Juan Landeo

Annual Report CIP 1981

INTERNATIONAL POTATO CENTER (CIP)

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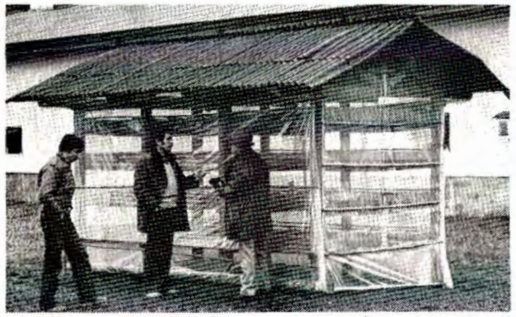
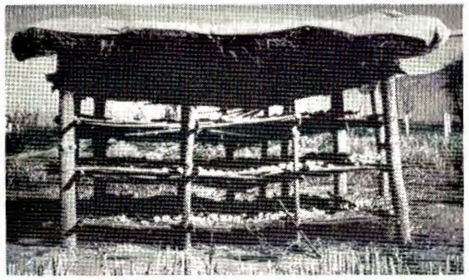
Annual Report CIP 1981 - Lima-Peru

Seed Potato Storage

Huancayo, Peru



Chile



Guatemala

Colombia

Peru

It started with experimental potato storage structures at CIP's Huancayo highlands station.

Objectives were simple on-farm stores of low-cost local materials and updating the old diffused light principle to prevent unwanted sprouting in seed potatoes.

After objectives were met, the idea spread rapidly.

By December 1981 some 350 farmer-adopters were identified worldwide. Fifty-two national scientists from 21 countries were trained in post-harvest technology. Use of this technology in some countries is being tested, other countries are adapting it to local situations, and still others are recording widespread farmer-acceptance. (See Thrust VIII and Social Science Department sections).

Both farmer and experimental stores are shown on these pages.

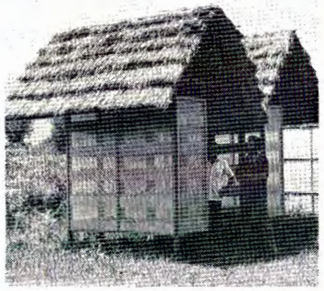
COVER PHOTO — Experimental potato store under evaluation in **Colombia, South America.**

Thailand

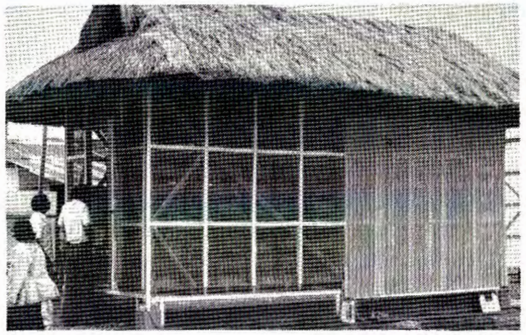
Sri Lanka

Tunisia

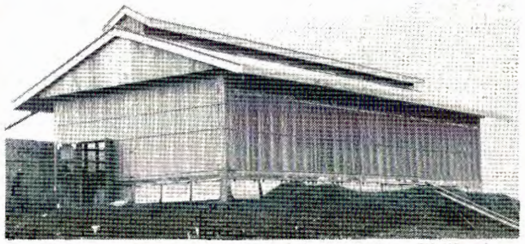
Nepal



Nepal



Philippines



Farmers' Association, Philippines

Contents

This is the tenth annual report published by the International Potato Center, Apartado 5969, Lima, Peru. Printed for worldwide distribution, the report covers the period of 1 November 1980 - 31 October 1981.

The International Potato Center (CIP) is a non-profit, autonomous scientific institution established by agreement with the Government of Peru for developing and disseminating knowledge for greater use of the potato as a basic food. International funding sources for technical assistance in agriculture finance the Center.

Detailed reporting of CIP's extensive activities is beyond the scope of this publication. Mention of specific products by name does not imply endorsement of or discrimination against such products by CIP.

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Director General's Message

CIP celebrated its 10th anniversary by holding a Congress on "Research for the Potato in the year 2000" in February 1982. Potato scientists and research managers from 56 countries attended making this the broadest global representation of potato workers ever to meet. CIP utilized the opportunity of the Congress to up-date long term plans for a number of high priority research thrusts.

A large number of complimentary letters have been received on the success of the Congress. The principle ingredients to the success were, first, the excellent mix of capable scientists, and, second, the excellent team approach by all CIP workers to see that guests were well attended. Probably due to the Congress and its concentration on long term planning, and also the recent publication of the third edition of CIP's long term plan to the year 2000, CIP is receiving an increasing number of requests to help developing countries produce their own advanced planning for potato improvement.

During 1981, CIP's annual internal review was used to implement CIP's strategy for increasing the involvement of Third World countries in the planning of CIP's program. Management has felt for some time that Third World countries should be involved actively in the periodic reviews but was concerned about the possible effect on the excellent open frank and critical discussions on program content which have been developed since the start of CIP. The participation of leaders of potato programs in developing countries in no way hindered the frank discussions and added a new dimension to the reviewing and planning of their program which CIP is conducting. Furthermore at the 1982 internal review, CIP will be the first Center to have in attendance members of a TAC quinquennial review team.

Due to CIP's development strategy the economic pressures on the CGIAR system have had little if any effect on CIP's program. The quality of research being produced, the quantity of relevant technology in CIP's transfer system, and CIP's ability to transfer technology with national scientists into growers' fields continue to increase even though CIP's real costs are slightly decreasing.

Donors continue to show their interest in CIP's program and the credibility which has been developed. We welcome the many favorable comments Third World countries have given to donors about CIP's program. The real criteria for funding CIP should be not what we say we have done but what Third World countries say we are doing for their food production systems and the economy of their farmers. Three new donors joined CIP in 1981 and in the early months of 1982 four additional donors have indicated that they will invest in CIP's program for the first time.

Dr. Burton who has been chairman of the program committee of CIP's Board of Trustees for the past 6 years must receive special recognition in this report. He has not only been a dedicated board member, helping to guide CIP's program during its rapid growth period, but he has also participated in many CIP training programs and the evaluation and planning

of collaboration efforts with national programs. Also to be mentioned is the excellent participation of Dr. Fausto Cisneros, who has given continuity of representation from the host country institutions for the past 7 years.

As we move into the second 10-year period of CIP's existence, it is good to look back and see how far we have come. Also we must look forward and see how far CIP has to go, what still needs to be done between now and the year 2000 for potato improvement in Third World countries. There can be no relaxing. I am confident that the quantity and quality of CIP research will continue to grow with the same level of real funding. And I am very sure that the level of our collaboration and peer relationship with scientists in Third World countries will make a quantum jump during these next 10 years.

Richard L. Sawyer
Director General
International Potato Center

CIP's MANDATE

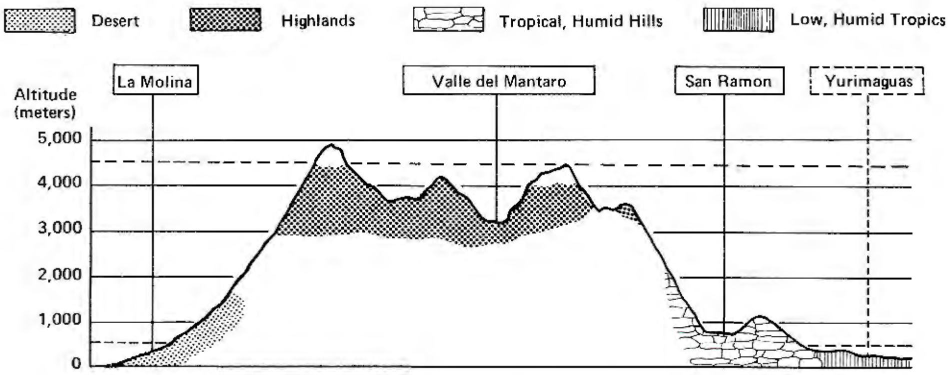
As one of the worldwide network of centers funded by the Consultative Group on International Agricultural Research (CGIAR), CIP has the following mandate:

"To develop, adapt and expand the research necessary for the technology to solve priority problems that limit potato production in developing countries. This includes adapting the collective knowledge that has contributed to the stepwise increase in potato production in developed countries.

"The World Potato Collection which has been accumulated by CIP provides ample opportunity for research breakthroughs through the exploitation of this large quantity of previously unavailable genetic resources."

Board of Trustees

CIP Research Sites



Cross Section, Central Andes

At any one time research at CIP's Peruvian facilities may be ongoing in desert, alpine and high and low jungle environments. These four zones represented in CIP field locations are those in which nearly two billion people live worldwide.

The range of physical environments is broad: from near sea level to 3,000 meters altitude, from desert to 2,000 mm rainfall, and −5°C to 40°C in temperature. The daylength range is limited.

The potato originated on the high plains, *altiplano*, in what is now parts of Peru and Bolivia. This center of diversity is not only for potatoes themselves, but also for most major potato diseases and pests.

CIP facilities are ideally located for testing and identifying clones with resistance to a wide spectrum of biotic and abiotic pressures. These natural test environments are augmented by extensive screenhouse and growth chamber facilities. The long-term comparative advantage of CIP is the exploitation/distribution/use of the World Potato Collection maintained at Huancayo. Breeding and genetic manipulations provide new combinations of genes from this gene bank for screening for climatic adaptation, resistance to specific pests and diseases, and good yield.

Station	Latitude (S)	Altitude (m)	Temperature °C			Rainfall (mm)	Daylength hr:min		
			Max (mean)	Min (mean)	Mean		22 Jun	22 Dec	Range
La Molina	12°05	240	22	16	19	15	11:25	12:50	01:25
Huancayo	12°07	3,280	21	5	13	720	11:25	12:50	01:25
San Ramon	11°08	800	30	18	24	2,000	11:28	12:46	01:18
Yurimaguas	5°41	180	31	21	26	2,134	11:49	12:28	00:39

CIP Donors 1981

In 1972 only three donors were listed as contributing to the financial support of the International Potato Center. The donor list for 1981 is as follows:

	Core	Special Project
Australian Development Assistance Bureau	X	X
Belgian Government	X	X
Canadian International Development Agency (CIDA)	X	X
Danish International Development Agency (DANIDA)	X	
European Economic Community	X	
Federal German Government	X	X
French Government	X	
Inter-American Development Bank (IDB)	X	
International Development Research Centre (IDRC)		X
Netherlands Government	X	
Philippines Government	X	
Swedish Agency for Research Cooperation with Developing Countries (SAREC)	X	
Swiss Development Cooperation and Humanitarian Aid	X	X
United Nations Development Programme		X
United Kingdom Overseas Development Administration (UKODA)	X	
United States Agency for International Development (USAID)	X	
W. K. Kellogg Foundation		X
Spanish Government	X	
Mexican Government	X	
Japan Economic Cooperation Bureau	X	
International Fund for Agricultural Development (IFAD)	X	
World Bank	X	

Regional Headquarters

REGION I Andean Latin America	:	CIP Apartado Aéreo 92654 Bogotá 8, D.E., **Colombia**
REGION II Non-Andean Latin America	:	CIP c/o EMBRAPA Caixa Postal (11) 1316 70 000 Brasilia, D.F., **Brasil**
REGION III Tropical Africa	:	CIP P.O. Box 25171 Nairobi, **Kenya**
REGION IV Near and Middle East	:	CIP P.K. 9 Menemen, Izmir, **Turkey**
REGION V North and West Africa (Francophone)	:	CIP 11 Rue des Orangers Ariana, Tunis, **Tunisia**
REGION VI South Asia	:	CIP c/o NBPGR IARI Campus New Delhi, 110012, **India**
REGION VII Southeast Asia	:	CIP c/o PCARR Los Baños, Laguna, **Philippines**

THRUSTS

The International Potato Center uses the term "Thrust" to refer to integration of research projects into units of common research activities.

Each of the nine Thrusts has a Coordinator responsible for the unification of project activities within that Thrust. Thrust activities in developing countries are coordinated by CIP's Regional Research and Training organization. Five research Departments serve as administrative units for grouping personnel according to their professional discipline and for allocating project funding. The Department of Training and Communications, the Department of Social Science and the Department of Regional Research and Training are support units.

Various research disciplines cooperate through the Thrusts to develop technology for low income farmers.

Survey of Research 1981

The principal scientific resource CIP has is the World Potato Collection.

Within this collection of primitive cultivars and wild species are resistance factors and other beneficial characters required by developing countries. The major portion of CIP's research is directed to exploitation of this resource and involves cooperation between several disciplines.

Collection of wild species continued with new accessions added, including rare species and two previously believed extinct. Five new species were named after exhaustive study of herbarium collections in the Smithsonian Institute (Washington, D. C.). Classification and identification of duplicates by electrophoretic and morphological methods continued. Removal of duplicates has reduced the collection by 14 percent. Duplicates were retained as true seed. More than 4,000 tuber samples and 200 seed lots were distributed to cooperating scientists.

Tubers with combined PLRV and PVY virus resistance were distributed to several national programs and a controlled field evaluation was conducted through Regional Research in Turkey and Argentina. A 15,000-clone set was evaluated during the year in Turkey and a smaller set in Argentina. To increase the frequency of combined resistance of the two viruses in CIP material available to national potato programs, parental clones which transmit PLRV resistance to their progenies efficiently (good general combiners) have been identified. More than 50 percent of seedlings from these parents resist PLRV infection in the seedling exposure test. Recurrent selection has led to a dramatic increase in frequency of PVY immunity, up to 82 percent.

Among fungal pathogens, late blight continues to be first rank priority both for breeding and in demand from national programs. The selection process was accelerated by seedling screening under greenhouse conditions at CIP's highland research station in Huancayo. Field screening was reorganized and a new cooperative project developed in Medellin, Colombia with the Instituto Colombiano Agropecuario (ICA). In 1982 this project will include a previous test site at Toluca, Mexico in collaboration with Instituto Nacional de Investigacion Agropecuaria (INIA) of Mexico. There is a much greater spectrum of pathogenic races of late blight in Colombia than in Peru and it is hoped that testing both in Colombia and Mexico will greatly improve screening efficiency. Advanced clones evaluated by national programs in Colombia, Kenya, Rwanda and Sri Lanka show useful levels of resistance and yield performance and are being considered for varietal status.

The second most important disease worldwide in tropical countries is bacterial wilt. To identify sources of resistance, two races of the pathogen are used. Sources of resistance presently identified include *Solanum sparsipilum*, *S. chacoense* and *S. phureja*. Progenies derived from crosses with *S. phureja* have performed well in Brazil, Uruguay, Colombia, Kenya and Sri Lanka.

Some advanced clones have survived severe field infection in Peru for three seasons. In the Philippines, where the disease is severe in medium altitude areas, genetic resistance, combined with agronomic practices, is being tested to get adequate control.

The World Potato Collection is a good source of nematode resistance. Some diploid cultivars have high levels of resistance to four species and eight races of root-knot nematodes. This is being incorporated into tetraploid material. Resistance to various cyst nematodes was identified in some wild *Solanum* species and tetraploid crosses. Some advanced clones have been tested in Colombia and Ecuador and are being entered in national variety trials.

Root-knot nematode control by a parasitic fungus, *Paecilomyces lilacinus* has proved of practical value in the coastal areas of Peru. After 3 years of field tests it appears to be comparable with control by the most effective nematicides. There is evidence that the fungus will give some control of cyst nematodes as well. Cultures of the parasite are being distributed for testing under the aegis of the international Meloidogyne project of North Carolina State University.

A major objective of CIP research is development of technology to produce potatoes from true potato seed (TPS). Genetic variability for most necessary traits is available in the germ plasm collection. Resistance to late blight is being introduced from *S. demissum* using a multiline approach. Hybrid seed is better than open-pollinated seed tuber yield. Good progenitors of high yielding uniform TPS progenies have been identified, several families produce more than a kilogram of marketable tubers per plant.

Parallel with the TPS breeding, agronomic research continues on improved ways to establish seedlings in the field. Adequate supply of phosphorus stimulates seedling growth. Under heat stress, mulching or transplanting in the shade of maize improves seedling establishment. Pre-emergence damping-off of seedlings principally caused by *Rhizoctonia* can be reduced by fungicidal treatment of seed. Post-emergence control of *R. solani* and *Pythium* spp. is more complex and involves soil temperature effects.

Combining use of TPS with production of commercial potatoes from tubers has led to research on using TPS as a method to produce seed tubers. High density planting of TPS seedlings can produce a yield of 500 to 600 useable tubers per square meter. Thus, approximately 100 square meters of nursery, in the first multiplication, would produce sufficient tubers to plant a hectare. Subsequent multiplications of these tubers would reduce the nursery area required.

Tuber moth is a major pest of many tropical potato growing areas. The problem of control is being investigated in several parallel projects. Resistance has been identified in several advanced clones and this trait is incorporated in the breeding program. Chemical control by "safe" insecticides such as synthetic pyrethrins has proved valuable in Peru and in Middle East and North Africa. Recently field control by trapping male moths with synthetic female pheromone traps has been effective in Peru. The technique can also be used in potato stores.

Technology transfer has resulted in considerable use of low-cost diffused light storage by farmers. In the Philippines, which was the first pilot project for this technology, more than 150 stores have

been built by farmers to preserve their seed potatoes. Sri Lanka has also taken up this technology, 70 stores have been constructed and Government credit for several hundred more is reported to be currently available.

New research contracts have been placed with national institutions in developing countries to perform research of interest to CIP. Included are: a project in Chile to produce a milk-like product from potato starch by enzyme hydrolisis, evaluation of the performance of heat tolerant clones in Sri Lanka, evaluation of late blight resistance in Colombia and cyst nematode resistance in Ecuador. All these contracts and others are associated with the research of the CIP Thrust teams.

Social Science research continues to be integrated with the biological research priorities. From a case study of the Regional storage technology transfer project, a general transfer philosophy has evolved which includes problem identification, technology, design, testing and evaluation. This is being incorporated into other Regional transfer projects. One new area of specific interest is the development of the TPS technology. The social scientists are collaborating in this project at all stages, both technological and for evaluating social factors such as potential cost savings. Research on consumption and nutrition studies and how they relate to agroecological zones, rural versus urban population, have continued. This aspect will be concluded in 1982.

Thrust I

Collection and Classification of Tuber-Bearing *Solanums*

Extensive collecting in southern Peru and short trips to northern Peru when weather permitted growth of wild potatoes. Approximately 80 living wild accessions were collected, including several scarce species. Among the group were two species formerly believed extinct.

Five new species were named from the wild germ plasm collections of CIP following careful comparison with herbarium specimens of the Smithsonian Institute, Washington, D.C. Germ plasm distribution of 680 accessions were made as true seed or tubers to CIP research departments, Japan, Peru National Programs, URSS, and USA.

Collection of new specimens of wild potatoes continued. Explorations in Ecuador and northern Peru were canceled due to unavoidable circumstances, including unusually dry conditions especially in northern Peru. In southern Peru several areas of the Departments of Arequipa, Tacna, Puno, Cusco and Apurimac were explored. Short supplementary collecting trips were made to La Libertad and Lambayeque. During these trips, 145 sites were identified with wild potatoes in different stages of growth. Approximately 80 living accessions were collected. Unfortunately it is sometimes impossible to collect specimens as seed balls or tubers, for example, may not be present.

Valuable Collections

Some collections obtained in 1981 are extremely valuable. For instance, the rediscovery of *Solanum buesii*, a rare species which was considered extinct. After a frustrating search in 1980, it was finally found in March 1981, in a remote and isolated ecological niche of Urubamba in the Department of Cusco. It belongs to the series Conicibaccata and is diploid $2n = 2x = 24$ chromosomes. Another attempt was made to recollect *S. pillahuatense*, a species also facing extinction. The place where this species might be found was located. It was impossible, however, to collect living material because the main access road was blocked and lack of horses frustrated further attempts.

Another little-known species, also in the process of extinction, is *S. amabile*. Fortunately, after several futile attemps during the past 10 years, several ripe berries of this species were collected during 1981.

As a complementary work, collections were made of several accessions of other species rather difficult to obtain including, *S. limbaniense*, *S. rhomboideilanceolatum*, *S. coelestispetalum*, *S. santolallae*, *S. lycopersicoides* and *S. abancayense*. Other fairly common and widely distributed wild species such as *S. bukasovii*, *S. megistacrolobum*, *S. acaule*, *S. raphanifolium* and *S. marinasense* were also collected during these trips.

New Species

New species identified during taxonomic studies of wild tuber-bearing species included *S. calacalinum* and *S. correllii*, both from Ecuador and *S. antacochense*, *S. irosinum* and *S. sawyeri*. Direct consultations during a short visit to the National Herbarium, Smithsonian Institution, Washington, D.C., helped to clarify some taxonomic problems.

An attempt is being made to reduce the complex work of taxonomic interpretation in the tuber-bearing *Solanum* and its biosystematics. An active program of intercrossings has been started. This permits, among other things, the understanding of some "species" which are not more than panmictic populations or, accessions which in the past have been modified through introgression from sympatric species.

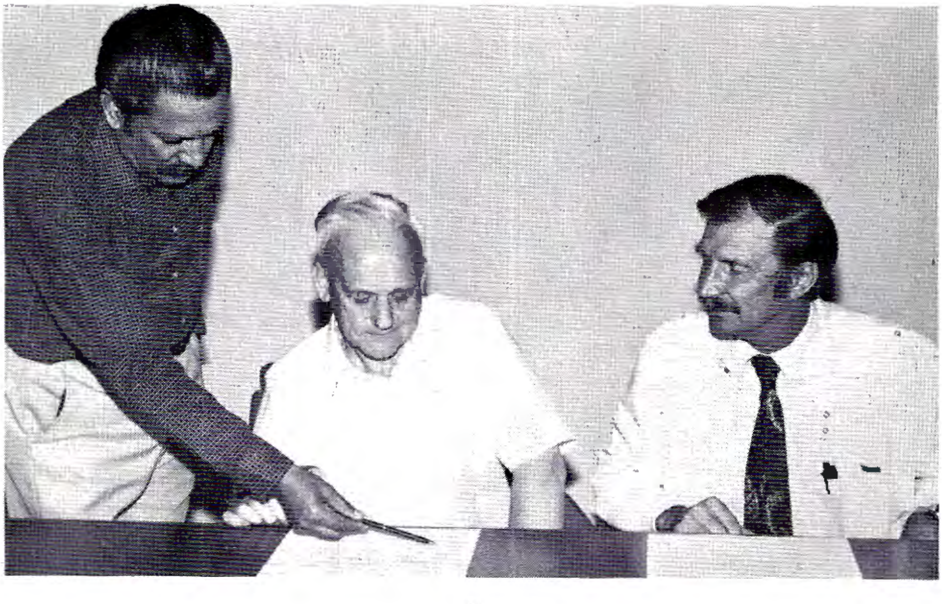
In addition to collecting samples, a donation of more than 200 accessions of wild potato species from Bolivia was made by the German-Dutch-British-CIP Expedition to that country. All these samples are true seed and are being kept under storage at CIP.

