.** *G. Scott.*

261. Improvement of Potato Storage Techniques in Burundi. **Special Project.** *Z.*

Nzoyihera (ISABU, Burundi)/*D. Berrios*

262. Research and Transfer of Postharvest Technologies to African Countries. **Region III.** National Scientists of African Countries/*S. Nganga*

263. Sweet Potato Storage (Post Maturity Technology). **Region III.** *A. Abubaker* (Min. of Agriculture, Kenya)/*S. Nganga*

264. Low-Cost Potato Processing. **Region III.** *J. Kabira* (Min. of Agriculture, Kenya)/*G. Hunt*

265. Assessment of Promising Potato Clones Under Seed Storage Conditions. **Region III.** *J. Kabira* (Min. of Agriculture, Kenya)/*G. Hunt*

266. Storage of Ware and Seed Potatoes. **Region IV.** *S. Doss* (Min. of Agriculture, Egypt)/*R. El-Bedewy*

267. Studies on Potato and Sweet Potato Storage and Processing. **Region V.** *J. Lekunze* (IRA, Cameroon)/*C. Martin*

268. Rustic Stores for Ware and Seed Potato and Sweet Potatoes. **Region VI.** *R. Nave* (SOTEC, India)/*S. Mehra*

269. Table and Seed Potato Storage for Lowlands of Southeast Asia. **Region VII.** National Scientists of Southeast Asian Countries/*P. Vander Zaag* (Terminated)

270. Improved Sweet Potato Processing in China. **Region VIII.** *Z. F. Tang*/*B. F. Song*

271. Evaluation of Potato and Sweet Potato Clones for Food Processing and Cooking Quality. **Physiology.** *K. Tantidham*/*S. Wiersema*

272. Sweet Potato Processing. Java-An Interdisciplinary Baseline Study. **Special Project.** *A. Dimyati*/*S. Wiersema*/*R. Rhoades* (UPWARD)

273. Thai Food Habits and Potential Processing of Sweet Potato. **Special Project.** *P. Duluyapach*/*S. Wiersema*/*R. Rhoades* (UPWARD)

Contract Projects

274. Society for the Development of Appropriate Technology (SOTEC), *India*. "Village-Level Processing of Potato and Sweet Potato." **Region VI.** *R. Nave*

275. The Philippine Root Crop Research and Training Center (PRCRTC), the *Philippines*. "Development of Simple Processing Technologies for Sweet Potato/Potato-Based Products for Low-income Groups as Target Consumers." **Region VII.** *T. Van Den*

276. Use of Sweet Potato Starch and Flour in Food Processing. Institute of Food Research and Product Development. *Thailand.* **Physiology.** *S. Maneepun*/*S. Wiersema*

277. Screening for Natural Sprout Inhibitors of Potato Tubers Using Plants of the *Libiatae* Family. **Region VII** *E. G. Quintana, O. K. Bautista*/University of the Philippines, Los Baños

Thesis Projects

278. Pre- and Postharvest Factors Influencing Consumer Potato Tuber Storability in the Tropics. **Physiology.** UNA, *Peru. A. Tupac (S. Wiersema/J. Elphinstone/E. French)* (Terminated)

279. Production and Utilization of Solar Dried Potatoes in Kenya. **Region III.**

University of Nairobi, *Kenya. J. Kabira* (*G. Hunt*)

280. Effect of Growing Conditions and Postharvest Management on Quality of Potatoes for Processing and Fresh Consumption. **Region VII.** Chiang Mai University Wiwat/*S. Wiersema*

281. Chemical and Nutritional Evaluation of Some Sweet Potato (*Ipomoea batatas*) Cultivars with Low Sugar Content for Possible Use in Baking. **Region I.** UNA, *Peru. H. Cardenas, (Z. Huaman/N. Fong)*

Thrust IX Seed Technology

Departmental Projects

282. Agronomic Technology for Growing Potatoes from TPS. **Physiology.** *P. Malagamba/J. Bryan/R. Cabello*

283. Physiological Studies on True Potato Seed (TPS) Quality, Storage, and Handling. **Physiology.** *N. Pallais*

284. Investigation of Environmental Conditions During the Development of Sexual Reproductive Organs of *Ipomoea batatas* and Other *Ipomoea* species. **Physiology.** *H. Beaufort-Murphy*