During 1981 distribution of wild germ plasm was extensive (Table I-1).

Table I-1. Distribution of wild potato species in 1981

Institution	No. Accessions
International Potato Center, Perú	
Breeding and Genetics Dept.	39
Nematology Dept.	96
Pathology Dept.	200
Physiology Dept.	38
University of Kobe, Japan	4
National Potato Program, Perú	52
Vavilov Institute, USSR	73
U.S.D.A. IR-1 Project, USA	168
International Plant Research Institute, USA	10
TOTAL	680

Drawings of new potato species, *Solanum burtonii* and *Solanum sawyeri*, are viewed by their namesakes, Dr. Glynn Burton (center), long-time member of CIP's Board of Trustees, and Dr. Richard L. Sawyer (right) CIP's director general. Pointing out details is Carlos Ochoa, who discovered the new species and who heads CIP's Department of Taxonomy.



Thrust II

Maintenance, Distribution and Utilization of Tuber-Bearing *Solanums*

Andean cultivars in the World Potato Collection of 7,050 clones were reduced by 14 percent after placing morphologically and electrophoretically similar duplicates in true seed storage. More than 4,000 tuber samples and 200 seed lots were distributed.

A population breeding approach for the highland tropics combines selection of earliness and resistance to frost, late blight, and potato virus Y (PVY).

Tuber production from hybridized true potato seed (TPS) is generally superior to that produced by open pollination or selfing. Genetic variability exists for most of traits important to TPS. Late blight resistance is being introduced using major genes of *Solanum demissum* in a multiline approach. Good progenitors of high yielding, uniform TPS progenies have been identified. Several TPS families produce more than 1 kg of marketable tubers per plant.

Major progress was made in selecting parental materials with high general combining ability for tuber yield, earliness, and adaptation to hot and humid environments. Disease resistance was incorporated in these populations.

Field evaluation of potato leafroll virus (PLRV) and/or PVY resistance in 22,000 seedlings at mid-elevation tropics yielded approximately 2,500 selections for further evaluation. Yields compared favorably with tropically-adapted clones.

Three parental clones were identified with high general combining ability for potato leafroll virus (PLRV) resistance. Pollen from the third cycle of selection for PVY resistance in which 82 percent of the segregates are immune will be used on PLRV resistant parents for combined resistance in TPS populations. These populations should have up to 70 percent PVY resistant seedlings and will be distributed to regional and national programs.

Average yield of bacterial wilt resistant selections from *S. phureja*, *S. sparsipilum*, and *S. chacoense* crosses has significantly improved and resistance to five pathotypes exists.

Andean cultivars planted in the field in 1981 totaled 7,049 accessions of which 2,639 were identified as duplicates in 719 groups. A total of 1,003 accessions, both morphologically and electrophoretically identical, were eliminated from clonal propagation to be preserved only as true seed.

A breeding program began to create bulk hybrid populations combining special attributes identified in Andean potato cultivars. Emphasis was on the production of seed stocks using single and bulk crosses of accessions with resistance to the same pathogens. Of 213 seed families obtained, 175 were resistant to one of eight pathogens; 28 to two different pathogens, and 10 to three different pathogens (Table II-1).

A total of 4,162 tuber samples and 198 seed lots of Andean cultivars were distributed for screening and use.

Combining Resistances

Population breeding was initiated to combine frost resistance (F), late blight (LB), PVY and earliness in current material developed for the highland tropics. Preliminary-seedling screening of crosses between LB + F resistant clones and PVY immune clones are in Table II-2.

Two-factor seedling screening for LB + PVY and F + PVY independently is expected to average 16 percent and 9 percent of survivors, respectively. Selected progenitors derived from clonal testing for three factors and selection for desirable agronomic characters will be used in a phenotypic recurrent selection breeding scheme.

Earliness

In regard to earliness, a preliminary experiment on tuberization response to long photoperiod under artificial conditions was conducted on five families that combine late x early, medium x early and early x early material. Tuberization response under 16- and 24-hour daylength indicates that when late maturing material is crossed to

Table II-1. World Potato Collection. Hybrid seed combining resistances to pathogens within Andean potato cultivars.

Number female parents	Bulk pollen from Andean cultivars resistant to:
13	Late Blight (LB)
6	Powdery Scab (PS)
14	Black wart (BW)
30	Soft rot (SR)
35	Potato virus X (PVX)
6	Potato virus Y (PVY)
53	Root knot
18	*Globodera pallida* (GP)
(Sub-total 175)	
1	LB + PS
2	LB + RK
2	LB + PVX
1	LB + PVY
1	BW + PVX
2	BW + RK
8	PS + GP
1	PS + RK
1	SR + PVY
3	PVX + PVY
4	RK + PVX
2	GP + *G. rostochiensis* (FR)
(Sub-total 28)	
1	LB + BW + GP
1	LB + PS + PVY
2	LB + PVX + PVY
3	LB + RK + GP
1	BW + PVX + RK
1	BW + PVX + GR
1	RK + GP + GR
(Sub-total 10)	
TOTAL 213	

Table II-2. Frequency of resistance to LB, F, and PVY independently in (LB + F) x PVY crosses in seedling screening.

Families screened	Seedlings screened for:	Seedlings	Survivors	% Survivors
19	Frost	2055	347	17
19	Late blight	1778	533	30
19	PVY o/	878	469	53
19	PVY n/	878	850	97

PVY o/ = common strain PVY n/ = necrotic strain

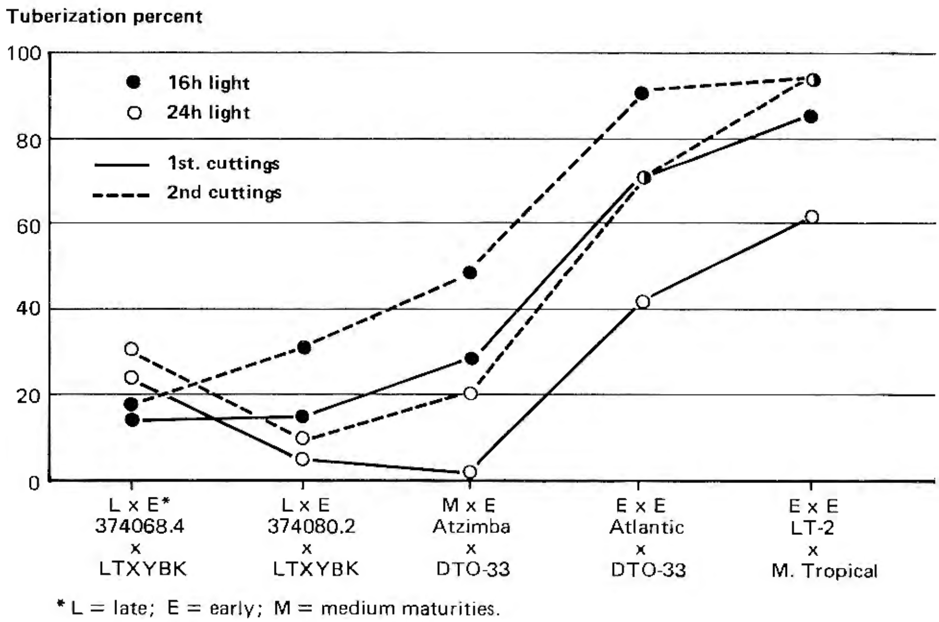


Figure II-1. Percent tuberization of single leaf node cuttings from seedlings.

early material there is a range from 4.5 percent to 30.8 percent of genotypes that tuberize early. Response to tuberization increases as material approaches early maturity in remaining crosses.

This technique may help accomplish two purposes:

(1) To improve earliness as a complement to other screenings on material so far developed for the highlands provided earliness is introduced from other sources, and
(2) To screen out late maturing genotypes in segregating families that will be distributed to regions or country programs.

A total of 22,057 virus resistant seedlings were field evaluated in San Ramon for agronomic performance. Of these, 10,231 were from the PVX + PVY group, 11,207 from the PLRV group and 619 from the PVY + Late Blight group. Retained 2,783 clones were for further evaluation and selection in 5-hill plots. Distribution of seedling yields compared favorably with tropically adapted control clones, LT-1, LT-2, and DTO-2 (Figures II-2 and II-3).

Seedling screening of the new generation of seedlings continued for PVY + PVX, PVY alone and PLRV alone. Frequency of phenotypes resistant to PVY during three cycles of recurrent selection increased from 43.4 percent in cycle I to 82.1 percent in cycle III. A pollen bulk from the third cycle if crossed with susceptible female parents would yield 70.2 percent resistant progenies.

PLRV Resistance

In the PLRV resistance work the general combining abilities of a

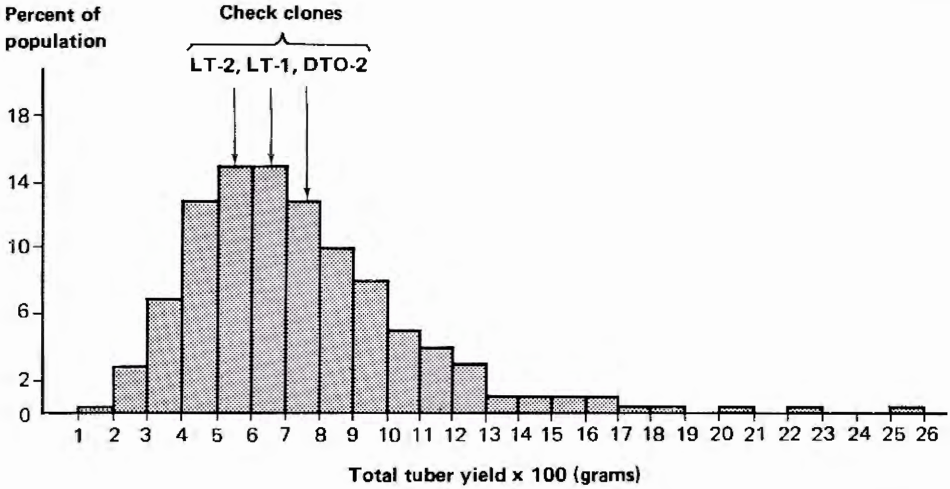
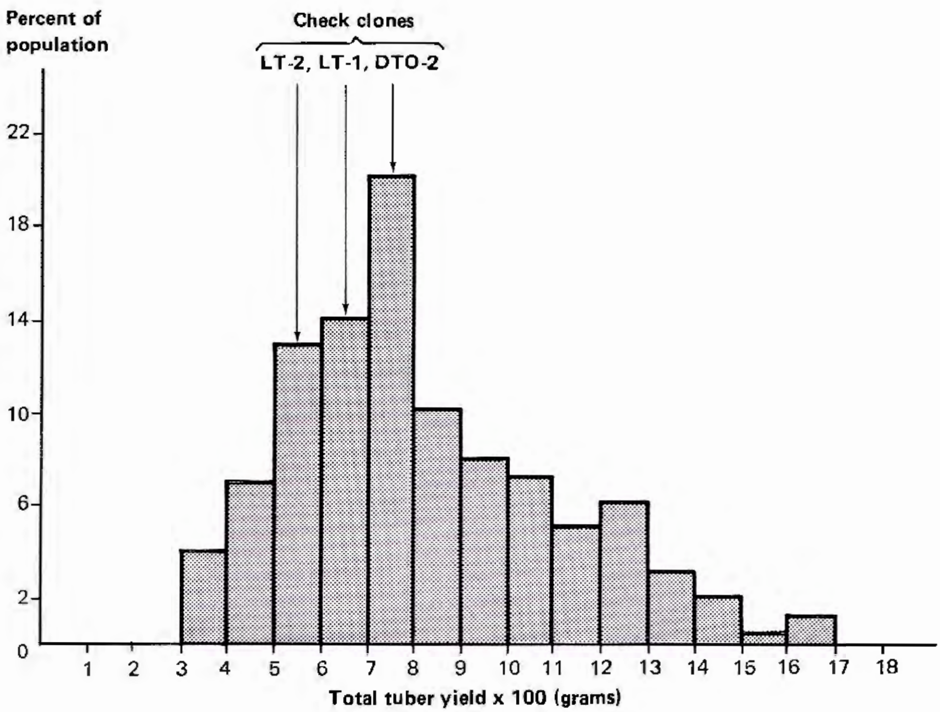


Figure II-2. Tuber yield distribution of PVY and PVY + PVX resistant clones of first year seedlings, San Ramon, January-April 1981.

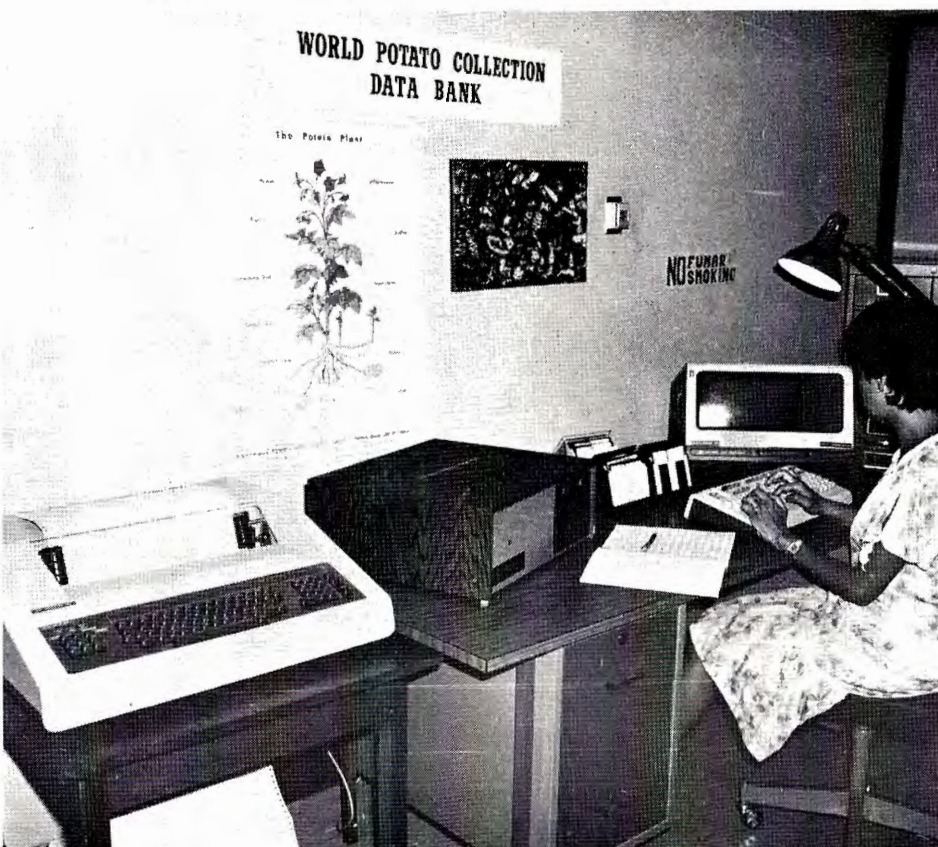
Figure II-3. Tuber yield distribution of PLRV resistant clones of first year seedlings, San Ramon, January-April 1981.



number of female parents was tested. Each clone identified previously as resistant to PLRV in field exposures, was crossed to three distinct pollen bulks. The pollen bulks served as wide genetic based testers. The high performance of progenies resulting from crosses with highly heterozygous testers indicates that these clones have a superior general combining ability. As expected, clones resistant to PLRV (LR bulk) contributed the highest pollen bulk effect when seedling progenies were exposed to PLRV-bearing aphids.

The pollen from the third cycle of selection for PVY resistance will now be crossed with the best combiners for PLRV resistance to produce a high frequency of combined PVY + PLRV resistance. For instance, leafroll resistant clone LR 5.3 produced an average of 56.7 percent symptomless progeny when inoculated with PLRV. An expected 70.2 percent of the progeny resulting from the cross with the third cycle PVY population will be resistant to PVY. Nearly 40 percent of the progeny from the cross LR 5.3 x PVY-R-III bulk will possess combined resistance to PLRV and PVY. This type of progeny, when provided as tuber families to National Programs, will be ideal material from which to select locally adapted clones resistant to the major aphid-transmitted viruses, PVY and PLRV.

Data evaluation and storage for CIP's World Potato Collection.



Bacterial Wilt

Breeding for resistance to bacterial wilt, *Pseudomonas solanacearum*, concentrated on three groups of genetic material. The first group consisted of 24 highly selected resistant clones derived from *S. phureja.* These clones were intercrossed and also crossed with several sources of resistance different from *S. phureja.* Eight percent of 30,000 seedlings survived following screening with pathotype 013, race 3 of *P. solanacearum.* Eighteen clones from earlier cycles of selection had a survival rate of 90-100 percent when grown in an infested field. Average yield per plant was 1.1 kg.

The second group was derived from tetraploid x diploid crosses. The diploid resistant parents were selected from a population consisting of the two wild species *S. chacoense* and *S. sparsipilum* and the cultivated species *S. phureja.* The tetraploid parents came from a population adapted to the lowland tropics and selected for earliness. From 343 clones grown under hot conditions and after a second field evaluation only 19 clones were retained. Despite cases where two genomes were contributed from a wild parent, excellent tuber shape and yields of up to 1.45 kg per plant were recorded. The average yield of the population selected for further breeding was 1.34 kg per plant.

The third group used in 1981 was a population consisting of *S. chacoense*, *S. sparsipilum* and *S. phureja.* Wild species were used to incorporate new sources of resistance to bacterial wilt into the breeding populations. Selected resistant diploid clones from recurrent selection were used in tetraploid x diploid matings as indicated in the previous paragraph. The diploid population underwent a further cycle of selection. From 11,500 seedlings tested against four and sometimes five pathotypes of *P. solanacearum*, 40 clones were intercrossed in 203 different combinations and about 100,000 seeds were obtained. Ten thousand seeds were sown and 7,468 seedlings raised and tested against the virulent strain 013 of race 3 of the bacterial wilt pathogen. More than 2,000 seedlings (33 percent) of the population survived this test. When the original wild diploid population was tested against the same pathotype, it showed a similar survival rate (about 30 percent). The increase in individual families was up to 67 percent.

True Potato Seed (TPS)

As part of a study of the genetics of true potato seed (TPS), a North Carolina Mating Design II and Type Family Comparisons were used.

A set consisted of the progenies of eight parental clones, four plants designated females and each mated to four plants used as males. Ten sets were included. The sixteen families of a set were grown in two replications per set in a randomized complete block design at Lima and San Ramón.

Parental clones used in the Design II were also selfed, allowed to open pollinate, or bulk pollinated to derive additional family types. Multilines were created by mixing equal numbers of seeds of four of the crosses made in each set. These families were included in the sets which contained the controlled crosses from the same parents. The number of entries included in each of the family types was: single crosses (160); open-pollinated (20); selfed (20); bulk cross (20); and, multiline (10).

Table II-3. Genotypic and phenotypic correlations design II.

	Phenotypic Correlations	Genotypic Correlations
No. Tub x Yield	.7442	.8058
No. Tub x Gn. Un.	.1059	.0673
No. Tub x Gn. Appl	.2347	.1040
No. Tub x Tub Size	–.1277	–.2401
No. Tub x No. Berries	.4027	.7371
Yield x Gn. Un.	.1324	–.2455
Yield x Depth Eye	–.1663	–.3123
Yield x Gn. App.	.6251	.7570
Yield x Tub Size	.7331	.4471
Yield x No. Berries	.3816	.5094

Genetic variance components and heritability estimates indicate the presence of additive genetic variance from most of the trials studied. Heritability estimates show that considerable progress can be made when selecting to improve these populations for the exploitation of TPS as means of producing a commercial potato crop.

In Table II-3 a number of phenotypic and genotypic correlations for pairs of traits are presented. Of greatest interest is the rather high genotypic correlation between total yield and number of berries suggesting that families with high yield and prolific berry production will be an easy combination to achieve.

Comparisons of progenies comprised by multilines, single crosses, open-pollinated families (OP), selfs, and females crossed with pollen bulks (bulk crosses) are presented for a series of traits in Table II-4. Bulk crosses, multilines, and single crosses have a higher total yield than OPs and selfs. This, combined with the greater uniformity of single crosses compared with multilines and bulk crosses, has led to the policy of emphasizing single crosses for future testing in CIP's regional trials.

In development and identification of good progenitors which will generate high yielding, uniform TPS progenies, several clones were identified having good general and specific combining ability for yield and uniformity of tubers. Several

Table II-4. Mean trait values measured in different family types propagated from true potato seed *.

Traits	Family types				
	Multiline	Single cross	Open pollinated	Self	Bulk cross
Germination (%)	92.2 a	88.5 b	87.7 b	85.2 c	81.4 d
Transplant survival	40.7 a	40.4 a	39.5 b	39.6 b	39.8 b
No. tubers (log)	2.39 a	2.37 a	2.24 b	2.13 c	2.43 a
Yield (log)	.77 a	.75 a	.54 b	.45 c	.79 a
Uniformity **	5.46 b	5.89 a	5.84 a	6.06 a	5.42 b
Tuber size	.02 a	.02 a	.02 a	.02 a	.02 a

* Mean separation by Duncan's .05, horizontal comparisons only.