285. Soil Fertility and Mineral Nutrition on Potato Flowering and Fruit Setting. **Physiology.** *S. Villagarcia*

286. Sweet Potato Propagation. **Physiology.** *H. Beaufort-Murphy.*

287. TPS Production in Warm Climates. **Physiology.** *P. Malagamba*

288. Potato Seed Programs in Developing Countries. **Social Sciences.** *C. Crissman.*

289. Different Breeding Approaches for Hybrid TPS Production. **Breeding and Genetics.** *A. Golmirzaie*

Collaborative Projects

290. Basic Seed Production in *Peru.* **Special Project.** *A. Hidalgo* (INIAA, Peru)/*R. Wissar*

291. Client-oriented Seed Programs. **Special Project.** *A. Hidalgo* (INIAA, Peru)/*E. Franco*

292. Potato Basic Seed Production in Burundi. **Special Project.** *Sinduhija* (ISABU, Burundi)/*D. Berrios*

293. On-farm Potato Seed Production. **Special Project.** *Z. Nzoyihera* (ISABU, Burundi)/*D. Berrios*

294. Production of Basic Potato Seed in Colombia. **Region I.** *P. Corzo* (ICA, Colombia)/*O. Hidalgo*

295. Production of Seed Tubers from True Potato Seed. **Region I.** *E. Ortega* (FONAIAP, Venezuela)/*O. Hidalgo*

296. Production of Basic Seed in Venezuela. **Region I.** *E. Ortega* (FONAIAP, Venezuela)/*O. Hidalgo*

297. Adaptive Research on TPS Production. **Region I.** *J. S. Rojas* (INIA, Chile)/*J. Bryan*

298. In Vitro and Rapid Multiplication for Basic Potato Seed Production. **Region I.** *J. Rojas* (INIA, Chile)/*J. Bryan*

299. Seed Potato Production in Paraguay. **Region I.** *M. Mayerreger* (Min. of Agriculture, Paraguay)/*A. Strohmenger*

300. Potato Production from True Potato Seed in Paraguay. **Region I.** *T. Mayerregger* (IAM, Paraguay)/*A. Strohmenger*

301. Studies on Potato Hybridization, Pollen Management, and Outcrossing Rates. **Physiology.** *J. Kalazich* (INIA)/*P. Malagamba*

302. Use of TPS for Potato Production in Monserrat, Dominica, St. Kitts, and Jamaica. **Region II.** *R. Fletcher* (CARDI)/*O. Malamud*

303. Use of TPS for Potato Production in Nicaragua and Haiti. **Region II.** *F. Torres* (Nicaragua), *M. Bastiat* (Haiti)/ *O. Malamud*

304. Basic Seed Production in Kenya. **Region III.** *I. Nyoroge* (KARI, Kenya)/ *C. Carli*

305. Agronomic Techniques for Potato Seed Production. **Region III.** National Scientists of African Countries/*C. Carli*

306. Evaluation of Rapid Multiplication Techniques for Potato Basic Seed. **Region III.** National Scientists of African Countries/*C. Carli*

307. Multiplication Methods for Sweet Potato Propagation. **Region III.** National Scientists of Kenya/*C. Carli*

308. Development of Cultural Practices for Potato Production from Seed Tubers and Seedling Tubers. **Region IV.** *A. Sharara* (Ministry of Agriculture, Egypt)/*R. El-Bedewy*

309. Potato Production from True Potato Seed. **Region IV.** *N. Farag* (Ministry of Agriculture, Egypt)/*R. El-Bedewy*

310. Potato Production from True Seed in Morocco. **Region IV.** *A. Hilali* (IAV, Morocco)/*R. Cortbaoui*

311. Potato Production from True Potato Seed in Tunisia. **Region IV.** *M. Fahem* (CDRA, Tunisia)/*R. Cortbaoui*

312. Development of a Propagation System for Potato and Sweet Potato in Cameroon and Other Countries in the Region. **Region V.** National Scientists of African Countries/*C. Martin*

313. Production of Hybrid True Potato Seed. **Region VI.** National Scientists (CPRI, India)/*K. Takur*

314. Screening of True Potato Seed Families as Transplants and Seedling Tubers as Seedling Materials. **Region VI.** National Scientists (CPRI, India)/*M. Upadhya*