** Rated 1-9, where 1 = least and 9 = highly desirable.

TPS families have a yield of more than 1.0 kg of marketable tubers per plant and about 0.2 kg of smaller tubers which may be used as seed tubers (Table II-5). It should be noted that, in spite of the arbitrary choice of the pollen source to produce the bulk cross hybrids, marketable tuber yields in these TPS families were comparable with that of the single cross TPS families. In general, however, the uniformity of tubers (size, shape, color) in the single cross TPS families was superior to the bulk cross hybrids.

Another group of 48 TPS families produced from the North Carolina Design I Mating System was also evaluated in La Molina for its potential adaptability to produce potato from true seed. Table II-6 gives the tuber yield and uniformity characteristics of the 12 most promising TPS families. The yield and uniformity of these families are as good as the commercial varieties produced from seed tubers which were used as testers.

CONTRACT RESEARCH

During the year CIP continued contract support of the neotuberosum breeding program at Cornell University, Ithaca, New York, U.S.A. Research is directed toward development of populations and selected clones within these populations which will be suitable for broad adaptation.

Clones of andigena representing 371 original accessions were backcrossed for the second time to the more advanced neotuberosum population. These populations should segregate for a high frequency of resistance to potato viruses Y and

Table II-5. Tuber yield (kg/plant) and uniformity ratings of 10 single and 10 bulk cross TPS families.

	Hybrid TPS families	Tuber yield		Uniformity**
		Marketable	Unmarketable	
1	377935.27 x Bulk ESR*	1.059	0.16	4
2	" x 378017.2	1.225	0.11	4
3	377922.30 x Bulk ESR	1.100	0.16	3
4	" x 378017.2	1.234	0.09	5
5	377892.7 x Bulk ESR	1.100	0.14	3
6	" x 378017.2	1.406	0.15	3
7	377891.19 x Bulk ESR	1.108	0.18	2
8	" x 378017.2	1.049	0.15	5
9	377888.17 x Bulk ESR	1.077	0.11	2
10	" x 378017.2	1.042	0.11	4
11	377887.17 x Bulk ESR	1.013	0.13	3
12	" x 378017.2	1.084	0.13	4
13	377885.15 x Bulk ESR	1.222	0.08	2
14	" x 378017.2	1.223	0.12	3
15	377877.9 x Bulk ESR	0.930	0.18	2
16	" x 378017.2	1.281	0.10	4
17	377871.28 x Bulk ESR	0.961	0.15	2
18	" x 378017.2	1.221	0.15	4
19	65-ZA-5 x Bulk ESR	1.352	0.12	3
20	" x 378017.2	1.163	0.21	3

* ESR = Early clones adapted to San Ramon conditions.
** 1 = least uniform 5 = very uniform.

Table II-6. Tuber yield (kg/plant) and uniformity traits of the 12 promising TPS families.

	Hybrid TPS families	Tuber yield		Uniformity *
		Marketable	Unmarketable	
1	377250.7 x 377904.10	1.331	0.17	3
2	377877.15 x 377904.10	1.174	0.19	3
3	377887.74 x 377877.9	1.192	0.06	4
4	377922.15 x 377964.5	1.115	0.11	4
5	377935.27 x 377964.5	1.161	0.07	5
6	377964.3 x 378017.2	1.172	0.01	4
7	377891.19 x 378017.2	1.310	0.08	5
8	377887.59 x 377904.1	1.314	0.15	4
9	377933.13 x 377904.1	1.332	0.20	3
10	378015.7 x 377904.1	1.520	0.10	3
11	377887.29 x 377896.12	1.104	0.11	5
12	377887.74 x 377920.37	1.050	0.20	4

* 1 = least uniform, 5 = very uniform.

Wild potato collection in greenhouse, Huancayo, Peru.

X, late blight and wart as well as early maturity and good tuber type. The advanced neotuberosum 7th cycle selections were grown in two observation plots and retested for resistance to late blight, scab PVX and PVY. On the basis of these tests, 27 clones have been selected from an initial population of 36,000. It is believed that all clones are resistant to PVY; PVX resistance is being verified. The mean blight score on a 1 to 10 scale was 5.4 in 1980 and 1.6 in 1981.

Eighty-nine new selections were made from 5,702 hills which used the same clones which produced the 7th cycle neotuberosum population. These had prior screening for late blight and PVX and PVY. Several hundred selections have been made which are tuberosum x neotuberosum hybrids. The most advanced of these has been released as the variety Rosa. Three other advanced hybrid selections are in regional yield trials.

The evaluation of large numbers of clones under different environmental conditions is a formidable task for a breeding program serving a broad geographic area. To assist CIP a predictive system for yield performance is being developed by Agriculture Canada Research Station. During 2 years eight cultivars were tested at nine sites using Kennebec and Spunta as "control cultivars" to estimate environmental effects at each site. Data from four sites were used as "control sites" for developing regression equations for each of eight cultivars.

Using these regression equations and the values of the "control cultivars" for the other five sites, it is possible to predict the yield of each of the "test cultivars" in each of the five "test sites." In reality, data from each of the five "test sites" provided both actual and predicted yield for each "test cultivar." This permitted the measurement of the correlation between observed and predicted yield values. In four of the five locations the model predicted the actual yield. It is anticipated that the efficiency of the model will be improved with an expanded array of controls.

Agricultural University, Wageningen, The Netherlands, has produced colchicine-doubled *Solanum etuberosum* x *S. pinnatisectum*, coded 4x - EP, in which CIP has detected leafroll virus immunity. Further successful crosses with 4 x - EP material open the possibility of transmitting PLRV-immunity into more advanced material. Etuberosa species also appear to have good PVY resistance.

S. jamesii, accession PI 275265, with resistance to brown rot and root-knot nematode, has been successfully crossed with *S. bulbocastanum* and with the bridging TV^5 genotype (*S. verrucosum* with *S. tuberosum* cytoplasm).

In breeding new late blight resistant material special attention is directed to a newly created tetraploid gene pool of three Mexican species, *S. verrucosum*, *S. bulbocastanum* and *S. stoloniferum*. Crosses of this tetraploid material with a diploid *S. tuberosum*, producing 2n gametes, resulted in sterile triploid hybrids which are being doubled through explant culture. The diploid *S. tuberosum* clone contributed only n-gametes to the progeny.

The potato breeding program at Balcarce, Argentina continued on the utilization of genetic variability in tuberosum, andigena, hybrid tetraploids and diploids to improve virus resistance and adaptation to tuberization under long days. More than 360 parental combinations were crossed successfully resulting

in more than 100,000 seeds for subsequent planting.

In field selections, occupying approximately 8 hectares, 10,458 clones were harvested including 1,249 clones from five previous years. In cytogenetic studies of 2n gamete production involving 157 diploid clones, the percentage of 2n microspores: 89, 0 percent; 18, 1 percent; 17, 2 percent to 5 percent; 2, 6 percent to 10 percent; 1, 21 percent to 25 percent; 3, 81 percent to 90 percent; and, 7, 91 percent to 100 percent.

Materials with virus resistance and the capacity to tuberize under intermediate photoperiod and relatively high temperatures sent to CIP: two Argentine tbr cultivars; six introduced tetraploid clones; 11 diploid hybrids and four tetraploid hybrids obtained by species crosses at Balcarce.

At the Instituto de Producción y Sanidad Vegetal of the Faculty of Agrarian Sciences, Universidad Austral, Valdivia, Chile, research has been coordinated on the collection, maintenance, identification,

Wild potato species growing on rocky hillside near Lima, Peru.

recovery and clonal evaluations of wild old species cultivated from Etuberosa (*Solanum brevidens, S. etuberosum, S. fernandezianum*) and tuberosa potato series (*S. maglia* and *S. tuberosum*). The collection contains 496 entries collected between 32°48' and 44°40' south latitude and 71°20' to 78°50' longitude. Maintenance is by tubers, plants, cuttings, meristem and true seed. Collection identification by electrophoretic tuber protein spectra has shown 246 percent coincidence with some of the primitive cultivated varieties. A range of useful agronomic and nutritional characteristics has been identified in the collection.

Thrust III

Control of Important Fungal Diseases

More than 70,000 seedlings were screened for late blight resistance in growth chambers and in a new greenhouse inoculation facility at Huancayo.

Twenty superior resistant clones were selected from 2,000 in cooperative field screening with the Instituto Colombiano Agropecuario (ICA) and transferred to the national program for multiplication and breeding. Advanced selected clones of Mexican origin performed well in Colombia, Kenya, Rwanda, and Sri Lanka.

Pre-emergence damping-off of TPS is mainly caused by *Rhizoctonia* and can be reduced by fungicide seed treatment. Post emergence damping-off, particularly at high temperatures, is a complex involving soil temperature, *R. solani* and *Pythium* spp. and seems more difficult to control.

Chemical control is effective for smut and pink rot but not for *Sclerotium rolfsii.*

Late Blight

Field screening at Rionegro Colombia, in cooperation with Instituto Colombiano Agropecuario (ICA), during two further evaluations resulted in selection of 20 superior clones for varietal testing by the national program. These clones and some other selections were used in the ICA breeding program. Following an initial evaluation, an additional 179 clones were selected for further testing.

Duplicates of all selected clones were multiplied in the low aphid population area of San Jorge, Colombia to assure low virus incidence. In all evaluations of late blight resistance, infection rate was low. However, in comparing yield of clones not protected by fungicides with protected clones low infection rate in the unprotected plots correlated well with a difference in yield between treatments.

In Rionegro trials CIP-pathogen-tested clones, ASN-69.1, CGN-69.1, CEX-69.1, Atzimba and Murca had consistently low infection rates. These clones are of Mexican origin. Atzimba and CGN-69.1 produced more than 1 kg per hill. In Kenya, Rwanda and Sri Lanka, among consistent blight resisters and highest yielders were Atzimba and other Mexican clones.

Out of 212 clones and varieties tested for blight resistance at Huanuco, Peru, 50 were resistant while 27 were not infected (suggesting apparent immunity due to R-genes). Most isolates of the fungus from Huanuco were of the 1, 3, 7 race, possibly the result of the rather wide dispersal of the new variety Molinera with the R1 R3 R7 genes.

Growth chamber tests with some 30,000 seedlings resulted in an average selection of 15 percent. Greenhouse tests in Huancayo on a 10 percent selection level from 50,000 seedlings are being evaluated.

Table III-1. Effect of fungicidal seed treatment on *Rhizoctonia* damping-off in artificially-infested soil*.

Treatment	TPS fungicidal tolerance (g/kg seed)	Average % germination at 28 days**	Average wet wt. at 28 days (gm)
Dithane M-45	3.7	77 a	10
Cupravit	3.7	73 a	12
Vitavax	2.5	85 a	12
Vitavax + Dithane	3.7	76 a	12
PCNB	1.2	72 a	6
Control	0	44 b	5
	Tuckey's test .05 = 24.1		

* Seed treatment by acetone infusion for 10 minutes. Seeds generally tolerate higher fungicidal amounts up to about 5 g/kg seed. The seed tolerance range for PCNB was extremely narrow.

** Average of two experiments each with four replications.

True Potato Seed (TPS)

Studies on control of pre-emergence damping-off of TPS caused by *Rhizoctonia solani* indicate a solution through fungicidal seed treatment (Table III-1) or soil treatment (Table III-2). Post emergence damping-off complex in the field involves soil temperatures of 30°C and above, and infection by *Rhizoctonia* and *Phythium* spp. Integrated control is the most appropriate in reducing field losses. Included are use of vigorous seedlings at transplanting, use of shade corn and timed applications of soil fungicides during the critical infection phase.

Soil-Borne Pathogens

Repeating experiments on control of pink rot (*Phytophthora erythroseptica*) gave similar results. The method consists of a pre-planting fumigation, followed by application of Ridomil (a systemic fungicide with specificity to *Phycomycetes*) at planting. The method was employed on a large scale using

Table III-2. Effect of fungicidal treatments of artificially-infested soil on incidence of pre-emergence damping-off caused by *Rhizoctonia solani.*

Treatment	Optimum dosage (g/kg soil)	Dosage causing phytotoxicity (g/kg soil)	Average % germination at 28 days*	Average wet wt at 28 days (gm)*
Dithane M-45	0.1	0.5	83 a	14.5 a
Cupravit	0.15	1	51 b	5.5 cd
Vitavax	0.1	0.4	82 a	12.5 ab
Vitavax + Dithane	0.3	0.5	78 a	10.9 b
PCNB**	0.15	0.5	43 b	3.8 d
Control	0	0	47 b	7.3 c
	Tuckey's test	.05 =	13.1	3.5

* Average of two experiments each of four replications.

** Causes delayed germination and leaf burn of primary leaves.

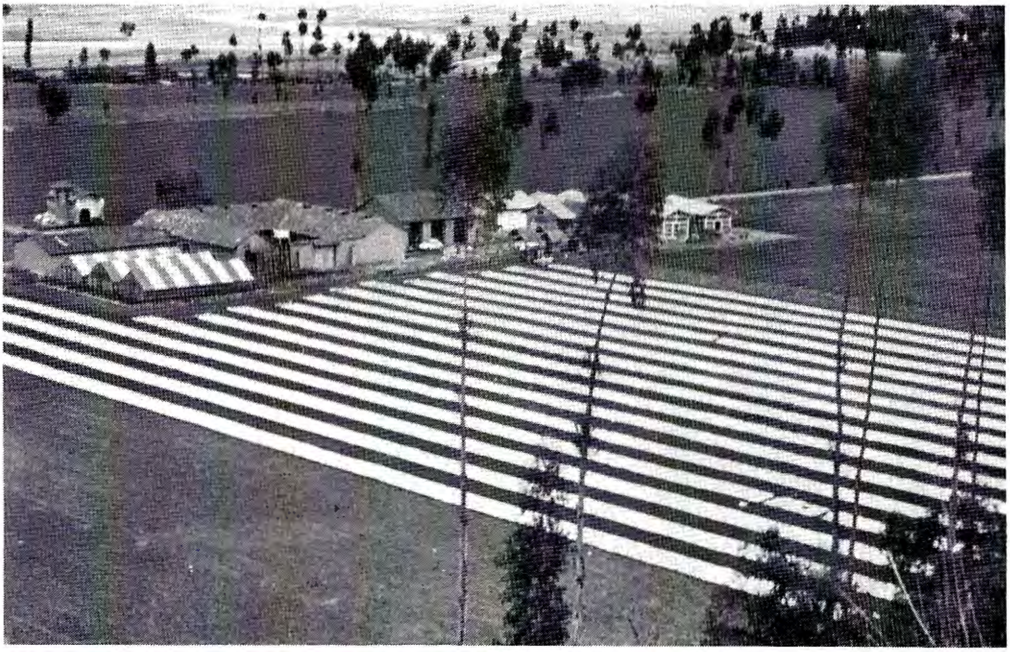
methyl bromide fumigation below a plastic tarp (Figure III-1) or Dazomet (a methylisothiocyanate-releasing compound) followed by irrigation and sealing of the upper soil-layer. The result was low incidence of pink rot in the germ plasm collection. Experiments to optimize the dose of the fumigants Dazomet and Ridomil (Table III-3), showed that rates of 200 to 300 kg Dazomet and 20 kg Ridomil per ha gave best control.

In addition to chemical control methods, a gradual improvement of soil structure by incorporation of organic material from rotation crops (corn, wheat and peas) helped reduce disease incidence.

In control of smut, *Angiosorus solani*, one fumigant application of Dazomet or methyl bromide significantly reducted this disease and increased yield during two cropping seasons. PCNB, Allisan and Tecto-60 applied to the crop were as effective in increasing yield as fumigants. PCNB reduced disease incidence as well as the fumigants tested.

Fungicides did not significantly control southern blight (*Sclerotium rolfsii*) in the field in San Ramon. Supporting evidence was obtained in greenhouse tests. Preliminary results on effects of crop rotation on incidence of southern blight indicate that the number of sclerotia in soil is high when potatoes follow potatoes but is reduced when beans follow potatoes and is virtually zero when rice or corn follow potatoes.

Figure III-1. Part of the field at Huancayo being fumigated with methyl bromide for control of pink rot (*Phytophthora erythroseptica*). Plastic sheets (white strips in photo) alternately cover soil injected with the fumigant. A week later the plastic is removed and the alternate strips are fumigated. As a result of this treatment, followed by use of a systemic fungicide at planting, the germ plasm collection and most of the breeding stock were for the first time virtually free of pink rot.



During the current planting season in San Ramon, *Rhizoctonia solani* was important in the soil-borne complex. Of various fumigants and fungicides tested under laboratory conditions Benlate and Vitavax were the most potent inhibitors of this fungus (Table III-4). Results also suggest that under the warm conditions of San Ramon, PCNB may be less effective than Benlate and Vitavax.

Table III-3. Effect of Dazomet and Ridomil on pink rot (*Phytophthora erythroseptica*) incidence*.

Chemical applied (kg/ha)		Yield (kg/plot) at harvest	
Dazomet	Ridomil 5g	Infected tubers	Healthy tubers of over 60 g
0	0	3.9 e	17.0 e
0	20	2.2 abcde	26.2 d
0	30	0.9 abcd	31.5 b de
0	40	0.5 ab	32.8 b de
200	0	2.4 bcde	28.8 de
200	20	0.3 a	37.3 ab
200	30	0.7 abc	36.3 ab
200	40	0.5 ab	35.6 abc
300	0	2.7 cde	26.2 d
300	20	0.3 a	42.1 a
300	30	0.2 a	36.5 ab
300	40	0.2 a	39.8 a
400	0	2.8 a cde	32.9 b de
400	20	0.8 abcd	38.5 ab
400	30	0.2 a	37.9 ab
400	40	0.2 a	36.2 abc

* Potato variety Ticahuasi was planted in a factorial 4 x 4 design in randomized complete blocks. Tubers were disinfected with sodium hypochlorite prior to planting. Plots of 3 rows of 3 m at 1 m spacing and 10 hills per row. Dazomet (Basamid, 98% granulate, BASF) applied 1 month prior to planting, disked into soil, irrigated, kept under plastic tarp during 2 weeks and left to aerate for another 2 weeks prior to planting. Ridomil 5g, applied to furrows at planting. Controls were treated the same as other in all respects except for product to be tested. All treatments received Furadan and Temik at time of planting at a rate of 60 and 25 kg/ha, respectively.

CONTRACT RESEARCH

During the past 10 years considerable progress has been made at Cornell University in incorporating resistance to *Phytophthora infestans* from *Solanum tuberosum* spp. *andigena* into Cornell breeding populations. In plant pathology contract research 277 advanced breeding lines and heat tolerant clones were tested for general resistance to *P. infestans*. Clones N 503-158, and NY 59 had high levels of foliar resistance to late blight. In cooperative field tests of Cornell material in Colorado, clones NY 59, NY 61 (Rosa) and NY 63 showed high levels of early blight (*Alternaria solani*) resistance. NY 59 and NY 63 also had high levels of resistance to *Verticillium* spp.

In other potato disease research at Cornell, enzyme-linked immunosorbent (ELISA) assays are used routinely to detect potato leafroll virus and viruses Y, S and M. Potato leaf tissue has been used from both field and greenhouse grown plants and from plants grown in vitro.

Table III-4. Laboratory screening of selected fungicides against soil-borne fungi.

Fungus *R. solani*	Fungicide and concentration		% Control of Fungus (after 10 days) 18°C Mycelium	18°C Sclerotia*	28°C Mycelium	28°C Sclerotia*
	Beniate	100 μg/ml	100	100	100	100
		100 μg/ml	100	100	100	100
	Vitavax	100 μg/ml	100	100	100	100
		200	100	100	100	100
	Cupravit	100	28	NA	6	61
		200	43	NA	11	53
	Basamid	100	38	NA	28	62
		200	52	NA	44	NA
	PCNB	100	83	NA	77	NA
		200	50	NA	47	NA
	Dithane	100	27	NA	80	70
		200	88	NA	82	40
	Polyram	100	80	NA	74	65
		200	78	NA	73	9
	Ant Racol	100	82	NA	80	56
		200	85	NA	88	57
	Tecto	100	NA	NA	NA	NA
		200	NA	NA	NA	NA

* A sclerotial species of *Rhizoctonia solani*
Based on sclerotial counts in treated plates and control after 15 days.

$$\% \text{ Control for Sclerotia} = \frac{\text{No. of Sclerotia in control test} - \text{No. of Sclerotia in treatment}}{\text{No. of Sclerotia in control}} \times 100$$

Control of Important Bacterial Diseases

Selection for bacterial wilt resistance is now made with two races of *Pseudomonas solanacearum* before late blight testing. Resistance sources include *Solanum sparsipilum* and *S. chacoense* as well as *S. phureja*. Progenies from the latter are now performing well in Brazil, Uruguay, Colombia, Kenya, and Sri Lanka. Resistant survivors from over 54,000 seedlings were identified with some of the advance selections yielding 1 kg or more per plant. Wilt resistance in highly selected clones has survived over three seasons under severe field infection at two locations in Peru.

Survival of *P. solanacearum* in soil is largely dependent upon presence of susceptible plant roots as roots of non-hosts do not support bacterial multiplication. Infection of potato (CIP-Lima) was most severe in infested soil with roots of susceptible *Heliconia* spp. and *S. nigrum*.

Of the tuber soft rot bacteria, *Erwinia chrysanthemi* is generally more invasive than *E. carotovora* subsp. *carotovora* which is only slightly more invasive than *E. c.* subsp. *atroseptica* in potato tubers.

Seedling screening and field evaluation of tuber families developed for resistance to bacterial wilt received major emphasis. Screening included tuber families for export and for field testing in Peru. In both cases seedlings were separately inoculated with strains of races 1 and 3 of *Pseudomonas solanacearum*.

From a total of 19,840 seedlings 73 resistant clones were selected (Table IV-1). Half were distributed to CIP Regions and half were evaluated for agronomic performance at CIP-Lima. Most clones are also being field tested for bacterial wilt resistance in Peru and in other countries. The source of resistance to bacterial wilt in all these clones continues to be *S. phureja* although the final incorporation of resistance genes from some diploid clones such

Table IV-1. Seedling screening for development of potato clones with bacterial wilt resistance for export (1980-1981).