315. Physiological Studies on True Potato Seed. **Region VI.** National Scientists (CPRI, India)/*M. Upadhya*

316. Technology to Use Cuttings for Seed and Table Potato Production in Southeast Asian Countries. **Region VII.** National Scientists of Southeast Asian Countries/*P. Vander Zaag*

317. Seed Production Systems Using True Potato Seed in the Philippines and Vietnam. **Region VII.** National Scientists of Vietnam/*P. Vander Zaag*

318. Potato Production from True Seed in Cameroon and Other Countries in the Region. **Region V.** NARS Researchers/ *C. Martin, C. Ntonifor*

Contract Projects

319. Istituto di Agronomia, Universita de Napoli, *Italy*. "Selection of TPS Parental Lines in High Seed Production." **Special Project.** *L. Monti, L. Politano*

320. UNA, *Peru*. "Training and Consultancy Research on Effects of Soil Management and Fertilization on Flowering, Fruit Setting and Seed Quality of the Potato and Sweet Potato." **Physiology.** *S. Villagarcia*

321. An Investigation to Determine Optimum Environmental and Cultivation Requirements for Maximum Flowering, Seed, and Storage Root Production in Argentina, 1988-91. **Physiology.** *A. Boy/J. Ploper*

322. Instituto de Investigaciones Agropecuarias (INIA), Osorno, *Chile.* "True Potato Seed Production in Chile." Region I. *J. Santos Rojas, A. Cubillos*

323. AARI, *Turkey.* "TPS Production in Turkey for the Needs of the Middle East and North Africa." **Region IV.**

324. AARI, *Turkey.* "Identification of Suitable Locations for Germplasm Multiplication." **Region IV.**

325. Victoria Department of Agriculture, *Australia.* "Production of Pathogen-tested Potato Germplasm for Southeast Asian and Pacific Countries." **Region VII.** *P. Smith*

Thesis Projects

326. Embryo Culture and Sweet Potato. UNA, *Peru.* **Physiology.** *R. Salinas,* (*J. Dodds*) (Terminated)

327. An Investigation of the Flowering Responses of *Ipomoea purpurea* in Lima, from Accessions Collected in Peru, Ecuador, Venezuela, Colombia and Bolivia. UNA, *Peru.* **Physiology.** *A. Reyes,* (*H. Beaufort-M.*)

328. Promotion of Flower and TPS Production Via Growth Regulators. UNA, Peru. **Physiology.** *R. Garcia* (*P. Malagamba*)

329. Cutting Production and Utilization Under Warm Conditions. UPLB, the Philippines. **Region VII.** H. Wei (*P. Vander Zaag*)

330. Evaluation of Different Types of Progenies for TPS Production. **Breeding and Genetics.** *S. Buendía* (*A. Golmirzaie*)

Thrust X
Food Systems Research

Departmental Projects

331. Constraints to Potato and Sweet Potato Production and Use. **Social Science.** *G. Scott*

332. World Potato Geography. **Social Science.** *R. Rhoades*

333. Marketing and Demand for Potatoes and Sweet Potatoes. **Social Science.** *G. Scott*

334. Sweet Potato in Asian Food Systems. **Social Science.** *R. Rhoades* (umbrella)

335. Sweet Potato in Latin American Food Systems. **Social Science.** *G. Prain/A. Swindale* (umbrella)

336. Sweet Potato in African Food Systems. **Social Science.** *P. Ewell* (umbrella)

337. Patterns and Trends in Root Crop Production and Use. **Social Science.** *G. Scott*

Collaborative Projects

338. Farmer Participatory TPS Research. **Physiology.** *N. Gunadi* (LEHRI, Indonesia)/*M. Potts*

339. Socio-economic Studies of Sweet Potato in India: Benchmark Survey in Two Major Producing States. **Social Science.** *T. K. Pal,* K. R. *Lakshmi,* CTCRI/*M. S. Jairth*

Contract Projects

340. *"Sweet Potato: An Untapped Food Resource."* **Social Science.** *J. A. Woolfe*

341. International Food Policy Research Institute (IFPRI), *U.S.A.* "Potato and Sweet Potatoes in China." **Social Science.** *B. Stone*

342. H. P. University, India. "Demand Study for Processed Potatoes". **Social Science.** *B. K. Sikka* (Terminated)

343. INTA Argentina. "Marketing and Consumption of Sweet Potatoes in Buenos Aires." **Social Science**

344. International Food Policy Research Institute (IFPRI), *U.S.A.* "Potato and Sweet Potato Demand in Pakistan and the Philippines." **Social Science.** *H. Bouise*

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Adrián Fajardo, M. S.,
Executive Officer

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Controller

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(Managers and Associate Managers)

I. Collection, Maintenance and Utilization of Unexploited Genetic Resources
(J. Dodds – Z. Huamán)

II. Production and Distribution of Advanced Breeding Material
(H. Mendoza – A. Golmirzaie)

III. Control of Bacterial and Fungal Diseases
(E. French – O. Hidalgo)

IV. Control of Virus and Virus-Like Diseases
(L. Salazar – U. Jayasinghe)

V. Integrated Pest Management
(K.V. Raman – P. Jatala)

VI. Warm-Climate Potato and Sweet Potato Production
(D. Midmore – M. Potts)

VII. Cool-Climate Potato and Sweet Potato Production
(J. Landeo – A. Devaux)

VIII. Postharvest Technology
(S. Wiersema – G. Scott)

IX. Seed Technology
(P. Malagamba – P. Vander Zaag)

X. Food Systems Research
(G. Prain – R. Rhoades)

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María Scurrah, Ph.D., Breeder*

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Peter Schmiediche, Ph.D., Geneticist, Head of Department (until Dec. 1989)

Fermín De la Puente, Ph.D., Germplasm Collector

Zósimo Huamán, Ph.D., Germplasm Curator

Kazuo Watanabe, Ph.D., Cytogeneticist

Michael Hermann, Ph.D., Andean Root and Tuber Crop Specialist (Ecuador)†

Bodo Trognitz, Ph.D., Geneticist (as of Sept. 1990)

Norio Sato, Ph. D., Tissue Culture Associat Scientist†

Carlos Ochoa, M.S., Consultant

Nematology and Entomology

Parviz Jatala, Ph.D., Nematologist, Head of Department. (Sabbatical leave as of Aug. 1990)

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Hirotaka Kokubu, Ph.D., Entomologist, (Dominican Republic)

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Luis Valencia, Ph.D., Entomologist (Colombia)

Pathology

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John Elphinstone, Ph.D., Bacteriologist*

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Gregory A. Forbes, Ph.D., Mycologist (Ecuador)

Upali Jayasinghe, Ph.D., Virologist

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Nöel Pallais, Ph.D., Physiologist

Indira Ekanayake, Ph.D., Physiologist*

Frederick Payton, Ph.D., Agronomist (Dominican Republic)

Michael Potts, Ph.D., Agronomist (Indonesia)

Siert Wiersema, Ph.D., Physiologist (Thailand)

Jukka Korva, M.S., Agronomist (Ecuador)†

Andréas Oswald, M.S., Physiologist†

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Social Science

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Peter Ewell, Ph.D., Economist (Kenya)

Gordon Prain, Ph.D., Anthropologist. (Acting Head of Department as of Jan. 1990)

Robert E. Rhoades, Ph.D., Coordinator, UPWARD (The Philippines)

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Keith Fuglie, Ph.D., Economist (Tunisia)†

Anne Swindale, Ph.D., Economist (Dominican Republic)†

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Carmen Podestá, M.A., Librarian/Information Officer

Fiorella Sala Cabrejos, M.S.T., User Services Manager, Information Unit

Christine Graves, M.A., Writer/Editor

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Francisco Muñoz, Ph.D., Superintendent, Quito, Ecuador

Víctor Otazú, Ph.D., Superintendent, San Ramon, Peru

Mario Pozo, Ing.Agr., Superintendent, Lima, Peru

Miguel Quevedo, Ing.Agr., Field Supervisor, (off station)

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James E. Bryan, M.S., Seed Technologist

Fernando Ezeta, Ph.D., Head Training Department

Margarita Villagarcía, M. S., Training Assistant

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Lukas Bertschinger, Ir., Associate Scientist SEINPA (Peru)†*

Jorge Recharte, Ph.D., Antropologist, SEINPA (From September 1990)†

Ricardo Wissar, M.S., Agronomist, SEINPA (Peru)†

André Devaux, Ph.D., Agronomist, Team Leader PROINPA (Bolivia)†

Nicole Bezançon, Ir., Anthropologist, PROINPA (Bolivia)†

Nelson Estrada, Ph.D., Breeder, PROINPA (Bolivia)†

Javier Franco, Ph.D., Nematologist, PROINPA (Bolivia)†

Joanne Parker, Ph.D., Pathologist, PROINPA (Bolivia)†

Greta Watson, Ph.D., Human Ecologist, PROINPA (Bolivia)†

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Oscar Malamud, Ph.D., Regional Leader