Nº families	Nº seedlings	L-BT. survivors	Nº cuttings	Nº resistant clones
40 ('80/'81)	5,840	607	473	38
30 ('81)	10,000	1,614	1,234	23
12 ('81)	4,000	458	70	12
9 ('81/'82)	1,785	—*	—**	—**
Total 91	21,625			73

* As of mid '81 seedlings were not screened initially for resistance to late blight.

** Data unavailable.

as *S. sparsipilum* and *S. chacoense* is underway. The resistant clones presently available were derived from crosses among advanced resistant clones as well as crosses with clones adapted to tropical conditions. Information on resistance and agronomic behavior indicates that some of these clones are promising in Brazil, Uruguay, Colombia, Kenya and Sri Lanka.

In other research institutions evaluated a total of 23,948 seedlings to select outstanding clones for distribution to CIP Regions. Of 11,000 evaluated during two field tests 153 remained resistant. Clones are now no longer screened initially for resistance to late blight, because large numbers of potentially bacterial wilt resistant seedlings were previously eliminated.

Yield potential trials were planted near San Ramon, one in the infested plot at 1,050 m elevation during the rainy season, and the other in a wilt-free plot at 850 m during the drier season (supplementary irrigation). Of 126 clones planted in infested plots 13 were without foliar wilt symptoms or tuber infection. After three seasons of consecutive evaluation 26 clones had up to 10 percent wilted plants; nine clones were without tuber infection (Table IV-2). Of 68 clones in the wilt-free plots 21 yielded more than 500 g/plant.

At Umari (2,400 m) out of 70 clones planted in the wilt-infested plot 15 clones did not show foliar wilt or tuber infection. After three seasons of consecutive planting at Umari 11 clones have shown up to 10 percent wilted plants with no tuber infection (Table IV-2).

A 57-clone trial in an infected field in Yurimaguas at 180 m in the Amazon basin had four clones without wilt symptoms or tuber infection. Yields were low because of heat stress.

Table IV-2. Clones showing from up to 10 percent wilted plants and no tuber infection by *P. solanacearum* after 3 years of consecutive field evaluation at Umari (2,400 m) and San Ramon (1,050 m).

San Ramon	Umari
BR 62.5	BR 62.5
Cruza 148	Cruza 148
BR 63.15	BR 63.76
MB 5.39	MB 6.42
MB 6.1	MB 14.1
MB 14.8	MB 42.11
MB 34.22	MB 56.1
MS 36.19	MB 56.11
MS 82.60	MB 60.32
	MS 35.4
	PSP 30.10

At La Molina at 240 m in coastal desert 110 clones were planted for multiplication and agronomic evaluation, including the first field evaluation of 27 clones developed for export in 1980. Twenty-two clones yielded above 1 kg/plant and six over 1.5 kg/plant.

Some common jungle floor weeds at Yurimaguas were tested for their influence on survival of *P. solanacearum* in soil, using susceptible potato as the indicator of survival. The plants tested were two *Heliconia* spp. var. Amarilla and var. Cresta de Gallo, and two Solanaceae, *Solanum topiro* (cocona) and Suikawito (unidentified). *S. nigrum*, a common field weed in Yurimaguas, was also tested. Plants were inoculated by soil infestation with Yurimaguas potato isolates 077, 141, 108 and 142, Tea Gardens 015 and a Huancayo 042 isolate. To each pot were added 40 ml of 2×10^8 bacteria/ml. Results are shown in Table IV-3 and illustrated in Fig. IV-1. *S. nigrum* was infected by all Yurimaguas isolates, and two of the isolates infected 10 percent of *Heliconia* sp.

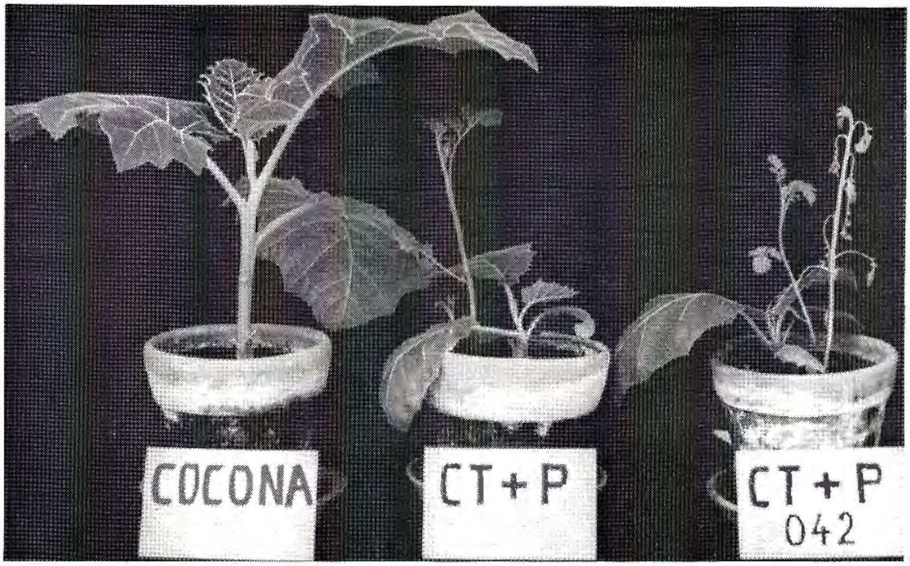
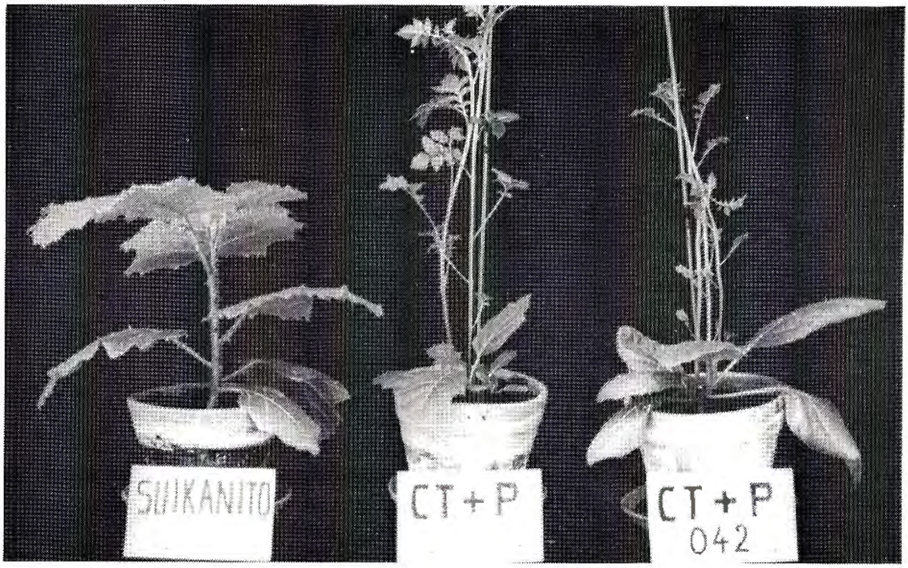


Figure IV-1. Determination of persistence of *P. solanacearum* in soil by planting a potato (P) next to the test plant the top of which has been cut (CT) at pot-brim level, 52 days after soil infestation. Left, whole plant; center (CT+P), uninoculated cut check and right, soil infested with isolate 042. In this example the emerged potato is wilting after 20 days, demonstrating greater persistance with Cocona, than with Suikawito.



var. Amarilla. Persistance of isolates determined by infection of susceptible potatoes grown in the same pots for a further 60 days, occurred in varying degrees as influenced by the initial weed host. Heliconias and solanaceous plants appear to play a role in maintaining *P. solanacearum* in jungle soil.

A study began to determine capabilities of strains of *P. solanacearum* of tropical origin to produce

Table IV-3. Percentage of plants infected (Inf.) with isolates of *Pseudomonas solanacearum* 52 days after soil infestation and persistance of the bacterium (Per.) in the soil determined by infection of susceptible potatoes grown in the same pots for an additional 60 days.

Isolates (and their biovar)	Test Plants*										
	S. nigrum		Cocona		Suikawito		Cresta		Amarilla		Check
	Inf.	Per.	Inf.	Per.	Inf.	Per.	Inf.	Per.	Inf.	Per.	Per.
015 (I)	0	–	0	80	0	0	0	50	0	20	0
042 (I)	100	–	0	60	0	40	0	0	0	20	0
077 (I)	30	–	0	100	0	20	0	50	10	50	0
141 (I)	30	–	0	100	0	20	0	100	10	40	0
108 (II)	30	–	0	60	0	0	0	50	0	40	0
142 (II)	20	–	0	80	0	0	0	67	0	60	0
Average	35		0	80	0	13	0	52	3	38	0

* Based on 10 plants each, except for Cresta in which there were three.

bacteriocin. Bacteriocins are non-replicating, protein-containing bactericidal substances, produced by certain strains of bacteria and active against other strains of the same species. In a preliminary test of 22 strains only four produced a significant amount of bacteriocin that inhibited the growth of the other strains. A non-virulent mutant of one of these strains will be used in a control study of bacterial wilt in Yurimaguas.

Erwinia Diseases

Screening tubers of selected clones for resistance to *Erwinia chrysanthemi*, a soft rot organism, continued using the Infectivity Titration Inoculation method. A total of 403 clones were evaluated: two of 120 tropically-adapted clones, two of 159 clones with frost and late blight resistance, and seven of 124 diploid clones were moderately wilt resistant (Table IV-4). Clones rated as resistant in 1980/1981 will be planted for multiplication, retested for tuber resistance to *E. chrysanthemi* (Ecy) and for the first time also to *E. carotovora* subsp. *carotovora* (Ecc) and subsp. *atroseptica* (Eca).

The pathogenicity of the three *Erwinias* was tested on tubers of cultivars Revolucion and Yungay with two strains of each *Erwinia* at three inoculum concentrations. As Figure IV-2 shows, Ecy strains were significantly more pathogenic than Ecc or Eca strains.

CONTRACT RESEARCH

Research at the University of Wisconsin confirms the reduction in decay by *Erwinia caratovora* following vacuum infiltration with different concentrations of calcium solutions into potato tubers. Analyses of periderm and cortex tissue by atomic emission spectrophotometry indicated that bacterial decay decreased from 48.9 percent to 2.6 percent when the concentration of calcium increased from 0.1 percent to 0.51 percent in the periderm and from 0.02 percent to 0.08 percent in the cortex. Similar analyses were made of periderm samples from tubers harvested from a field study involving different levels of calcium

and nitrogen sources. Calcium concentrations and soft rot potential indices were also inversely correlated in this study. Calcium nitrate was the preferred source of calcium. The specific role of calcium with respect to the inverse correlation between levels in periderm tissue and the ability of soft rot bacteria to decay potato tubers has not been determined.

Conflicting reports exist regarding the capacity of *Pseudomonas solanacearum* to survive in the soil. CIP contract researchers at the University of Wisconsin have concluded that the bacterium is not capable of long-term survival in the soil as observed under growth room and greenhouse conditions. Using a highly selective medium which they developed, quantitative determinations of *P. solanacearum* in soil, rhizosphere and roots were possible. The finding that the bacterium can infect and multiply in the roots of non-host, symptomless plants may explain the controversial survival of the bacterium in soil and the failure of many rotation programs.

In studies of the binding of *P. solanacearum* to host cell walls, labelled strains of the bacterium were interacted with suspension of cultured cells from tobacco and potato. Avirulent strains of *P. solanacearum* were found to bind more rapidly and strongly to plant cell walls than virulent strains. This attachment has been considered as an initial recognition step leading to the hypersensitive response in tobacco.

Initial attempts to induce resistance in potato to *P. solanacearum* by prior inoculation with avirulent, bacteriocin-producing strains have given promising results.

Table IV-4. Moderately resistant clones to *Erwinia chrysanthemi* out of 159 developed for resistance to frost and late blight (F-L), 120 selected for lowland tropics (LT) and 124 diploid clones (DC).

Clone	Diameter of rotted area (mm)* at different inoculum concentrations			Program
	4.4×10^6	8.8×10^5	1.76×10^5	
373059.9	6.2	3.4	0.0	F-L
379483.3	6.8	4.75	0.0	F-L
377823.3	6.3	3.6	2.0	LT
(377891.11 x Neo tbr. Bulk)	6.6	5.3	2.3	LT
CUS 122	4.5	3.0	0.0	DC
OCH 8587	6.4	5.6	1.0	DC
702199	6.4	5.0	0.0	DC
OCH 10840	5.6	3.5	0.0	DC
OCH 5604	6.2	5.75	0.0	DC
702832	6.0	2.6	0.0	DC
702014	6.2	4.0	0.0	DC
H-32 (Check)	11.1	13.3	14.0	

* Diameter of rotted area (mm) 72 h after injecting 0.01 ml of inoculum 5 mm deep in the tuber. Inoculum concentration expressed in bacteria/ml.

Agronomists explain results of bacterial wilt infection to women farming in Rwanda.

Thrust V

Control of Important Virus Diseases

Resistance to potato leafroll virus (PLRV) was identified by exposing more than 10,000 TPS as seedlings to PLRV-carrying aphids, transplanting resistant survivors to the field, growing them to large plants in PLRV exposure and evaluating for vine and tuber type, and yield within 8 months. Resistance is now present in good quality, high yielding clone survivors of heavy and successive PLRV exposures. Extreme resistance exists in selections of *Solanum etuberosum* x *S. pinnatisectum* which will not accept PLRV by graft inoculation.

PVY immunity is now positively identified in parents by grafting and in more than 10,000 seedlings by spray inoculation. Population breeding for PVY immunity in three generations increased resistant segregates from 43 percent to 82 percent. Resistance to the potato spindle tuber viroid is in one accession of *S. acaule*. Sensitized latex or antiserum for virus detection in almost double the quantities previously supplied was sent to 14 developing countries.

Potato Leafroll Virus (PLRV)

Extreme resistance, not accepting PLRV by either graft or aphid (*Myzus persicae*) inoculation, exists in 14 colchicine-doubled seedling segregates from crosses of *Solanum etuberosum* x *S. pinnatisectum* (4X-EP) produced in the Netherlands. Moderate resistance, becoming infected by graft inoculation but not by aphid inoculation, and susceptible, becoming infected by both methods, was also detected. Freedom from PLRV following exposure was established by ELISA serology and by grafting to *Datura stramonium*. The mode of inheritance of this resistance is being studied. Extremely resistant 4X-EP seedlings can be crossed with the TV^5 hybrid, (*S. verrucosum* with *S. tuberosum* cytoplasm).

Seedling Resistance Evaluation

During winter, 10,920 seedlings exposed for one week to PLRV-carrying *M. persicae* were later transplanted and moved outdoors for symptom development and hardening. Visibly healthy survivors were transplanted to the field during cool weather, May to September. This season is best for obtaining good populations of aphids, strong symptoms of leafroll, and good tuberization. Scheduling one large annual evaluation test of 10,000 seedlings (Figure V-1) saves 9 to 10 months of screenhouse bench space and 8 to 9 months in time required to reach the 5- to 10-hill field evaluation freeing screenhouse space for clone resistance evaluation in increasingly large numbers. PLRV seedling resistance in families is best evaluated in the second generation.

PLRV Resistance in Clones

CIP-703266, one of three outstanding 1980 clones, did not show virus infection in 1981 field trials (Figure V-2). It was the second

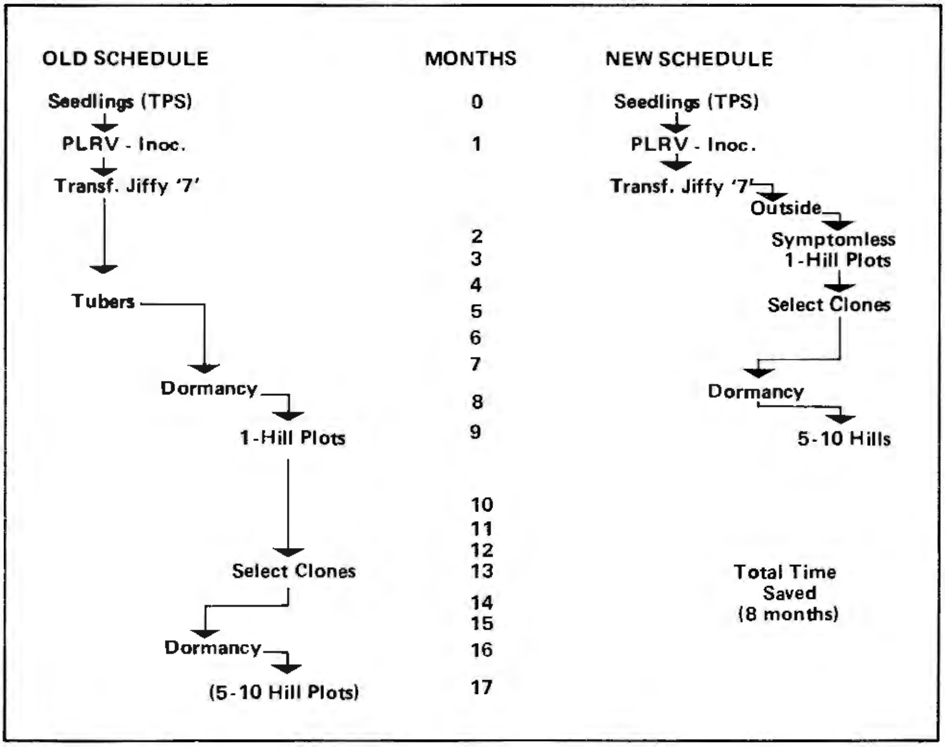


Figure V-1. Modifications in methods for selecting PLRV resistant segregates.

highest yielding clone among 118 producing more than 5 kg from a 5-hill plot in 97 days. Clones CIP-701752 and CIP-703232 were similar in performance.

Relative PLRV Resistance

Relative resistance of 4 selected clones to PLRV was determined with various densities of aphid populations (Table V-1). Although all clones had been resistant to natural field infection, differences in levels of resistance became apparent with increased inoculum pressure.

Thirty-two isolates from different sources maintained in *Physalis floridana* were compared by ELISA serology using two antiserum sources, a Swiss isolate from cv. Claustar and a Scottish isolate PLRV-G. All PLRV isolates reacted similarly with both antisera suggesting a serological relationship. Two isolates originally from wild species in the Andean region caused mild symptoms in *P. floridana*. They had the lowest

Table V-1. PLRV resistance in advanced CIP clones exposed to population densities of PLRV carrying aphids *.

Clone	Aphids per plant		
	5	25	50
4.2	0/5**	0/5	1/5
15.12	0/5	3/5	3/5
23.2	0/5	3/5	3/5
11.4	2/5	2/5	4/5
Renacimiento (susceptible control)	5/5	5/5	5/5

* Sprouts at the 2-3 leaf stage exposed to PLRV carrying *Myzus persicae* in screenhouses, La Molina, 1981. PLRV was detected by visual symptoms confirmed by ELISA serology.

** Numerator = plants infected. Denominator = plants exposed to infection.

Figure V-2. After 2 years of PLRV-field exposure, clone CIP-703266 (right) showed no PLRV and good vigor. A susceptible clone (left) with PLRV symptoms and poor growth.

ELISA values suggesting a serological difference to European strains or a peculiar characteristic to develop only low concentrations of virus in infected plants.

PVY Immunity in Seedlings

Before clones are used as parents they are thoroughly tested for immunity to PVY. Immunity to PVY was present in five clones of *S. tuberosum* ssp. *andigena* and in *S. stoloniferum*. PVY immunity in clones PG 295 and BL 61.74.167 was constant with seven other distinct Peruvian PVY isolates.

Table V-2. Recurrent selection for increasing frequency of PVY immune tetraploid genotypes.

Cross*	Generation of selection	Number plants	% resistant genotypes
S x S		118	0
R x S	R_1	617	43
$R_1 \times R_1$	R_2	524	60
$R_2 \times R_2$	R_3	700	82

* R = resistant; S = susceptible.
Tukey's w (0.05) : 9.32.

Increasing frequency of resistant genotypes in three generations of crossing was demonstrated in a population breeding approach (Table V-2) by inoculating seedling populations twice in selecting for PVY immunity. Resistant genotypes increased in each generation at statistically significant levels.

Resistance to Potato Virus Y (PVY)

Seedlings were spray inoculated with PVY^O alone or simultaneously with PVX_{cp} and later symptomless plants were again inoculated by hand. From a total of 9,457 inoculated seedlings, 19 percent were potentially immune to PVY and 25 percent to both PVY + PVX. Of these, 47 and 28 plants, respectively, are haploid ($2n = 2x = 24$).

Progenies first screened for frost or late blight resistance were mechanically inoculated with PVY^O. From 347 frost resistant seedlings, 59 percent survived PVY selection and from 533 late blight resistant seedlings 73 percent were selected.

PVY Strains in South America

Potato virus Y (PVY) strains in farmers' fields of the Andean region exist as: Ecuador — PVY^O and PVY^C; Peru (coast) — PVY^O; Peru (sierra) — PVY^N; Central (Chile) — PVY^O and PVY^N; South (Chile) — PVY^O; and Argentina — PVY^N. In Ecuador PVY^N and in Argentina PVY^O were not detected in commercial potato fields.

All isolates from Ecuador (PVY^O or PVY^C) and all from Chile except one (PVY^O or PVY^N) induced necrotic local lesions (NLL) on detached leaves of clone A6. On A6 plants they induced first NLL and later systemic necrosis and mosaic. One isolate from Chile did not induce NLL on detached leaves but caused mosaic on inoculated plants. These deviant strains have been detected previously in Peru and Europe.

Selected PVY isolates from the Andean region were mechanically inoculated to commonly grown Andean cultivars. More virulent PVY isolates were obtained in higher frequency from Argentina and Chile than from Peru. PVY^O and PVY^C from Ecuador were the least virulent.

Plants or detached leaves of two clones of *S. chacoense*, TE_1 and TE_2, used for PVY detection in Poland and in the Soviet Union, were mechanically inoculated with 39 isolates from Ecuador, Peru, Chile, and Argentina. Pinpoint NLL were induced by most PVY^O and PVY^N isolates. No PVY isolate became systemic on TE. Generally TE_1 and TE_2 were not as useful as A6 except that TE differentiates Ecuadorian isolates of PVY^O and PVY^C and certain other deviant potyvirus strains. Some isolates induced NLL 1 to 1.5 mm in diameter that killed non-detached leaves.