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Sylvester Nganga, Ph.D., Regional Leader

Patricio Callejas, M.S., Agronomist (Ethiopia)†

Marco Soto, Ph.D., Coordinator PRAPAC (Rwanda)

José Luis Rueda, M.S., Agronomist (Burundi)†*

Lyle Sikka, M.S.C., Seed Specialist (Uganda), Consultant†

Donald Berrios, Agronomist (Burundi)†

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M. Kadian, Ph.D., Agronomist

M.S. Jaikath, Ph.D., Socio Economist

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Song Bo Fu, Ph.D., Regional Leader

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Rosa Rodríguez, Head of Visitor's Office

Internal Auditor

Carlos Niño Neira, C.P.A., Internal Auditor

Office of the Executive Officer

César Vittorelli, Agr.Eng., Assistant Executive Officer

Logistics Supervision

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

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Germán Rossani, M.D., Medical Officer

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Marcela Checa, Liaison Officer

Transportation Supervision

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Jacques Vandernotte, Chief Pilot

Equipment and Maintenance Supervision

Gustavo Echecopar, Ing.Agr., Supervisor

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Auxiliary Services Supervision

Nancy Oshiro, Supervisor

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Budget Unit

Guillermo Romero, Chief Accountant

Alberto Monteblanco C.P.A., Accountant

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Edgardo de los Ríos, C.P.A., Accountant

Blanca Joo, C.P.A., Accountant

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Roxana Salinas, Ing. Agr.
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Hugo Fano, Economist
José Herrera, M.A., Economist
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Alberto Monteblanco, C.P.A.

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Jorge Queiroz, Ing.Agr. (Reg. II)

Stan Kasule, B.S. (Reg. III)

John Kimani, B.S. (Reg. III)

M. Shahata, B.S. (Reg. IV) (Egypt)

M. Sharkani, B.S. (Reg. IV) (Egypt)

S. K. Menra, M.S., Postharvest Assistant (Reg. VI)

A. Demagante, M.S. (Reg. VII)

V. Escobar, M.S. (Reg. VII)

B. Fernández, M.S. (Reg. VII)

C. Montierro, M.S. (Reg. VII)

B. Susana, B.S. (Reg. VII)

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*Left during the year.

†These positions 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 Resources
Japan, Tropical Agriculture Research Center
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

Moreno Patiño y Asociados
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Moreno Patiño

REPORT OF INDEPENDENT ACCOUNTANTS

March 14, 1991

To the Members of the Board of Trustees
International Potato Center - CIP

1 We have examined the statements of financial position of **International Potato Center - CIP** (a not-for-profit organization) as of December 31, 1990 and 1989, 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.

2 As mentioned in Note 3, at December 31, 1990, the accounts receivable from donors include US$1,444,000 of the 1990 dollar core contribution from the Inter-American Development Bank. The agreement for this contribution has not yet been signed. At this time, it is not possible to determine with reasonable accuracy if this contribution will be received by the Center.

3 As described in Note 2, in accordance with guidelines established by the Consultative Group for International Agricultural Research Secretariat for the preparation of financial statements by International Agricultural Research Centers, the Center does not record depreciation on its property, plant and equipment. Generally accepted accounting principles require, since January 1, 1990, the recognition of depreciation by not-for-profit organizations. The effect of not recording depreciation at December 31, 1990 and 1989 has not been determined.

4 In our report dated February 26, 1990, our opinion on the 1989 financial statements was qualified because of a possible overstatement of the core donation receivable from the Inter-American Development Bank of approximately US$1 million, due the manner in which the bank transfers its contribution to the Center. As explained in Note 3, this donation was received during 1990 and 1991 in local currency at the market exchange rate with no material effect on the afore-mentioned financial statements of the Center. Accordingly, our present opinion on the 1989 financial statements, as presented herein, is different from that expressed in our previous report.

5 In our opinion, except for the effect in 1990 of the matter described in paragraph 2, and for the effect in 1990 and 1989 of the situation mentioned in paragraph 3, the financial statements examined by us present fairly the financial position of **International Potato Center -CIP** as of December 31, 1990 and 1989 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

F. J. Moreno
------------------------------(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, 1990 and 1989
(Expressed in U.S. dollars)

	1990	1989
ASSETS		
CURRENT ASSETS		
Cash and short-term deposits	854,603	2,396,335
Accounts receivable:		
Donors (Note 3)	6,163,869	3,930,728
Advances and current portion of loans to executives and employees (Note 4)	260,308	277,547
Other	580,300	485,084
Inventories of laboratory and other supplies	832,771	820,347
Prepaid expenses (Note 5)	659,829	506,460
Total current assets	9,351,680	8,416,501
RESTRICTED FUNDS (Note 7)	207,767	325,131
LOANS TO EXECUTIVES AND EMPLOYEES – NON-CURRENT PORTION (Note 4)	49,582	24,252
PROPERTY, PLANT AND EQUIPMENT (Note 6)	18,402,430	16,541,773
	28,011,459	25,307,657

* *The accompanying notes are an integral part of the financial statements.*

	1990	1989
LIABILITIES AND FUND BALANCES		
CURRENT LIABILITIES		
Bank indebtedness (Notes 4 and 7)	515,960	241,939
Accounts payable and other liabilities	884,238	691,231
Grants received in advance – donors	1,600,000	57,600
Other payables and accrued expenses	958,699	555,956
Total current liabilities	3,958,897	1,546,726
PROVISION FOR SEVERANCE INDEMNITIES, net of advances of US$31,599 (US$53,745 in 1989)	553,204	739,052
FUND BALANCES		
Operating funds – Unrestricted	(347,062)	574,940
– Restricted	1,070,201	942,358
Capital fund – Unexpended funds –	148,689	892,750
Invested in property, plant and equipment (Note 6)	18,402,430	16,541,773
Working funds	1,785,000	1,575,000
Special projects	2,222,194	2,287,427
Cooperative activities	217,906	207,631
	23,499,358	23,021,879
	28,011,459	25,307,657

GRANTS PLEDGED (Note 8)

The accompanying notes are an integral part of the financial statements.

INTERNATIONAL POTATO CENTER — CIP

STATEMENT OF OPERATIONS AND CHANGES IN UNEXPENDED FUND BALANCES (Notes 1 and 2)
for the years ended December 31, 1990 and 1989

(Expressed in U.S. dollars)

	1990	1989
REVENUE		
Operating grants:		
Unrestricted	13,402,659	13,170,541
Restricted	2,229,890	3,004,400
Other restricted core grants	1,131,085	1,232,165
	16,763,634	17,407,106
Special project grants	2,983,216	2,386,087
Grants for fixed asset additions	1,103,600	1,835,000
Grants for cooperative activities	200,331	247,713
Working fund grants	210,000	–
Other income, net	842,058	534,311
	22,102,839	22,410,217
EXPENSES		
Operating costs:		
Potato and sweet potato research program	5,483,698	5,102,430
Research services	1,743,836	1,765,771
Regional research program and training	4,018,637	4,083,905
Conferences and seminars	80,278	24,876
Information services and library	1,145,563	854,152
Administrative costs	1,880,156	1,619,473
Other operating costs	2,975,305	2,098,057
External program and management review	97,049	215,854
	17,424,522	15,764,518
Other restricted core expenditures	919,096	932,172
Special projects	3,104,683	2,317,776
Cooperative activities	190,055	141,838
	21,638,356	19,156,304
Additions to fixed assets	1,847,661	1,237,950
	23,486,017	20,394,254
(Deficit) excess of revenue over expenditures	(1,383,178)	2,015,963
Unexpended fund balance, beginning of year	6,480,106	4,464,143
UNEXPENDED FUND BALANCE, END OF YEAR	5,096,928	6,480,106

The accompanying notes are an integral part of the financial statements.