A potyvirus, code named UF, does not produce local lesions on inoculated leaves of clone A6 but becomes systemic producing vein necrosis. It produces local lesions in *S. demissum* 'Y' and *S. chacoense* as do other PVY strains. It was aphid transmitted from *Nicotiana occidentalis*. Cultivars Kennebec, Radosa, and Wauseon develop partial vein necrosis and lower leaf chlorosis with green areas. Clavela, Maria Tropical and Arran Pilot react with systemic chlorotic spots, mosaic, and deformation of leaf margins. The virus did not react serologically against antisera to PVY^O and PVY^N. However, it did give a positive reaction against an antiserum to an atypical strain of PVY^C (Glaadblaaje) from the Netherlands. UF and PVY^C Glaadblaaje behave similarly when grafted to potatoes and on certain indicator hosts. UF is apparently an unusual strain of PVY^C. Because UF cannot be detected by antisera to the common strains of PVY, an antiserum specific for UF has been prepared for distribution.

Potato Spindle Tuber Viroid

Polyacrylamide gel electrophoresis (PAGE) as now modified allows 50 samples per day with high sensitivity when test plants are grown at 25°C or higher. The PAGE and the tomato test under continuous light are equally sensitive; but the latter is not suited for large scale testing. Germ plasm clones maintained in our in vitro collection, free of PSTV by PAGE tests, were also tested by a nucleic acid hybridization (cDNA) technic. All CIP samples were free from PSTV confirming the high sensitivity of PAGE test and that CIP materials for export are indeed free of PSTV.

Difficulties exist in producing an antiserum to a protein induced

or enhanced by PSTV in infected plants. Isolation and characterization of the antigen in pure form have not been successful.

Resistance to PSTV

Several resistant clones from *S. acaule* accession, OCH 11603, were tested. They resisted infection under conditions permitting infection of susceptible plants. Other accessions of *S. acaule* and wild species did not carry similar resistance.

Antiserum for Virus Detection

Latex sensitized to PVY, PVX, and PVS was distributed in larger lots in 1981, total amounts more than doubled (Table V-3). Approximately the same number of countries received shipments. Brazil, Japan and Bangladesh received undiluted antisera, enough for 8,000, 6,000, and 7,000 tests for PVX, PVY and PVS, respectively.

Equally suitable for the latex tests are glass ring slides, Boerman slides, perspex plates and plastic petri plates. However, with plastic petri plates (as currently used at CIP) reactions are clearer and easier to read, plates are more suitable for large scale testing, and can be reused several times.

Potato Yellow Vein Disease (PYVV)

PYVV diseased plants free of PLRV indicate that the two viruses are independant of each other. Graft transmission was successful only to potato; mechanical transmission failed. A filamentous virus, c. 650 nm long, was isolated from infected plants of cv. Saco by enzymatic (Driselase) tissue digestion before differential centrifugation (Figure V-3). Unusual crystal-like structures seem to be internally associated with the cloroplasts of infected plants.

Potato Deforming Mosaic

This disease was present in cv. Serrana. Potato was the only sus-

Table V-3. Sensitized latex distributed to different countries or used at CIP in 1981.

Country	Sensitized Latex* for				
	PVX	PVY	PVS	APLV	APMV
Argentina	5	5	5	–	–
Bangladesh	62	62	62	–	–
Bolivia	6	6	–	–	–
Chile	40	40	40	–	–
Ecuador	6	6	6	6	6
India	21	21	21	6	–
Korea	8	8	8	–	–
Kenya	6	6	6	–	–
Mexico	7	7	7	–	–
Netherlands	3	3	3	3	3
Pakistan	8	8	8	–	–
Peru	10	10	10	–	–
Philippines	62	62	62	10	10
Turkey	10	3	3	–	–
	254	247	241	25	19
CIP	476	335	154	257	257
Total	730	582	395	282	276

* Amounts in ml. (1 ml = 80 tests).

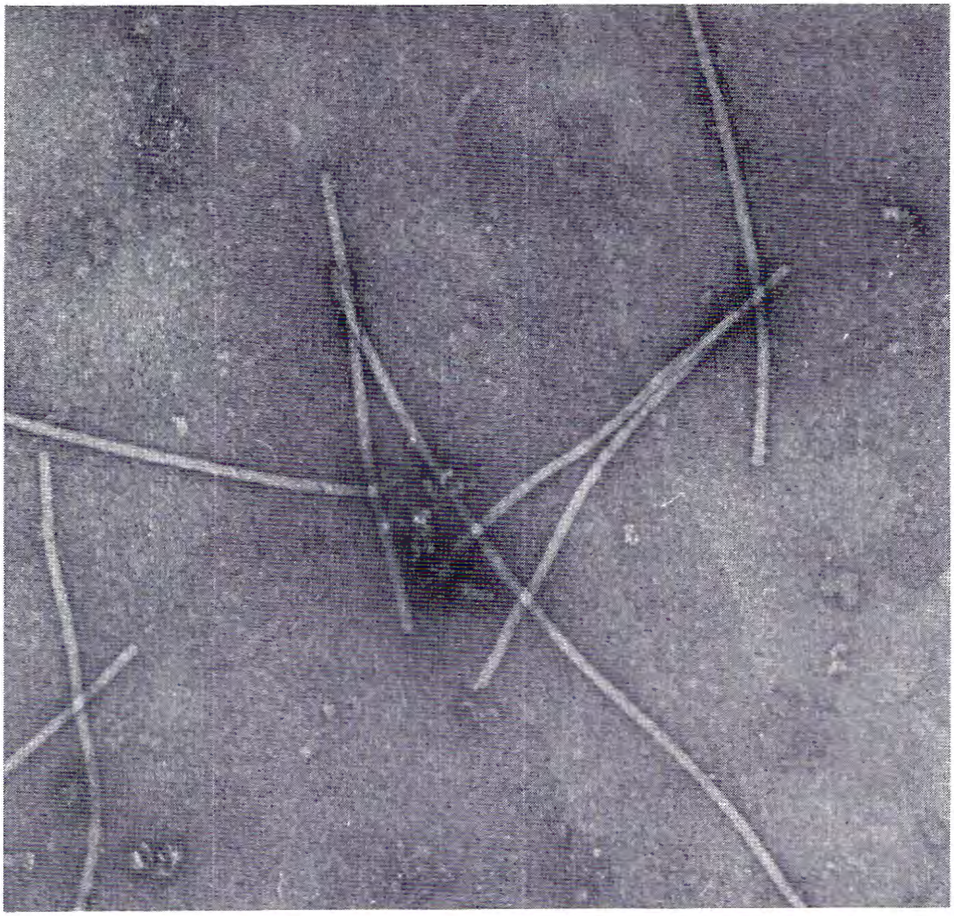


Figure V-3. Particles purified from potato with yellow vein symptoms. Cross-banding is visible in all virus particles. Stained in 1 percent uranyl acetate pH 4.0.

ceptible host by graft inoculation from an extensive host range attempted. The virus could not be purified following Driselase tissue digestion. Pectinase-cellulase before differential centrifugation yielded relatively low numbers of isometric particles approximately 28 nm diameter with hexagonal outlines. Further work will involve purification and production of an antiserum. The virus was not transmitted by aphids in either a persistent or non-persistent manner.

"P78" Disease

Defined, spreading, chlorotic spots develop on inoculated leaves of Samsum tobacco. Virus isolation directly from potato leaves and virus purification by conventional methods failed. No bacteria nor fungi were detected in diseased plants. In infected sap of clone Maria Tropical, adjusted to pH 4.5, elongated rod-shaped particles of undetermined length formed extensive masses. These are being studied further.

New Tobacco Streak Virus

A virus isolate from potato, coded SB10, causing a mild mosaic with host range and properties resembling

tobacco streak virus (TSV) is considered a new strain because of serological and comparative host range differences. It is serologically more closely related to TSV-B from soybeans in Brazil than to the type strain, TSV-HF. When inoculated onto potatoes, SB10 generally causes a mild mosaic or symptomless infection. Progeny tubers from infected mother plants were, except in two clones, virus-free. The virus seems not to be a threat to potato production. The virus is readily transmitted through seeds of *Nicandra physalodes* and *Chenopodium quinoa*. Enzyme-linked immunosorbent assay (ELISA) can be used to detect the virus at a concentration of 1 ng/ml or in infected *C. quinoa* sap diluted 10^{-5}.

Hair Sprout

Hair sprout has been of relatively high frequency in tuber sprouts grown from either tubers of from TPS in La Molina over the past 3 years. Sprouts from germinating tubers are thin and usually produce weak plants, late in emergence. Plants seldom reach normal size, resemble those with mycoplasma disease, purple top wilt, and yields are markedly reduced. Stem apices are frequently but not always severely rolled, somewhat chlorotic or pink, and aerial tubers in leaf axils are frequent. Plants wilt and die prematurely. Repeated attempts to observe mycoplasma-like bodies within such potato plants have failed.

Experimental hybrid potatoes growing in Peru.

Thrust VI

Control of Important Nematode and Insect Pests of Potatoes

High levels of resistance to four species and eight races of root-knot nematodes, found in some diploid crosses, are being incorporated in tetraploid populations. Resistance to various races of potato cyst nematode was identified in several wild *Solanum* species and some tetraploid crosses.

Adding a nematode parasitizing fungus, *Paecilomyces lilacinus*, to soil in farmer field trials reduced *Meloidogyne incognita* root-knot galls on roots and tubers. Fungus control equaled or exceeded that of nematicide application. Elsewhere control has been effective in three successive crops. The fungus readily spreads into non-treated control plots further indicating competitive survival. Corn yields in rotations including potato were markedly increased in fungus-treated plots.

False root-knot nematode infested soil which was cold treated and air dried was used as inoculum. This inoculum improved severity and uniformity of infection, and greatly facilitated testing for resistance.

Several tuber moth resistant clones in rustic storages were identified using the natural infestation which developed under farm conditions. Synthetic pheromone baited water traps are highly efficient in storages. At 100 square meters field spacing they reduced tuber infestation by 34 percent.

Several pest management control trials are in early stages of development in this recently-initiated program.

NEMATOLOGY

Potato Cyst Nematode (PCN)

Screening efficiency for resistance to potato cyst nematode (PCN) was increased by inoculating seedling crosses with 30 cysts each 10 to 15 days after transplanting into plastic cups. Degree of resistance was based on number of females observed on root balls after 10 weeks. When tubers of individual genotypes exhibiting no females were retested, an average of 42.3 percent showed resistance which represented 10.5 percent of the total populations tested (Table VI-1).

Globodera pallida pathotypes P_4A and P_5A were studied during two seasons on selected resistant clones from the Netherlands. The P_5A population (Table VI-2) overcame resistance more rapidly than the P_4A population. The P_4A pathotype is probably genetically less variable than P_5A suggesting that a better knowledge of nematode population stability is essential in breeding and screening programs. When six resistant *S. vernei* hybrids were inoculated with eight populations of *G. pallida* from Peru and Ecuador identified as pathotype P_4A, they were highly resistant to all the populations with a nematode multiplication rate less than one. Resistance to pathotypes of *G. pallida* has been confirmed in accessions of wild species (Table VI-3) and in

Table VI-1. Seedling and tuber screening tests for resistance and segregation of resistance to *Globodera pallida* race P_4A.

Crosses		No. seedlings	% Resistant segregation	
			Seedling test	Tuber test
			o female/root ball	0-5 females/root ball
	P_4A resistant			
P_5A Res.	x 702535	1380	17.1	7.0
Susceptible	x 702535	1481	11.8	3.3
P_5A Res.	x 702698	913	11.0	1.3
Susceptible	x 702698	1174	9.0	0.0
702535	x 702698	81	75.3	40.7
$\bar{X}$			24.8	10.5

clones representing intercrosses of wild and cultivated species from Cornell. Moreover, resistance was confirmed in 42 clones from Holland by a nematode multiplication rate of one to two compared with ten in the check.

Seven of 25 advanced clones selected in a replicated yield trial possess combined resistance to pathotypes P_4A and P_5A of *G. pallida* (Table VI-4). Greenhouse resistance to P_5A pathotype correlated well with root examinations in the field.

Table VI-2. Multiplication rate of two pathotypes of *Globodera pallida* on selected resistant clones inoculated with field and self-clone multiplied populations.

Clones	Multiplication rate		
	P_5A (Otuzco)		P_4A (Huancayo)
	Field	Self	Field
AM-72-6368	1.86	1.61	0.30
AM-73-259	0.21	4.60	0.19
AM-73-508	1.40	3.83	0.35
AM-73-605	8.09	3.48	0.16

Table VI-3. Resistance to P_4A and P_5A pathotypes of *Globodera pallida* in wild species.

Species	Accession number	Resistance*	Origin
S. bulbocastanum (2x)	PI 243345	4	Mexico
S. capcisibaccatum (2x)	WRF 1730	4 - 5	Bolivia
S. cordiophyllum (2x)	PI 255219	4	Mexico
S. gourlayi (4x)	OKA 3802	4	Argentina
S. lignicaule (2x)	HHC 5113	4 - 5	Peru
S. megistacrolobum (2x)	OKA 3775	4 - 5	Argentina
S. megistacrolobum (2x)	OKA 5526	4	Argentina
S. oplocense (6x)	OKA 4498	4	Argentina
S. papita (4x)	PI 283102	4	Mexico
S. sparsipilum (2x)	HHC 4476	4 - 5	Bolivia
S. stenophyllidium (2x)	PI 25530	4	Mexico
S. stenophyllidium (2x)	PI 25529	4	Mexico
S. vernei (2x)	OKA 4366	4 - 5	Argentina

* $P_4A = 4$; $P_5A = 5$.

Table VI-4. Field performance of selected clones possessing double resistance to *G. pallida* pathotypes (P_4A and P_5A).

Clone number	Yield (kg/hill)	Tuber shape (Scale)*
275131.22	1.500	4
276008.16	1.500	2
278072.10	1.200	4
278106.1	1.500	3
278111.18	2.300	3
278111.6	1.200	3
278108.3	1.400	4

* 1 = least uniform; 5 = very uniform.

However, highly resistant clones tended to yield less than local checks. Results of a test in Ecuador with CIP material sent as tuber families showed that CIP tester population P_4A is appropiate for selecting resistance in Ecuador, since 96 clones tested in both stations agreed in resistance ratings.

Tuber yield of potato varieties grown in an infested field was correlated to total root weight during the growing season (Figure VI-1). This behavior seems to be related to the ability of *S. tuberosum* subsp. *andigena* hybrids to develop and maintain an abundant root system which allows the plants to overcome the damage caused by the nematode invasion and multiplication. Field experiments indicate that some resistant clones also possess a certain degree of tolerance to *G. pallida*.

Potato cyst nematode was reported for the first time in Guatemala and identification of cyst nematodes from Central America is being done. A new non-cyst forming nematode attacking potato and other andean crops has been identified as *Thecavermiculatos andinus* n.p. Females of this nematode are similar in appearance to those of *Globodera* species and can be confused with the latter when observed in the field.

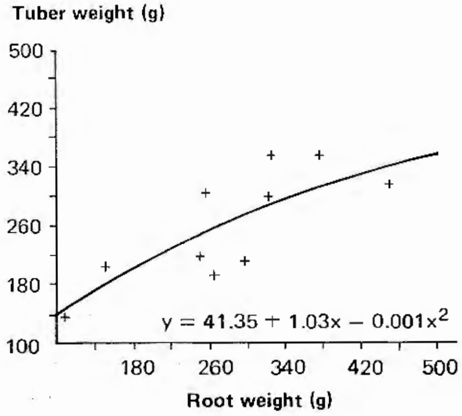
Root-Knot Nematodes

Only two clones (H/J244 and H/J635) showed moderate resistance to *M. incognita* out of 67 clones of the germ plasm collection previously considered as resistant. Clones were previously tested under field conditions hence their escape from nematode infections.

A total of 123 immune and 61 highly resistant clones from six families of the crosses of the 5th cycle of recurrent selections were selected for resistance to *M. incognita*. These clones are being increased for field evaluation and use in the breeding program.

Progenies of the crosses between a previously selected *M. incognita*-immune *S. andigena* clone 237A as a pollen source and a population of highly developed bacterial wilt resistant clone were tested for resistance to *M. incognita*. All offspring were susceptible indicating the possible cytoplasmic effect in inheritance of resistance to this nematode. In a similar test, progenies of 17 families developed from the crosses between selected clones

Figure VI-1. Quadratic correlation (r=0.82) between yield and root development of potato cultivars grown in a potato cyst nematode (*G. pallida*)-infested field.



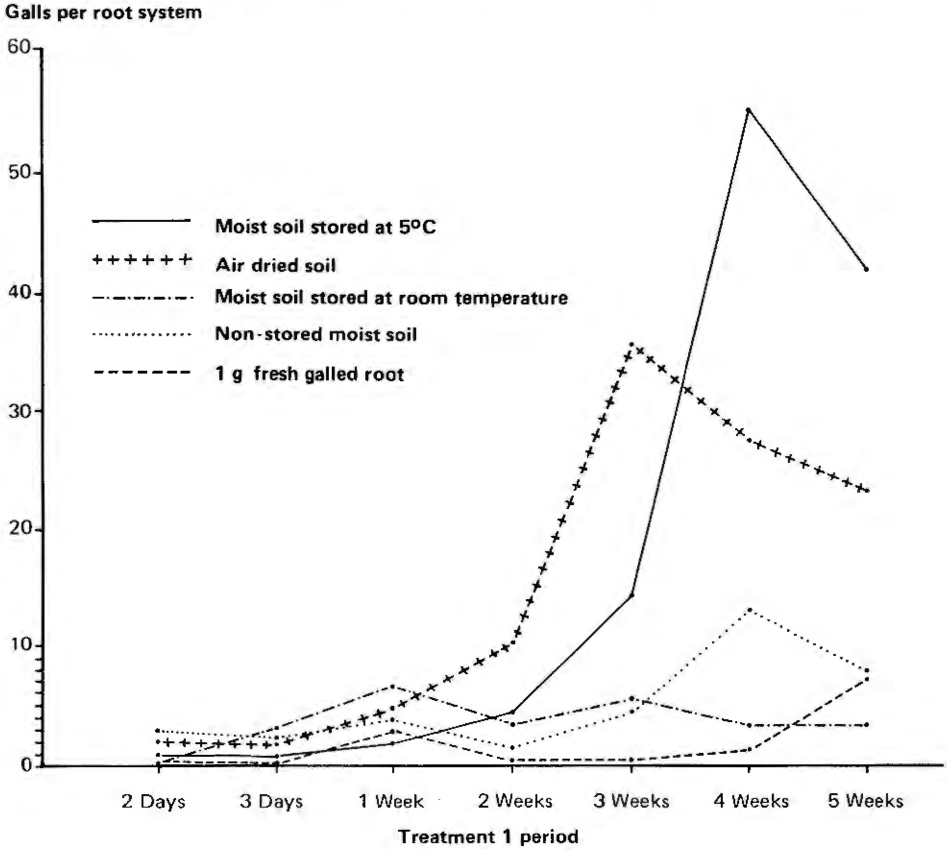
of the 3rd to 5th cycle of recurrent selections and a population of bacterial wilt resistant clones, were evaluated for resistance to *M. incognita*. A total of 27 immune and 23 highly resistant clones were selected for additional tests.

False Root-Knot Nematodes

In developing an efficient screening method eggs and larvae were discarded as inoculum because of difficulties in obtaining large numbers. Results with chopped galled roots were unreliable. Variations in the infection rate were noted in different treatments when using infested soil stored at 5°C, dry infested soil or non-stored infested soil (Figure VI-2). There were no significant differences in the number of galls per roots in plants inoculated with 50 cm^3 or 100 cm^3 infested soil. Results suggest that a cold treatment or drying period of soil will stimulate the activity of *Nacobbus aberrans*, increasing infection.

Although there was no significant difference in the root galling index between transplanted seedlings and the plants originating from tubers, the use of seed tubers is preferred when screening for resistance. Direct seeding of TPS in infested soil is not recommended for screening purposes.

Figure VI-2. Effect of various treatments on infection rate of *Nacobbus aberrans*.



Biological Control

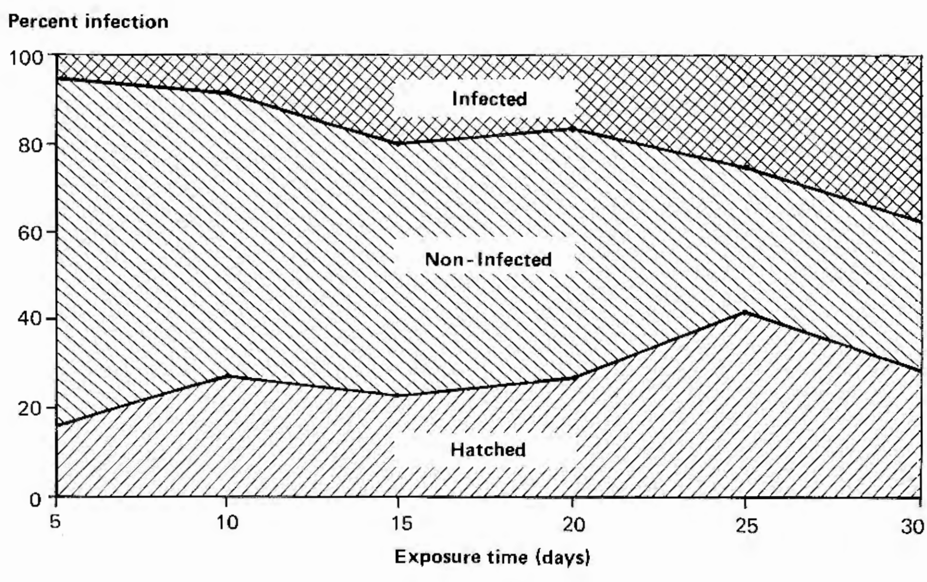
Trials of the use of *Paecilomyces lilacinus* for controlling *M. incognita* were continued in farmers' fields in several coastal locations in Peru. Treatments were: (1) no treatment, (2) fungus treatment and (3) Temik application 10 percent granular formulation at 25 kg/ha. Temik and fungus were applied at planting. Fungal inoculum was prepared by growing it on sterilized wheat and applying at the rate of 1.5 kg infected grains per 400 m^2. The fungus consistently reduced the tuber and root galling caused by *M. incognita* when compared to control and Temik-applied plots.

In other field experiments on coastal desert, the incidence of tuber and root galling caused by *M. incognita* was significantly reduced in fungus-treated plots after three crops. Additionally the fungus spread rapidly within the field, infesting adjacent control plots, a characteristic of a successful and competitive biological control agent. In the original field where this fungus was isolated, after 3 years of consecutive cropping of *M. incognita*-susceptible hosts, no nematode could be found infecting the root systems. The continued presence of fungus in the field was confirmed by its isolation from the soil.

In an experiment at La Molina, Temik (10 percent g at 25 kg/ha) and Temik plus fungus combined with rotation reduced nematodes and increased tuber quality in fungus and fungus plus Temik plots. Yield of corn, a rotation crop, in fungus and fungus plus Temik-treated plots was double that in control plots. Yield in fungus-treated plots was higher than the plots treated only with Temik.

Effect of *P. lilacinus* on multiplication rate of *G. pallida* under laboratory conditions show a correlation of infection rate with that of exposure period (Figure VI-3). There was a stimulation of hatching up to 25 days of exposure after which the reduction in hatching rate was correlated with egg infection.

Figure VI-3. Infection of *Globodera pallida* eggs by *Paecilomyces lilacinus*. Effects on hatching.



ENTOMOLOGY

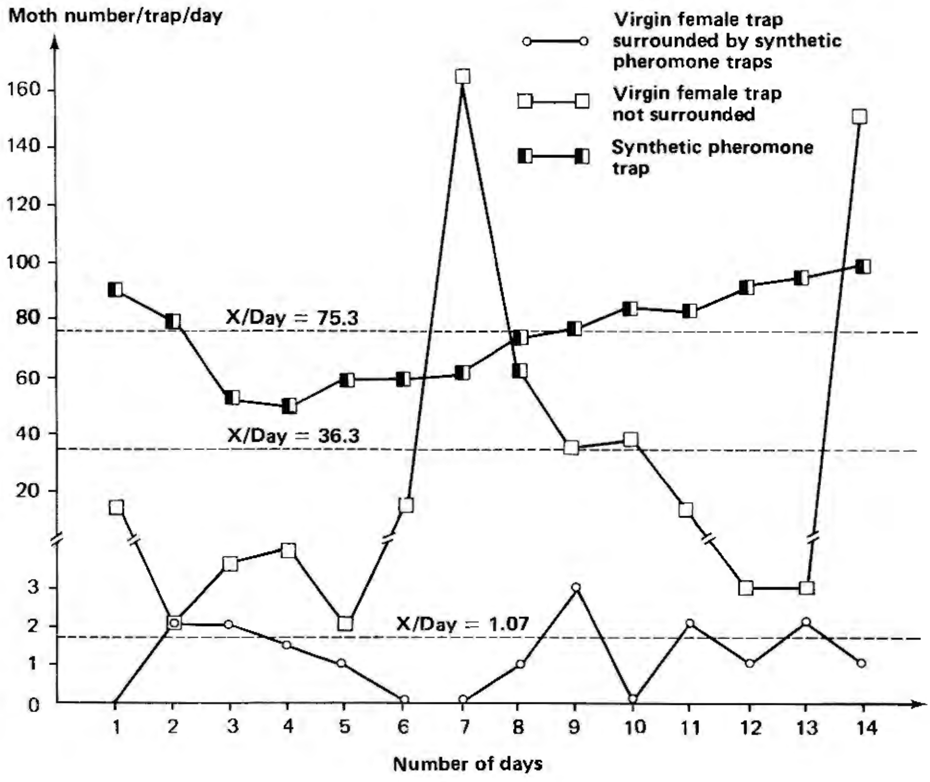
Potato Tuber Moth (PTM)

A useful screening method has been developed using natural populations of tuber moth, *Phthorimaea operculella*, which occur in storages. This eliminates time consuming laboratory screening which depends on an adequate supply of insects. The storage screening method was used in testing 2,000 potato clones for resistance from CIP's World Germ Plasm Collection. Several clones have been identified for further tests.

Resistance in diploid clones from an interspecific hybrid population (*S. chacoense*, *S. phureja* and *S. sparsipilum*) was transferred into the 4x level through 2x - 4x crosses. Tetraploids CFL69.1, R268, 377019.5, BR63.75, BR63.74, Atzimba and P2C6 adapted to lowland tropics but susceptible to PTM were used in the crossing program. A third of the hybrid tetraploid progeny were resistant under laboratory conditions. Of these, 49 highly resistant and 143 moderately resistant hybrids field evaluated in Lima had significantly lower tuber damage. Inheritance pattern and the relative high transmission rate of resistance to the 4x level from 2x level, in addition to recent discovery of new sources of resistance in diploid and tetraploid cultivated germ plasm, suggest that breeding for resistance to this pest should not be difficult.

A range of glycoalkaloid concentrations as found in potatoes grown under different environments were

Figure VI-4. Mass trapping of potato tuber moth using pheromones.



tested. Pure extracts of 35 percent Solanine and 64 percent Chaconine at 5, 10, 50, and 250 mg/100 ml of water had no effect on oviposition.

Pheromones

Synthetic pheromones placed in eight traps (one trap per 70 square meters) reduced the catch of male tuber moths in surrounded water pan traps baited with virgin females by 97 percent (Figure VI-4). Trap density of one to each 100 square meters indicated that tuber damage to clone DTO-33 could be reduced by 34 percent with the aid of pheromones. In small storage units, 90 percent of all males could be captured within 4 days after emergence. Damage to tubers was reduced by more than 50 percent using pheromone traps.

Other Pests

Andean Weevil. Thirty-eight clones were field evaluated for resistance to *Premnotrypes suturicallus.* Clones 375568.11, 375608.6 and 375608.7 selected in earlier trials again had tuber damage of less than 10 percent.

Leaf miner Fly. A total of 177 wild species clones grown in La Molina were field evaluated for resistance to damage by *Liriomyza huidobrensis*. Five clones OCH 11613, 11325, 11901, 12026 and 13267 had less than 5 percent foliar mining damage. These wild species can serve as parents for studies on inheritance of resistance to this pest. Leaf miner fly parasites identified included *Diglyphus* sp., *Chrysocharis* sp. (Eulophidae) and *Halticoptera* sp. (Pteromalidae).

Mites. Yield and resistance of tropically adapted clones and tetraploid hybrids developed for resistance to PTM were field evaluated for resistance to *Polyhagotarsonemus latus*. Clone LT-1 had significantly lower mite damage and infestation (Table VI-5). Of the PTM resistant hybrids, F_1 progeny of 120-13 x

Damage in the field by potato tuber moth.

CFL69. 1-3, 120-13 x 377019.5-3 and 702860 x 116-36 had significantly lower numbers of mites and eggs on terminal shoots.

Glandular trichomes. Selections were studied for trichome density and resistance to the green peach aphid, *Myzus persicae*. Clones selected averaged 4.2 four-lobed glandular trichomes/mm^2 and 6.8 simple trichomes/mm^2. These clones when field evaluated were highly resistant to aphids with most clones indicating less than five aphids per plant. These clones are being used as parents to transfer these useful genes to cultivated tetraploid clones.

Table VI-5. Yield and resistance of tropically-adapted potato clones to mites, La Molina, November-February 1981.

Clones	$\bar{X}$ Adult mites on terminal shoots/plant	$\bar{X}$ % Foliar mite damage/plant
LT-4	16.6	98.3
Desiree	32.8	90.8
DTO-33	21.6	87.5
Rosita	10.9	33.7
CEX 69.1	18.2	100.0
LT-1	8.0	14.2
LSD 0.05	13.6	32.2
0.01	18.6	44.1

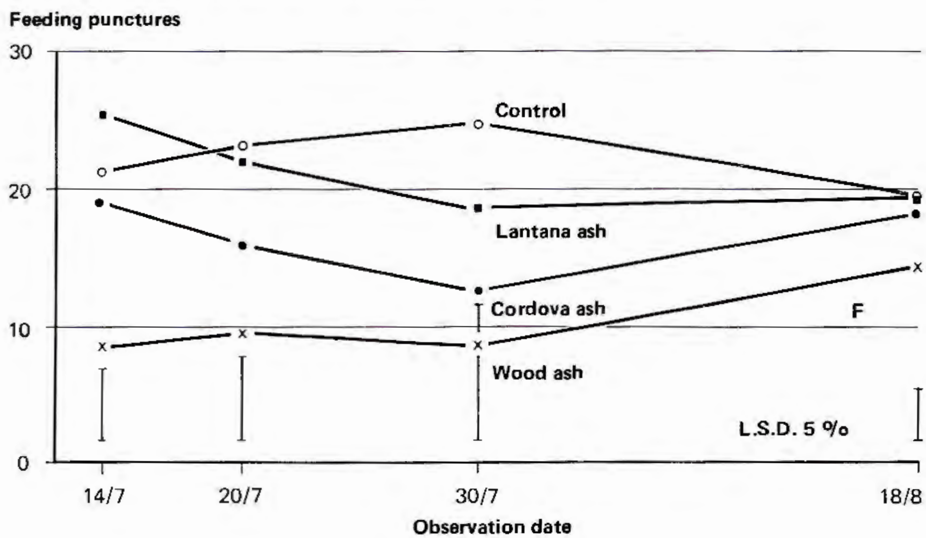
PEST MANAGEMENT

Research on pest management focused on identifying components with prospects of being incorporated into acceptable integrated control packages.

Soil Treatment to Control PTM

Impeding movement of PTM larvae down to developing tubers would be an effective measure to reduce damage. Application of repellant and/or toxic materials at the time of hilling up is one method. Out of five materials tested, Carbaryl dust, *Lantana camara* and muña (*Minostachys* sp.), both used as dried, chopped plants significantly reduced percent tuber damage in La Molina. The same materials were not as effective under higher temperature conditions at San Ramon.

Figure VI-5. Number of leafminer (*Liriomyza huidobrensis*) feeding punctures per 15 leaves treated with ashes. La Molina, 1981.



Control By Ash Dusting

Organic ash is regarded by many backyard crop growers a useful control against several pests. Out of three ashes tested (including Cordova ash used by crop growers of Huancavelica, Peru), wood ash was found superior in reducing the number of feeding punctures of leafminer fly, *Liriomyza huidobrensis*, as well as the number of adults. (Figure VI-5).

Bacterial Wilt Control

In Yurimaguas bacterial wilt was consistently reduced on plots where weed control was primarily through mulching rather than by manual weeding. It is hypothesized that the superior vigor of the plants in the mulched plots, along with the relatively undisturbed root rhizosphere helped in reducing incidence of the disease.

CONTRACT RESEARCH

Experiments at Oregon Agricultural Experiment Station, Corvallis, are to identify effective treatments to eradicate root-knot nematodes from infected seed tubers. Two chemicals provided protection for subsequent tuber generation or as an eradicant of *Meloidogyne hapla* and *M. chitwoodi* in infected seed pieces: Oxamyl at 3 percent, 6 percent and 12 percent; and, Phenamiphos at 0.5 percent, 1.5 percent, 2.5 percent and 3.5 percent. The chemical treatment involved 10 minutes soaking, 10 replications per treatment. Oxamyl, Phenamiphos and Thionazin have been identified as field candidates to evaluate protection of developing tubers from nematode invasion during the growing season.

The Foundation for Agricultural Plant Breeding (SVP) in Wageningen, The Netherlands, continued contract breeding research for resistance to *Globodera rostochiensis* and *G. pallida*, the potato cyst nematodes. Under ideal field growing conditions during 1981, 90 3- and 4-year-old "seedlings" were tested against Ro-1, Ro-5, Pa-2 and Pa-3. About 20 percent were resistant to all pathotypes. A spectrum of wild species from the Dutch-German potato expedition to Bolivia were tested for resistance to the Pa-3 pathotype of *G. pallida* and resistance was found in 13 species. In other research, two of 14 Pa-3-resistant breeding clones were resistant to 27 different sources of the Pa-3 pathotype.

Through "breeding" of mono-cyst-cultures sources of pathotypes have been purified to give clear cut resistance reactions on host differentials. It is hoped thereby to improve definitive resistance testing of breeding clones and potato varieties.

Tolerance to cyst nematodes differences in growth of plants from true seed on heavily infested soil was studied. Within seedling populations there were large differences in root and shoot growth when grown on *G. pallida*-infested soil. Seedlings from a cross involving Ehud x AM 71-1280 grew vigorously; some AM 71-1280 seedlings apparently reduced cyst formation.

Research at Cornell University on resistance to root-knot nematodes investigated the reliability of morphological characters and host differential plants in taxonomic identification and the relation of morphology and parasitism using two populations of *Meloidogyne*. Data support the synonymy of *M. incognita acrita* and *M. incognita*. A scheme for the identification of races of *M. incognita* is proposed (Table VI-6).

Temperature had a dramatic effect on resistance to *M. incognita*. Of three clones of *S. sparsipilum* x (*S. phureja* x *S. tuberosum* spp. *tuberosum*) the resistance of one of them (E2) was broken at 31°C and resistance of the other two clones (F2 and N4) broke down at 25°C. These data suggest the possibility of selecting for stable resistance at high temperatures.

Preliminary studies of inheritance of resistance to *M. incognita*, *M. javanica* and *M. arenaria* some maternal effect appears in the inheritance of resistance to *M. arenaria*. Resistance to each of the three species of root-knot nematode is controlled by more than two dominant genes. The resistance to *M. incognita* is controlled by more genes than for *M. javanica* but less than for *M. arenaria*. Six new tetraploids produced from crosses between diploids A442-17 and A442-4 (Sps x (phu x S. tubr)) and a neo-tuberosum population resistant to bacterial wilt, late blight, PVX and PVY showed high resistance to the three species of root-knot nematodes and to bacterial wilt.

Progeny from CIP tuber families that had segregated 70 percent or more against a Peruvian population

Table VI-6. Proposed race scheme for *Meloidogyne incognita* on potatoes.

Differential host	Number of diff.	Races*	
		1	2
S. tubr spp. *tubr* or *andigena*	0	+	+
S. sparsipilum x (*S. phureja* x *S. tubr.* spp. *tubr*) F2	1	–	+
S. spar x (*S. phu* x *S. tubr.* spp. *tubr*) E2	2	–	–

* + = Pf/Pi > 1; – = Pf/Pi 1 or < 1 where Pf = final Population and Pi = initial Population.

of root-knot nematode, *Meloidogyne incognita*, were evaluated for resistance to the major species of *Meloidogyne* at North Carolina State University, Raleigh. Nematode populations from various world regions were used in the study. A total of 389 seedlings from eight CIP families were examined individually for resistance to eight nematode populations. Percent segregation of acceptable resistance within individual CIP families varied from 38 percent to 100 percent. In CIP family No. 378924 the percent segregation for resistance ranged from 80 percent to 100 percent resistant against four races of *M. incognita*, 81 percent and 86 percent resistant to two races of *M. arenaria*, 90 percent resistant to *M. javanica* and 70 percent were resistant to *M. hapla*; 43 percent of the seedlings in the family had a combined resistance to the eight nematode populations. In general seedlings tended to be more susceptible to *M. hapla* (Table VI-7).

In addition to documenting types and densities of glandular trichomes (hairs) in 53 accessions of *S. berthaultii* x *S. tarijense* and *S. berthaultii* x *S. tarijense* hybrids, 11 additional glandular pubescent species of *Solanum* have been identified at Cornell University. In studies of biological activity of glandular trichomes, green peach aphid mortality and immobilization due to encasement of tarsi and labia by trichome exudate increased with the rise in 4-lobed glandular Type A trichomes and volume of Type A exudate on *S. berthaultii*. Simple trichomes type B exudate enhanced entrapment by accelerating discharge by type A exudate, particularly against immature aphids and leaf hoppers. Delay in probing and decrease in feeding activity by type B exudate may reduce the

Table VI-7. Percent segregation of high degree of resistance (no galls per plant) to several species and races of *Meloidogyne* in selected CIP breeding lines.

Families tested	*M. incognita* Races				*M. arenaria* Races		*M. javanica*	*M. hapla*	Combined* resistance
	1	2	3	4	1	2			
378857	61	83	86	89	83	42	41	30	0
378875	56	64	70	78	74	56	65	11	2
378908	63	62	57	60	76	34	80	41	3
378911	54	57	77	87	89	22	57	20	2
378916	31	44	36	58	49	36	56	32	0
378924	60	52	71	76	57	48	81	40	5
378930	45	60	47	55	45	62	71	18	2
378950	52	50	33	56	40	49	60	29	0

* Percent resistant to all species and races.

ability of *Myzus persicae* to transmit virus.

Solasonine and solamargine were the predominant foliar glycoalkaloids in assays of 15 accessions of *S. berthaultii*. However, glycoalkaloid content was not associated with magnitude of insect resistance; glandular trichomes appear to provide the major element of protection against aphids, leafhoppers and fleabeetles. Polyphenoloxidase and peroxidase activities along with phenolic substrates are involved in the dark brown product produced from clear trichome exudates which immobilizes insects and disrupts feeding.

Monitoring one type of potato tuber moth pheromone trap. The pheromone capsule is hanging from the funnel-like cover at the top of the trap opening.

Physiological and Agronomic Management of Potatoes

Potato yields under high temperature stress are increased by mulching and intercropping with maize or coconut. Intercropping improves soil water retention and lowers day soil temperatures. Scheduling potato planting so that maize matures after potato plants are established is advantageous. When intercropping, wider than normal row spacing is necessary in the intercrop.

Potato varieties tolerant to soils of high aluminum content have greater ability for utilizing phosphorus than intolerant varieties.

For production from TPS, adequate nutrition, especially phosphorus, stimulates vigorous seedling growth. Nitrogen as nitrate was superior to urea or ammonium possibly due to reduction of nitrification at high soil temperatures. Seedling establishment in the field under heat stress conditions was improved by mulching or transplanting TPS seedlings in the shade of maize.

Controlled cross pollinated progenies selected under different environments were superior to open pollinated or selfed progenies for seedling vigor, earliness, plant and tuber uniformity, and high marketable yields.

Potatoes from True Seed (TPS)

Transplanting potato seedlings from nursery to field is a convenient method of potato production from TPS, particularly under hot tropical conditions. Yields are comparable to production from potato tuber seed in a range of tropical environments.

When growing potatoes from transplants the production of vigorous seedlings in a short time at the nursery is of utmost importance (Figure VII-1). Fertility level of the seed-bed substrate and environmental conditions have a large influence. Well decomposed and fertile compost of bean crop residues, manure and leaf litter was used either alone or mixed with sand. Vigorous seedlings resulted 40 days after sowing with compost alone and without fertilizer. Addition of a slow release source of phosphorus, rock phosphate, did not affect the response (Table VII-1).

In experiments to determine needs for nutrients open pollinated

Figure VII-1. Vigorous potato seedlings 35 days after sowing TPS.

Table VII-1. Fresh weight of 100 seedlings, 40 days after sowing in different proportions of compost and sand.

Percent of		Fresh weight	
Compost	Sand	Without rock phosphate	With rock phosphate*
100	0	260.7 a**	238.6 a
50	50	144.3 b	175.2 b
25	75	100.7 b	90.2 c
0	100	7.5 c	5.9 d

* Rate of 0.3% ** Mean weights, P = 0.05 by Duncan's Test.

(op) seed of clone DTO-33 was sown at 5.0x2.0-cm spacing in seed beds with a substrate of a 1:1 mix (v:v) of shredded peat-moss and sand. This proportion has been the best for producing vigorous seedlings when adequatedly fertilized (Table VII-2) and is used as the standard mix. A fertilizer mix of

Table VII-2. Fresh weight of 100 seedlings 35 days after sowing in different proportions of peat moss and sand.

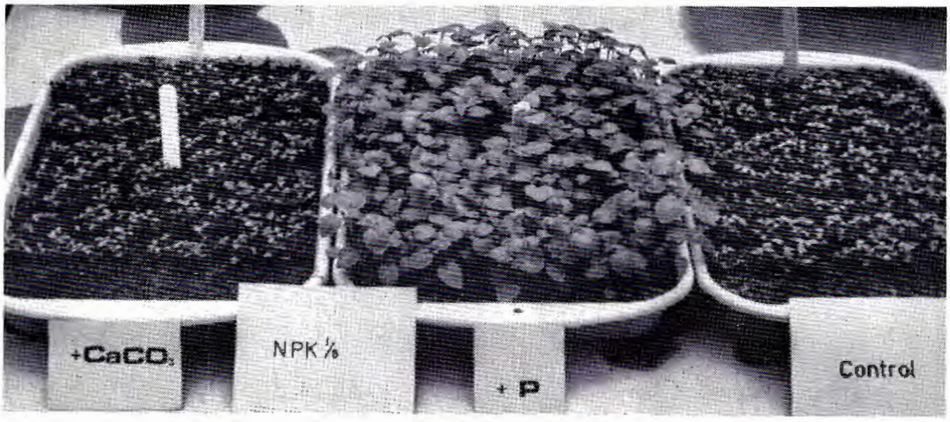
Percent of		Fresh weight
Peat moss	Sand	(g)
100	0	140.3 b*
75	25	196.8 a
50	50	204.5 a
25	75	162.8 b
0	100	35.5 c

* Mean weights, P = 0.05 by Duncan's Test.

N-P-K-Ca incorporated in the substrate (50-200-150-400 mg/kg, respectively) was the only one that produced vigorous seedlings in a fertilizer study. The importance of phosphorus was evident by the marked recovery of seedling growth when 400 ppm of P_2O_5 were incorporated in the substrate 25 days after sowing in the different solution treatments (Figure VII-2). Calcium added at a similar rate did not produce significant effects.