INTERNATIONAL POTATO CENTER — CIP

STATEMENT OF CHANGES IN FINANCIAL POSITION
for the years ended December 31, 1990 and 1989
(Expressed in U.S. dollars)

	1990	1989
SOURCE OF FUNDS		
Excess of revenue over expenditures	–	2,015,963
Decrease in restricted funds	117,364	–
Decrease in loans to executives and employees – non-current portion	–	49,960
Increase in funds invested in fixed assets	1,860,657	1,306,426
Increase in accounts payable and other liabilities	869,771	–
Increase in grants received in advance	1,542,400	57,600
Provision for severance indemnities	554,553	747,976
	4,944,745	4,177,925
APPLICATION OF FUNDS		
Excess of expenditures over revenue	1,383,178	–
Increase in loans to executives and employees long-term	25,330	–
Purchase and replacement of fixed assets		
– Core acquisitions	1,847,661	1,237,950
– Special projects	3,339	45,295
– Net cost of replacement	9,657	23,181
Increase in accounts receivable	2,311,118	2,700,590
Increase in inventories	12,424	99,998
Increase in prepaid expenses	153,369	169,911
Increase in restricted funds	–	121,553
Decrease in accounts payable and other liabilities	–	459,023
Decrease in long-term debt	–	55,237
Payment and advances of severance indemnities and exchange gain on the year	740,401	221,843
	6,486,477	5,134,581
Decrease in cash and short-term deposits	(1,541,732)	(956,656)
Cash and short-term deposits, beginning of year	2,396,335	3,352,991
CASH AND SHORT-TERM DEPOSITS, END OF YEAR	854,603	2,396,335

The accompanying notes are an integral part of the financial statements.

INTERNATIONAL POTATO CENTER — CIP

NOTES TO FINANCIAL STATEMENTS
as of December 31, 1990 and 1989
(Expressed in U.S. dollars)

1. Operations

The International Potato Center (CIP) is a non-profit organization located in Lima, Peru, with programs throughout Latin America, Central America and the Caribbean, 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 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 dollars 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) and depreciation (g, below).

c. Revenue —
Grant transactions are recorded as revenue on the basis of donor commitments.

Core unrestricted grants, 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 of its cancellation.

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 fixed 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, 1990, the amount recorded under this practice totalled approximately US$174,900.

Expenditures made by international programs are recorded on the basis of reports received. Expenses related to special projects 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. Property, plant and equipment —
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 expenses and subsequently capitalized. As an exception to generally accepted accounting principles, property, plant and equipment are not depreciated.

Costs of property, plant and equipment disposed in a fiscal period are charged directly to the capital fund and the corresponding asset account is reduced in the same amount.

Maintenance and repairs are recorded as operating costs in the year incurred.

h. Vacations —
Employee vacation expenses are charged to operating expenses when they are taken.

i. Provision for severance indemnities —
Peruvian employees' severance indemnities are accounted for on an accrual basis and are calculated in accordance with current legal dispositions. The amount accrued represents the amount that would have to be paid to the employees if they were to terminate as of the date of the financial statements.

3. Accounts receivable from donors

The dollar core contribution from the Inter-American Development Bank (IDB), for US$1,650,000 at December 31, 1989, was to be transferred to the Center via the Central Bank of Peru and converted to intis at the official rate, rather than at the market exchange rate, which is the rate with which the Center operates. The official rate at December 31, 1989 was approximately 40% of the published market rate; thus, if the donation had been received on these conditions, the Center would have received US$1,000,000 less than the bank dollar contribution. However, since August 1990, the Peruvian government has established the market exchange rate for the financial transactions; the contribution referred to above was received at this rate at the end of 1990 and at the beginning of 1991 with no material effect on the financial statements.

The 1990 agreement with the Inter-American Development Bank for the dollar core contribution of US$1,444,000 has not yet been signed. It is, therefore, still uncertain whether that contribution will be received.

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. Prior to 1990, these loans were funded by a term loan from Citibank N.A. - New York, which bore interest at the New York prime rate plus 1.5% and was repaid in monthly installments until June 1990.

Advances and loan balances with executives and employees at December 31, are as follows:

	1990	1989
Advances to personnel	150,765	124,097
Loans funded by line of credit of Citibank N.A., secured by related homes and/or vehicles, repayable under the same conditions as advances under the term loan at no direct cost to CIP	–	40,130
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	159,125	137,572
	309,890	301,799
Less current portion	(260,308)	(277,547)
	49,582	24,252

5. Prepaid expenses —

This balance is comprised of the following at December 31:

	1990	1989
Advances to organizations for research work	241,748	237,542
Travel advances	53,642	33,895
Advances to contractors and others	148,220	94,309
Other	216,219	140,714
	659,829	506,460