Needs were analyzed for NPK of potato seedlings grown either in shade (approximately 50 percent reduction of full sunlight) or under direct sunlight. Under both conditions increasing rates of P_2O_5 resulted in an increased growth response.

Figure VII-2. Effect of 400 ppm of P_2O_5 on seedling vigor, center tray.



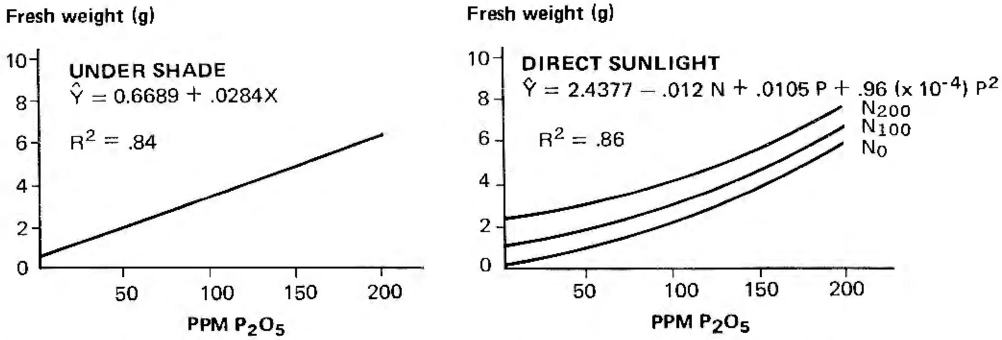


Figure VII-3. Effect of increasing rates of P_2O_5 on foliage fresh weight of 10 seedlings 30 days after sowing, grown under shade or exposed to direct sunlight.

Seedlings exposed to sunlight had a greater response to increasing rates of P_2O_5 when the rate of N was also increased (Figure VII-3). Potassium had no effect under either condition. The requirement for N was influenced both by growing the seedlings without shade and by length of seedling growing period.

Under Lima summer environment and experimental conditions, optimum level of P_2O_5 was between 300 and 400 ppm, as indicated by the total fresh weight of seedlings obtained 25 and 40 days after sowing (Figure VII-4) and to the better growth uniformity.

Figure VII-4. Effects of increasing rates of P_2O_5 on fresh weight of seedlings at 25 days and 40 days after sowing.

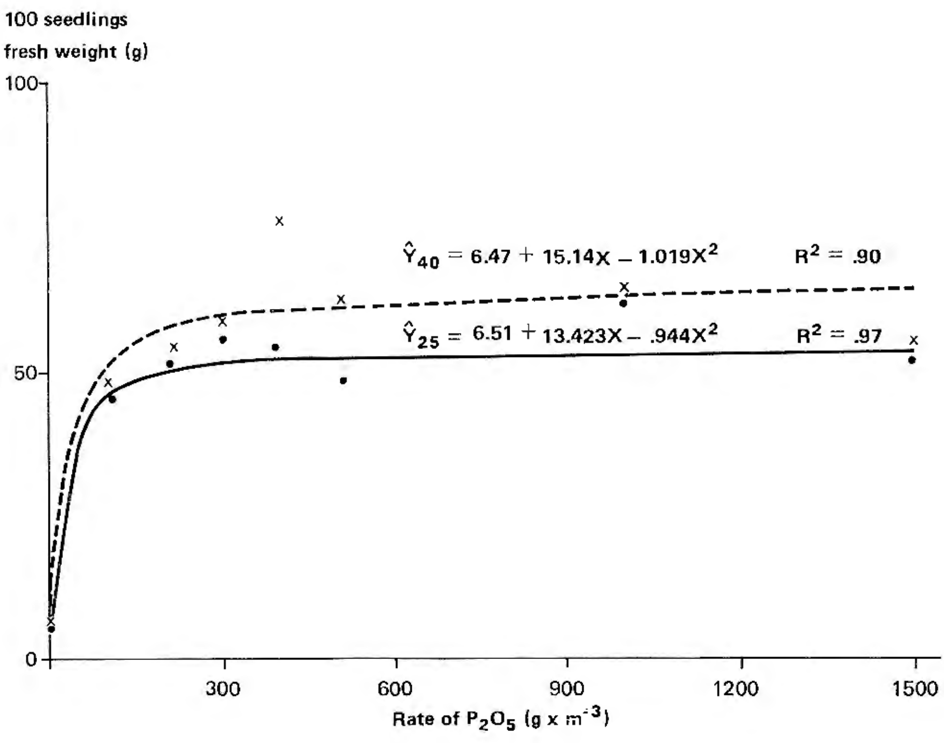


Table VII-3. Effect of different proportions of sodium nitrate and urea on fresh weight of leaves and roots of 100 seedlings 42 days after sowing. Lima (summer).

Nitrogen (ppm)		Fresh weight (g)	
$NaNO_3$	Urea	Leaves	Roots
100	0	95.5 a*	15.0 a
75	25	73.5 b	9.5 b
50	50	58.0 c	6.5 bc
25	75	43.5 cd	5.5 cd
0	100	35.5 d	2.0 d

* Mean weights, P = 0.05 by Duncan's Test.

Potato seedlings are sensitive to source of fertilizer. In one experiment a rate of 100 ppm of N was provided by different proportions of urea and sodium nitrate. A marked beneficial effect on seedling growth was obtained when increasing proportions of N were furnished in the nitrate form (Table VII-3). A similar effect occurred when nitrate forms of N produced significantly better seedlings than urea and ammonium N forms. A proper source of N is particularly important under hot environments where nitrification is usually affected.

Shading Experiments

Practices for improving seedling survival and establishment period under stress include: use of shade from other crops or protection of the soil surface with mulches.

Table VII-4. Seedling survival and yield during summer in Lima, as affected by different periods of shading after transplant.

Shade period	Survival (%)	Yield (g/hill)
7 days	95.0 a	272 a*
14 days	96.3 a	193 b
21 days	98.3 a	172 b
Control	81.7 b	309 a

* Mean yields, P = 0.05 by Duncan's Test.

Shading effect studies on seedling establishment and crop production during the hot summer in Lima used artificial shade for 7, 14 and 21 days after transplanting. Transmitted radiation at plant level was 47 percent. For 15 days after transplant, average soil temperatures (2 cm deep) at noon were 29.3°C in the shaded plots and 34.7°C in control plots.

High soil temperatures in control plots resulted in a significantly lower survival of seedlings. Except for the shorter shading period of 7 days, the longer periods of shading after transplant caused considerable yield reduction (Table VII-4).

Figure VII-5. Potato seedlings one week after transplanting between rows of maize.

Associated crops to provide adequate shade during the establishment period of seedlings in the field were studied under most stress conditions of the summer season in Lima and during the hot rainy season in San Ramon (Figure VII-5). In both locations one or two rows of potato seedlings were transplanted between rows of 65- to 75-day-old maize and soybean in Lima, or maize and crotolaria in San Ramon. The associated crops were not harvested until potatoes matured. Rows were 1 meter apart and oriented perpendicular to the sun direction. Seedling survival was significantly improved by any of the protective conditions provided by either maize or crotolaria plants in San Ramon where stress was extremely high. In the Lima experiment, two additional treatments were added by removing the maize plants 30 days after potato transplanting. Seedling survival was improved only by the maize-potato association where a larger proportion of radiation was intercepted (Table VII-5). Yield from the different treatments suggest that under Lima summer conditions potato yields would not be affected if the radiation reduction caused by an associated crop is less than 15 percent during the whole growing period and up to 30 percent in the case of relay crops if shading was maintained for not longer than 30 days. In treatments where maize was not cut absolute yield was reduced and tubers were also small. When maize was cut 30 days after transplanting, average size of tubers did not differ from the control.

The effect of soil mulches in hot climates are mainly related to reduction of soil temperatures and better maintenance of soil moisture. Under high temperature and rainfall conditions in San Ramon, a straw mulch produced a significant increase in yield when compared to other soil covers and to unprotected surface.

In Lima, the effect of different soil covers on soil temperature, yields and irrigation needs of the potato were studied. The covers placed on the ridges after seedling transplant included: clear, white and black polyethylene sheets, straw mulch, powdered gypsum on hills and uncovered control.

Irrigation was provided according to tensiometer readings. Soil temperatures (5 cm) in a 24-hour period under different mulches are shown in Figure VII-6.

The highest soil temperatures resulted from using a clear polyethylene mulch. During the day the soil temperature was up to 5°C higher under clear polyethylene

Table VII-5. Transmitted radiation, soil temperature at noon (2 cm) and seedling survival under different crop associations. Lima (summer).

Treatment*	Transmitted radiation** (%)	Soil temperature (°C)	Seedling survival (%)
M-P-M	44.2	25.5	93.0 a***
M-P-P-M	67.0	26.0	85.2 b
S-P-S	75.5	28.5	77.7 c
S-P-P-S	85.3	29.0	72.5 c
Control	100.0	29.5	76.5 c

* M = maize; P = potato; S = soybean, indicate rows of each crop.

** Average of three readings during the day for 10 days after transplanting.

*** Mean yields, P = 0.05 by Duncan's Test.

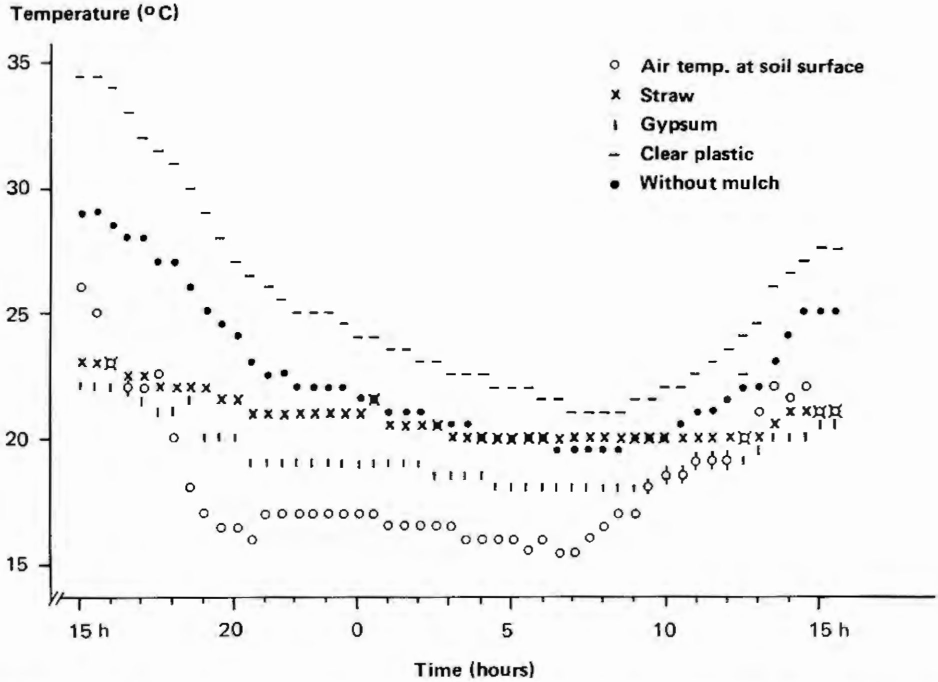


Figure VII-6. Soil temperature profile under different mulches (°C at 5 cm) at La Molina, recorded for 24 hours in November and 15 days after transplanting potatoes.

than the uncovered soil. Both straw mulch and gypsum cover produced a high reduction of soil temperature during the daytime, up to 6°C compared to the control. The straw mulch maintained a stable level of temperature throughout the day and near to the minimum night temperatures. Gypsum, because of its reflectivity resulted in the lowest maximum temperature values. At night, the soil covered by gypsum probably released heat easier than other treatments with solid covers, thus resulting in cooler values. The effect of the different treatments was reflected on the yield (Table VII-6).

In many tropical areas, weeds are a problem during TPS seedling establishment. Lima experiments indicate that selective herbicides such as Metobromuron should not be applied during the first 20 days after transplanting, while rapidly inactivated contact herbicides, such as Paraquat, can be applied up to 1 day before transplanting without affecting seedling survival. A combination of applications, using Paraquat 2 days before transplanting and Metobromuron 20 days after transplanting, has provided excellent weed control.

Table VII-6. Yield of potatoes from TPS under different soil covers. Lima (summer).

Treatment	Yield (t/ha)
Gypsum covering the ridges	24.9 a*
Straw mulch	22.5 a
White polyethylene	20.4 ab
Black polyethylene	17.1 b
Control (uncovered)	16.9 b
Clear polyethylene	16.2 b

* Mean yields, P = 0.05 by Duncan's Test .

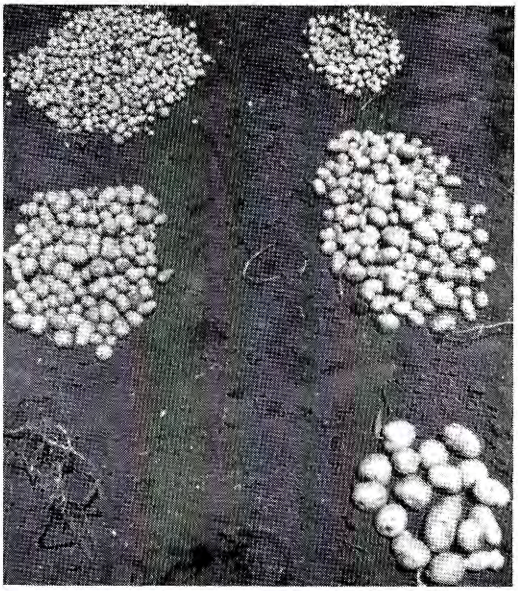
Figure VII-7. Progeny evaluation field at harvest in San Ramon.

Open-pollinated and controlled cross-pollinated progenies already selected for uniformity, were evaluated for adaptation and yield under different climatic conditions (Figure VII-7). Marketable yields above 35 t/ha were obtained with several progenies which more than doubled the control yields. Within the factors being considered for selecting progenies, especial attention has been given to growth uniformity at the seedling stage under hot environment, ability to recover rapidly after transplant, high yield and uniform tuber size. In general, wide variability is noted among progenies for these characters and marked improvement can be made by selection. In selecting for tuber size uniformity, a desirable characteristic in potato production from TPS, differences were observed (Figure VII-8). As an example of this variability, when the production of individual plants of a selected hybrid (377935.27 x 377964.5) and an open-pollinated progeny (DTO-33) were classified according to their average tuber weight, a marked improvement in the proportion of marketable size tubers was observed in the hybrid progeny (Figure VII-9).

Management for Tropics

Manipulation of soil temperature is important for successful production of potato from seed tubers under hot conditions. Traditional mulches improved yield in the high jungle site of San Ramon in both

Figure VII-8. Tuber size distribution in selected progenies.



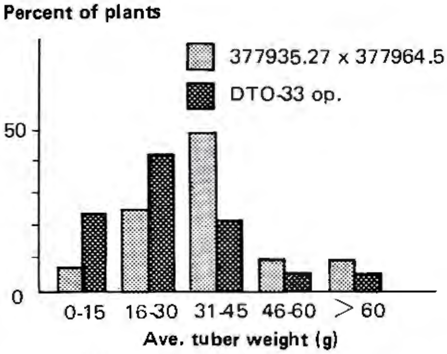


Figure VII-9. Proportion of plants in different average tuber weight categories.

the rainy and dry season, with or without irrigation (Table VII-7 and Table VII-8). The mulch effect is manifest through improved soil moisture as well as through lowering of daily maximum soil temperature. (The daily mean temperature did not vary between control and mulch plots).

Further evidence that reduction of day soil temperature rather than night soil temperature improves yield came from an experiment during the Lima summer season. Plots with or without a soil reflectant were covered at 3 p.m. to maintain a 2 to 3°C higher night soil temperature than the corresponding control. The extra two or three degrees at night did not reduce yield (Table VII-9); a cooler day and night significantly improved yield

Table VII-8. Effects of mulch and irrigation on mean yield, San Ramon, dry season, 1981.

	Yield (t/ha)	
	Control	Irrigated
Control	16.0	16.4
Mulch	21.5	22.3

LSD_5 between control and mulch 4.8.

in both clones, however, less so in the heat tolerant clone DTO-33.

Shade by companion crops is advantageous under hot conditions. Perennial crops (for example, coconut), reducing light transmission by approximately 25 percent throughout the potato growing cycle have

Table VII-9. Manipulation of soil environment for 2 months following planting and its influence on tuber yield, La Molina, 1981.

Day: Night	Yield (t/ha)	
	DTO 33	Desiree
Control	24.2	13.4
Soil reflectant	37.1	23.7
Transparent plastic	25.9	5.0
Control : Plastic	26.0	12.4
Reflectant: Plastic	37.1	27.8
Plastic : Control	26.0	12.4

SE difference between any two treatment means = 4.4.

Table VII-7. Yield of tubers following soil mulch treatment, San Ramon, rainy season, 1981.

	Yield (t/ha)				
	DTO 2	Desiree	6947.2	374080.5	Mean
Control	19.8	18.3	29.1	15.9	20.8
Mulch	16.8	23.8	33.6	22.8	24.3
Mulch effect %	–15	+30	+15	+43	

LSD_{10} between mulch and control means 3.2.

been succesful. Under such shade there is also an added yield advantage with closer row spacing especially for smaller statured clones. During the rainy season, however, the incidence of rotten tubers in shaded plots was increased relative to unshaded ones. Relay cropping of potatoes with maize — potato planted during the last month of maize growth when shade was decreasing with natural senescence — was better than the more coincident planting dates of potato and maize. The maize plots intercepted 30 to 50 percent of incident radiation during the first month of the potato crop, maintained a greater soil moisture content, reduced soil temperature during that period and improved emergence.

Aluminum Toxicity

Soils from different hot-humid tropical areas of Peru were used to evaluate different potato varieties and clones to high natural concentrations of aluminum. Differences in growth, vigor, tuberization and dry matter production of the potato plants and the ability to uptake, transport and accumulate nutrients when grown in soils containing four different levels of Al saturation were analyzed. Potato varieties such as Caxamarca, Cuzco, Mariva and Molinera and the clone B-71-240-2 showed tolerance to high Al concentration. Analysis made in plant tissues indicated that tolerant varieties have higher ability for using P under high Al concentration in the soil.

In Yurimaguas, with a soil pH of 4.2, CEC of 6.8 meq/100 g and 92 percent of Al saturation, the effect of two levels of lime and two levels of P supplied either as rock phosphate or triple superphosphate resulted in significant yield increases as a response to liming and P application. Rock phosphate showed adequate control of Al toxicity and as a good source of P.

Soils of low pH are frequent in the highlands of the tropical zone. In a farmer field near Huancayo, with a soil pH of 4.2 and low P availability, the effect of different rates of lime, P and K on potato yield was studied. The incorporation of 4 and 8 t/ha of lime to the soil increased yield 2.5 and 4 times, respectively, in relation to the control plots. The yield increase was larger at higher rates of P. No effect of K was obtained.

CONTRACT RESEARCH

Contract research at Cornell University, Ithaca, New York, also supports development of heat tolerant potatoes for the lowland tropics. Research primarily concerns a greenhouse screening procedure where selection for heat tolerance is based upon tuberization of cuttings under a 30°C night and up to 40°C day temperature, daylength 18 hours. The usefulness of this screening method has been confirmed in field trials in San Ramon, Peru, under heat stress conditions. Stem diameter, leaf length, leaf width and plant vigor were positively correlated with tuber yield accounting for 38 percent of yield variation in the field at San Ramon.

Growth chamber experiments are in progress to determine how closely heat tolerance is associated with long critical photoperiod.

Thrust VIII

Post-Harvest Technology and Management

Diffused light storage as compared to conventional seed tuber storage in the dark improves seed quality so that yields are increased approximately 18 percent. Diffused light storage has been successfully transferred to Regional and National Programs. Country training courses supported by UNDP funds have been successful in transfer of this technology and through the resultant "multiplier effect" diffused light stores are widely used in a number of third world countries.

Heat stress during the growing season adversely affects storage quality of tubers and increases loss in storage. CIPC, a well-known sprout inhibitor dust, in adobe stores of consumer potatoes in a tropical environment reduced storage losses from 22 percent to 8 percent.

Storage for Developing Countries

The 3 years of research station and on-farm trials on the effect of natural diffused light on storage behavior and subsequent field performance of seed tubers has been completed. The average results of all on-station trials at CIP/Huancayo for 24 cultivars are summarized in Table VIII-1. Although the 16 on-farm trials with eight cultivars during the same period are more variable because of differing farmer storage periods and conditions, they confirm on-station results in terms of both storage quality and field performance. Average yield increase from diffused light storage was 19.7 percent for on-farm trials compared with 17.1 percent for on-station trials.

Table VIII-1. Effect of natural diffused light on seed tubers. (CIP, Huancayo, 1978-81).

	Diffused light stored	Dark stored
A. Tuber condition after 6 months storage:		
Sprout length (cm)	1.8	21.7
Sprout number/tuber	3.4	1.4
Total storage loss (%)	9.9	20.3
B. Field performance		
Days to full emergence	30.6	38.1
Total yield (t/ha)	28.8	24.6

Traditionally, dark-stored seed tubers are desprouted prior to planting. Seed tuber samples stored in both natural diffused light and dark at ambient conditions in Huancayo were desprouted 20 days prior to planting and allowed to resprout in diffused light conditions. Other samples of dark-stored tubers were desprouted at planting time while samples of light-stored tubers were not desprouted. Results, Table VIII-2, show desprouting increased sprout number per tuber from an average of 3.1 to 4.9 in light-stored tubers and from 2.0 to 4.8 in dark-stored tubers. Desprouting slightly increased total storage losses (7.8 percent to 9.3 percent) in light-stored tubers but reduced

the much higher loss in dark-stored tubers (19.6 percent to 14.2 percent). Early desprouting improved field emergence in dark-stored tubers but had little effect on light-stored tubers. In all treatments both emergence and final yields were higher from light- than from dark-stored tubers. In light-stored seed, desprouting followed by presprouting in light had little effect on yield whereas yield was increased from an average of 41.4 Tm/ha to 48.6 Tm/ha in dark-stored tubers. Results suggest that under Huancayo conditions dark-stored seed, desprouted and subsequently resprouted in diffused light, can yield similarly to seed stored continuously in diffused light.