6. **Property, plant and equipment**

Property, plant and equipment at December 31, comprise the following:

	1990	1989
Buildings and constructions	4,703,347	3,853,956
Research equipment	2,056,970	1,852,690
Vehicles and aircraft	5,146;318	5,056,850
Furniture, fixtures, and office equipment	2,085,567	1,662,300
Operating farm equipment	657,250	592,625
Installations	2,252,934	1,856,300
Site development	830,860	822,182
Communications equipment and other	669,184	576,562
Construction in progress	–	268,308
	18,402,430	16,541,773

Vehicles and other fixed assets replaced or retired are transferred from the property, plant and equipment and related equity accounts to a memorandum account. Fixed assets sold or donated are eliminated from the memorandum account. The balance of the memorandum account at December 31, 1990 is US$519,967 (US$644,933 in 1989).

7. **Bank indebtedness**

The Center has various credit lines and loan arrangements with Citibank N.A. totalling US$250,000 (US$525,000 in 1989), which bear interest at the New York prime rate plus 1.5%. The amounts are guaranteed by a deposit of US$207,767 (US$325,131 in 1989) in the aforementioned financial institution, which earns interest at 6.6% per annum (7.5% in 1989).

8. **Grants pledged**

During 1990, the following donations were pledged to CIP for special projects in 1990 through 1993:

	1991	1992	1993
United Kingdom Overseas Development Administration	103,000	150,000	
Kellogg Foundation	10,000	10,000	–
Swiss Development Cooperation and Humanitarian Aid	1,310,059	528,730	–
United States Agency for International Development	220,500	–	–
Netherlands Government	133,956	–	–
Rockefeller Foundation	109,853	40,000	–
Belgian Government	220,320	291,320	–
Federal German Government Agency for Technical Cooperation – GTZ	290,862	140,000	18,520
Finnish Government	75,000	64,100	–
Chemical and Miner Society	8,000	–	–
	2,481,550	1,224,1505	18,520

The above amounts are not reflected in the accompanying financial statements.

The CGIAR:
A Global Agricultural Research System

The Consultative Group on International Agricultural Research (CGIAR) is an informal association of over 40 countries, international and regional organizations, and private foundations established in 1971 to support a system of agricultural research around the world. There are now 13 international agricultural research centers in the CGIAR system, most of them located in developing countries. Ten Centers have mandates covering food commodities, agroecological zones, or both. Their research includes improving plant varieties and methods of production, farming systems, plant protection, control of animal diseases, postharvest systems and various aspects of food policy. Their other basic functions besides research are information dissemination, training, and genetic resources conservation. Of the three remaining centers, one is devoted exclusively to the conservation and utilization of germplasm. An international system of gene banks has been established, and may be drawn on by researchers anywhere in the world. Another center deals with economics and food policy, and yet another provides advice to developing countries on the organization of their national research systems. Each of the 13 centers maintains close and collaborative relationships with these national systems.

International centers in the CGIAR system and their partners in developing countries conduct research into most of the principal foods consumed in developing countries. Crop improvement research includes all the major cereals, which as a group contribute 60 percent of the food energy and 55 percent of the protein in developing countries. In addition, the centers conduct research on all major root and tuber crops that are staple foods, on pulse crops and on livestock. Combined, these foods contribute 75 percent of the food energy and 4 percent of the protein in developing countries.

CIAT
International Center for Tropical Agriculture
Cali, Colombia

CIMMYT
International Maize and Wheat Improvement Center
Mexico City, Mexico

CIP
International Potato Center
Lima, Peru

ICARDA
International Center for Agricultural Research in the Dry Areas
Aleppo, Syria

IITA
International Institute of Tropical Agriculture
Ibadan, Nigeria

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
Hyderabad, India

ILCA
International Livestock Center for Africa
Addis Ababa, Ethiopia

ILRAD
International Laboratory for Research on Animal Diseases
Nairobi, Kenya

IRRI
International Rice Research Institute
Manila, Philippines

WARDA
West Africa Rice Development Association
Bouake, Ivory Coast

IBPGR
International Board for Plant Genetic Resources
Rome, Italy

IFPRI
International Food Policy Research Institute
Washington, D.C., U.S.A.

ISNAR
International Service for National Agricultural Research
The Hague, Netherlands

INTERNATIONAL POTATO CENTER (CIP)

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