Shoot and root growth of light- and dark-stored tubers were compared. Dark-stored tubers were desprouted 20 days prior to planting and resprouted in the dark so that at planting time sprout development was similar in both light and dark storage treatments. Following planting, no significant difference was noted in number of stems from seed tubers stored in diffused light (2.5) or from desprouted dark-stored tubers (2.7) using nine cultivars. However, diffused light-stored tubers produced, after planting, significantly more root weight per shoot (214 mg) than dark-stored tubers (129 mg). This better root development contributed to observed fast emergence and rapid initial foliage development of light-stored seed tubers.

During the storage of seed tubers in diffused light, natural infestations of *Myzus persicae* increased faster in San Ramon resulting in higher numbers per sprouted eye than at Huancayo. Following artificial infestation, in separate experiments at San Ramon and Huancayo, aphid numbers increased at similar rate in the light and dark. After 4 months storage in Huancayo significantly more winged aphids developed on tubers held in the dark than in diffused light.

To determine virus spread during storage, uniform samples of tubers were stored in both light and dark conditions together with tubers originating from plants with severe virus symptoms. In each store half the tubers were sprayed every 15 days with the insecticide Monitor to control aphids. After 5.5 months

Table VIII-2. Effect of desprouting on storage and subsequent performance of light- and dark-stored seed tubers.

	Storage	Desprouted and resprouted	Not resprouted
N° sprouts/tuber at planting	light	4.9	3.1
	dark	4.8	2.0
Sprout length, planting (cm)	light	.8	1.6
	dark	.6	20.0
Storage weight loss (%)	light	9.3	7.8
	dark	14.2	19.6
Emergence after 60 days (%)	light	97.1	97.1
	dark	90.2	79.0
Yield (t/ha)	light	51.0	51.3
	dark	48.6	41.4

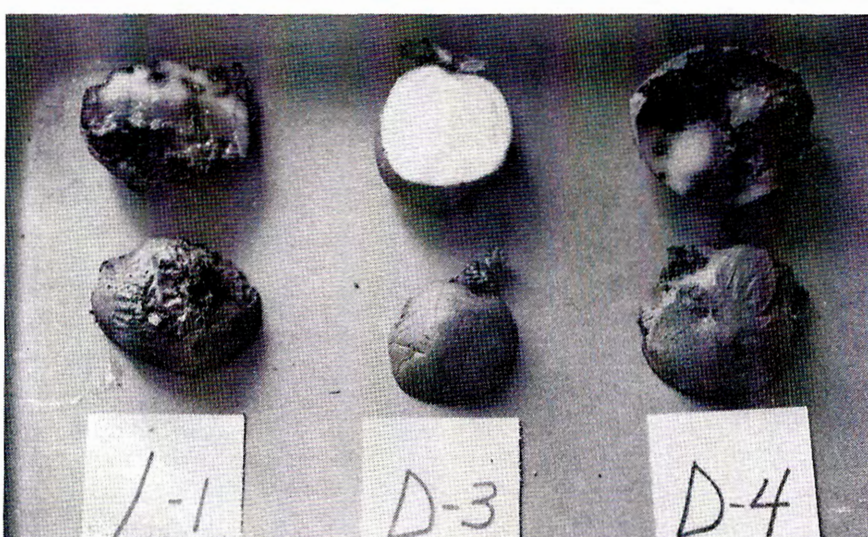
Table VIII-3. Effect of storage treatments on spread of aphid-transmitted virus.

Treatments	Aphids per sprouted eye at planting %	Healthy plants in the field %
Light-stored, insecticide	0	72.5
Light-stored, no insecticide	13.6	3.2
Dark-stored, insecticide	0	78.6
Dark-stored, no insecticide	12.1	11.6

storage the tubers were planted and severe aphid-transmitted virus symptoms recorded in the field 7 to 8 weeks later. The results (Table VIII-3) show extensive build-up of virus symptoms following either light or dark storage without regular aphid control.

Preliminary observations at San Ramon showed noticeably more potato tuber moth damage in tubers stored in diffused light than in the dark. This difference was attributed to a barrier effect of the walls of the dark store and also surface wetting of tubers. This was verified in a dark store by surrounding seed trays with a barrier of burlap sacks. The percentage of tuber moth damaged tubers was reduced from 93 percent to 14.3 percent after 2 months storage. Light spraying of stored tubers with water three times a day reduced tuber infestation from 96 percent in unsprayed tubers stored in the light or dark to 45 percent and maintained 100 percent sprout viability for 2 months (Figure VIII-1).

Figure VIII-1. Effect of water sprays on potato tuber moth damage on seed tubers stored for 2 months at San Ramon. (Left to right): L-1 – untreated seed tuber stored in diffused light; D-3 – seed tuber lightly sprayed with water three times a day in a dark store; D-4 – untreated seed tuber stored in the dark.



Insecticides tested against potato tuber moth infestation in stores at San Ramon included Sumicidin dust (a synthetic pyrethroid), an experimental organophosphate spray (Rohm and Haas 0994) and Belmark. Under the experimental conditions the organophosphate was superior followed by Sumicidin.

During two years trials were undertaken to determine if storage in diffused light influences resistance to infection and disease spread following infection by *Erwinia* spp. Tubers of the cultivars Ticahuasi and Yungay were stored for 2 and 4 months either in darkness or diffused light. After each storage period 20 tubers per treatment were inoculated by injection with an isolate of *Erwinia carotovora* var. *carotovora*. The tubers were wrapped in wet paper towels and two layers of polyvinylchloride (Saran wrap) to exclude oxygen and incubated at 26°C. After 3 days the diameter of rot was measured. No real differences were noted in tuber susceptibility after 2 months storage but after 4 months all treatments were more resistant to infection.

Research on management and use of chemical sprout suppressants in simple naturally ventilated stores and clamps at Huancayo in all cases showed chloro-*iso*-propyl-carbamate (CIPC) consistently gave better results than Fusarex. Effectiveness of CIPC is slightly improved by restricting store ventilation for 15 days immediately after store loading and dust application of the chemical. Using CIPC dust, losses in a naturally ventilated 35-ton capacity adobe store were reduced from 22 percent to 8 percent following 6 months storage.

San Ramon-grown tubers were harvested under dry conditions and better storage quality tubers were obtained than in 1980. An average loss of 14.8 percent loss was recorded following 3 months storage. The moist charcoal-walled store (Figure VIII-2) reduced losses from 20 percent in the traditional

Figure VIII-2. Experimental dark potato store at San Ramon. The walls are constructed of charcoal supported between wire mesh. In half the store water is allowed to trickle through the charcoal.

store (Figure VIII-3) to 10 percent after 3 months. Also in 1981, Huancayo-produced tubers were simultaneously stored in Huancayo and San Ramon. Following 4 months storage, average total losses were 9 percent in Huancayo under cooler conditions and 18 percent in San Ramon.

Figure VIII-3. Experimental "traditional" farmers' store at San Ramon.

CONTRACT RESEARCH

A project on "Hidrólisis de Papa" at the University of Santiago, Chile, has resulted in the production of a nutritious beverage for infants from potato. The cream-colored powdered product which can be mixed with milk has the following amino acid content:

Table VIII-4. Comparison of amino acid content of potato hydrolysate with potato, milk and egg.

Amino acid	Milligrams amino acid per gram of nitrogen				
	Potato	Milk	Hydrolysate	Egg	R = hydrolysate / egg
Isolencine	260	407	361	428	0.84
Lencine	304	630	528	565	0.93
Lysine	326	496	443	396	1.12
Phenylalanine	285	311	303	368	0.82
Tyrosine	99	323	253	274	0.92
Methionine	87	154	133	196	0.68
Threonine	237	292	275	310	0.89
Tryptophane	72	90	84	106	0.79
Valine	339	440	408	460	0.89

Thrust IX

Seed Production Technology

Maximum germination of TPS occurring between 15° and 20° C, varies between progenies. No wild species were identified that had higher TPS heat tolerance for germination than the cultivated species presently used. True seed selected for heavier seed weight produced larger plants than did lighter weight seed. Toasted polished rice as a desiccant reduced moisture of true seed to a safe level for storage.

Potato cell suspension cultures were grown in a high salt medium in selection for salt tolerance. Potato plants will be propagated from such colonies and further evaluated. Plantlet clones with in vitro ability for continued protoplast division have been identified.

Plantlets regenerated from anther culture are frequently homozygous. Such plantlets from bacterial wilt and nematode resistant clones are being tested for homozygosity and disease resistance.

Potato spindle tuber viroid (PSTV)-free plants were obtained by culture of apical domes excised from infected plants, grown at low temperature.

Pathogen tested materials were distributed to 41 countries as: tubers and advanced clones, 8,632; in vitro plantlets, 312; tubers of TPS families, 52,162; and more than 64,000 TPS.

Tuber and True Seed Research

TRUE POTATO SEED (TPS)

Germination

Maximum seed germination occurs at temperatures between 15°C and 20°C and it is inhibited at higher temperatures. Seed germination of 10 open-pollinated progenies indicated the optimum temperature varied according to seed progeny and, therefore, it was difficult to designate a single temperature as optimal for seed germination of all progenies.

The effect of temperature on germination of 28 samples of wild tuber-bearing solanums did not show significant relation to the climatic conditions of the collection site. This suggests that temperature adaptation and germination response are not closely linked in these materials. The best germination of any of the 28 wild accessions at 30°C did not exceed that found previously in cultivated species. This suggests that efforts to improve seed germination at high temperatures through breeding should begin with cultivated species having this characteristic.

The effect of constant temperatures on seed germination was compared to daily fluctuating temperatures similar to those under field conditions. Seed from open-pollinated plants of DTO-33 and Renacimiento were germinated

under regimes of 1, 2, 4, 8, 16 and 24 hours at 30°C with the balance at 24 hours at 15°C. Average differences between germination under constant and fluctuating temperatures were small enough (3 percent to 8 percent) to justify the use of constant temperatures in laboratory studies.

Studies on the effect of temperatures during fruit ripening after harvest showed that temperatures during ripening have a strong effect on degree of seed dormancy (Figure IX-1). Seed from three clones had a high degree of dormancy when obtained from fruits ripened at low temperature (15°C for 31 days). However, temperature during ripening had no effect on germination of seed treated with gibberellic acid to break dormancy.

Seed of DTO-33 separated into two weight categories did not reveal weight effects on germination or emergence, but an effect was noted on plant size at 33 days (Table IX-1). Whether or not such a plant size difference justifies seed separation by weight is under investigation.

Table IX-1. Effect of seed weight on seed quality.

	Heavy	Light	$L.S.D._{05}$
Seed wt. (mg)	.564	.432	
Germination, petri dishes (% at 12 days)	99.0	97.5	3.0
Emergence, trays (% at 12 days)	99.1	98.4	3.0
No. leaves/plant (33 days)	5.6	4.9	0.4

Three categories of embryo morphology were used to evaluate the effect of embryo shape on seed germination and seedling vigor:

(1) Spiral or U-shape,
(2) Straight or slightly curved,
(3) Aberrant or absent.

Germination with normal and irregular embryos was not significantly different but germination of seed from aberrant category was severely reduced (Table IX-2).

Figure IX-1. Effect of temperature on dormancy during ripening of TPS.

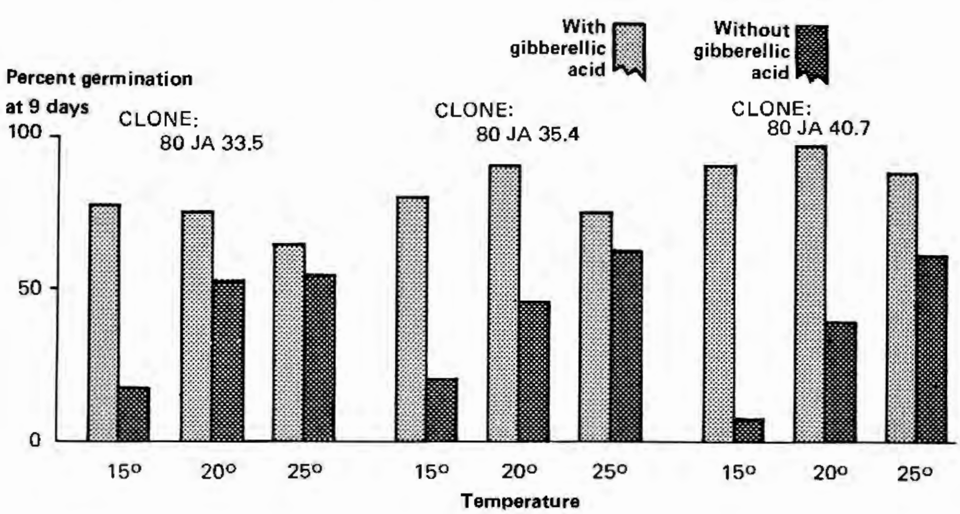


Table IX-2. Effect of embryo morphology on seed quality.

Treatment	Spiral	Straight	Aberrant	L.S.D.$_{.05}$
DTO-33				
Germination, petri dishes (% at 13 days)	97	87	65	14
Emergence, flats (% at 12 days)	84	58	23	18
Leaves/plant (33 days)	6.28	5.96	na	ns

Visual separation of seed by size and embryo morphology is impractical for large quantities. An attempt was made to separate seed by specific gravity after the onset of germination. Seed of DTO-33 allowed to germinate for 4 days was separated into two groups according to whether they floated or sank in a 22.5 percent sucrose solution. The seed was washed and sown in flats. After 21 days there were no significant differences in emergence, stem length or number of leaves between the two seed groups.

Effect of seed origin on dormancy and germination showed Huancayo-grown material had stronger dormancy and greater sensitivity to high temperatures during germination and at the same time had a much higher individual seed weight than seed from La Molina or San Ramon (Table IX-3).

A simple method for reducing TPS moisture content to the 4 percent to 5 percent safe level for storage consisted of toasting polished rice. The rice, with a moisture content below 1 percent, was effective as a desiccant for TPS during storage in sealed containers. To reduce the moisture content of about 20 g of TPS from 11 percent to about 4 percent, 20 to 40 g of toasted rice is needed, depending on the drying period desired.

Studies on possibility of inactivating potato spindle tuber viroid (PSTV) by elevated temperatures were terminated. Seeds infected with PSTV were dried to below 4 percent moisture content and then heated at temperatures above 100°C for 1 to 3 hours. Seedlings from the heated seed were assayed for the viroid. PSTV was neither depressed nor eliminated from infected seed following any of the heat treatments.

Table IX-3. Germination of DTO-33 from three sites, at 15 days.

Site	Seed weight (mg)	20°C		30°C	
		+GA	–GA	+GA	–GA
Huancayo	0.70	97	80	2	1
La Molina	0.58	100	93	18	1
San Ramon	0.57	100	99	14	0
L.S.D.		ns	10.1	12.8	ns

Table IX-4. Effect of seedling population on tuber production in directly-sown nursery beds. Progeny: DTO-33 op.

Plants/m²	Surviving plants (%)	Number tubers square meter					Total tuber yield (kg/m²)
		<1 g	1-10 g	10-40 g	>40 g	>1 g	
50	64	74	219	119	16	354	4.5
100	41	133	261	134	17	412	4.8
275	17	375	467	153	10	630	5.9
LSD 0.05		53	42	ns	ns	85	1.0

Seed Tuber Production

Seed tuber production from TPS was studied in Lima in 1 m wide ground beds filled to a 25 cm depth with a 1:1 mixture of peat moss and sand. Seed tubers harvested from nursery beds were planted in the field as well as replanted in ground beds to evaluate yielding capacity and multiplication rate. Seed tuber health was also evaluated visually and by serological test for viruses.

The effect of the following factors on yields and its components are summarized:

Seed Population. The number of usable tubers (larger than 1 g) as well as the total tuber yield increased significantly with increased seedling population, mainly through an increase in tubers smaller than 10 g. Strong competition between plants resulted in decreased number of surviving plants, especially at high population densities. This may have eliminated the less vigorous seedlings which might represent weak biotypes (Table IX-4).

Planting Configuration and Hilling. Number of tubers larger than 1 g and tuber yield per square meter were not significantly affected by seedling spacing at high population density. Hilling increased significantly the number of tubers smaller than 10 g and decreased the number of tubers larger than 10 g.

Table IX-5. Effect of seedling spacing* and hilling** on tuber production in directly-sown nursery beds at high population density. Progeny: DTO-33 op.

	Number plants square meter at harvest	Number tubers square meter					Total tuber weight (kg/m²)
		<1 g	1-10 g	10-30 g	>30 g	Total >1 g	
Seedling spacing: 6x6 cm							
With hilling	93	308	752	78	1	831	4.3
Without hilling	95	240	519	95	6	620	4.1
MEAN	94	274	636	87	4	726	4.2
Seedling spacing: 10x3.6 cm							
With hilling	96	395	624	75	1	700	4.1
Without hilling	98	261	439	106	4	549	3.9
MEAN	97	328	532	91	3	625	4.0

* Not significant.

** Significant at 1% level for tuber number per square meter.

Table IX-6. Field performance of three grades of seed tubers (DTO-33 op) planted at a similar seed tuber weight rate.

Seed tuber grade g/tuber	Plant spacing (cm)	Seed tuber rate (kg/ha)	Number main stems square meter	Tuber weight (t/ha)				Weight multiplication rate for 18-55 mm tubers
				18-35 mm	35-55 mm	> 55 mm	Total	
1-5	7.5	503	14.4	3.9	12.2	3.7	19.8	32
5-10	15	481	11.1	2.3	12.8	4.8	19.9	31
10-20	30	483	8.2	1.5	10.5	5.8	17.8	25
LSD 0.05			1.2	.2	ns	ns	ns	

This suggests that tuber size can be increased by eliminating hilling (Table IX-5).

Multiplication Rate. Seed tubers derived from TPS were sorted by weight (g) into three grades: 1 to 5, 5 to 10 and 10 to 20. These were planted in the field at a comparable seed tuber rate. Results of field performance (Table IX-6) show that tubers from TPS weighing 1 to 20 g can be multiplied into seed stocks of acceptable tuber weight for the production of potatoes for consumption.

Effect of Seed Size on Yield. Yields of small and large size tubers from TPS and clonally produced tubers were not significantly different when equal sizes were compared. This suggests that the progeny of small and large tubers from TPS have similar production potential to similar size tubers derived through vegetative propagation from the same clone (Table IX-7).

Seed Tuber Health. Plants from tubers produced from TPS in ground beds were grown in the greenhouse for virus testing. Forty plants out of 150 showed visual virus-like symptoms; however, only eight assayed positive by serology. This means a total virus incidence of approximately 5 percent.

Visual virus symptoms on field grown plants from tubers from TPS had poor correlation with serological testing, especially with respect to viruses causing mosaic symptoms. Plants with PLRV could be identified accurately by visual observation. This indicates that visual virus

Table IX-7. Relative yielding capacity* of six sizes of seed tubers from TPS (DTO-33 op) expressed as a percentage of the yield from vegetatively propagated tubers (DTO-33) of the same size and planted at the same spacing.

Tuber size (g)	Plant spacing (cm)	Relative number of tubers per plant (%)			Relative total tuber weight per plant (%)
		18-55 mm	> 55 mm	Total	
1-5	5	185	22	141	78
5-10	10	136	43	125	62
10-20	15	162	37	128	59
20-30	20	147	28	92	61
30-40	25	134	47	109	82
40-50	25	190	72	154	89

* Effect of size of tubers from TPS on relative yielding capacity was not significant.

readings in plants from TPS tubers are not reliable with respect to mosaic viruses and could be a handicap for roguing.

Physiological Quality of Seed Tubers

Two varieties with different response to storage conditions were used to study effect of growth environment and storage conditions on sprouting capacity and subsequent field performance of seed tubers. Varieties were: Désirée, in previous experiments insensitive to storage conditions, and Rosita, sensitive to storage environment. Low virus seed tubers of both varieties were produced in Lima, San Ramon and Huancayo and stored at 4°C in the dark and at ambient highland temperature (Huancayo) in diffused light. Results indicate that seed tubers from Huancayo produced significantly more root weight per sprout than seed tubers from Lima and San Ramon (Table IX-8), while the effect of storage conditions on root growth was not significant. These results reconfirm last year's results.

Subsequent evaluation of field performance (Table IX-8) Désirée seed tubers from Huancayo yielded significantly higher than Désirée seed tubers from Lima and San Ramon after both storage regimes, while Rosita seed tubers from Huancayo only yielded significantly more after storage in diffused light at ambient temperature. Seed tubers from both varieties produced in San Ramon yielded significantly more after 4°C storage than after storage at ambient highland temperature, while with seed tubers produced in Lima and Huancayo there was no significant effect of storage regime on yield.

Two year's results suggest that seed tubers from highland areas perform significantly better than seed tubers from warmer lowland areas. Better root growth in plants from highland seed tubers is likely to have affected this better performance through faster emergence, faster initial foliage growth and more vigorous plants.

Additionally this year's results indicate that seed tubers produced in San Ramon are more sensitive to storage conditions than those produced in Lima and Huancayo. This occurred in both varieties despite the fact that Désirée is normally relatively insensitive to storage conditions.

Table IX-8. Effect of seed tuber origin and storage conditions on root development and field performance in two varieties.

Variety	Seed tuber origin	Dry root weight per sprout (mg) in sprouting test**		Yield (t/ha)***	
		4°C	Amb. temp.*	4°C	Amb. temp.*
Désirée	Lima	61	73	26.5	25.0
	San Ramon	88	95	28.0	14.2
	Huancayo	151	126	34.5	32.4
Rosita	Lima	120	121	27.7	23.2
	San Ramon	104	124	26.0	21.4
	Huancayo	163	183	27.7	30.2

* Mean minimum and maximum temperatures ranging from 4°C to 20°C.
** Mean of tuber samples taken after 4, 6 and 8 months storage.
*** Mean of planting location Lima, San Ramon and Huancayo.

TISSUE CULTURE

Genetic Stability Following Storage in vitro. Genetic stability of plants derived from in vitro cultures stored under several regimes was studied at CIP and at the University of Birmingham, England. After storage in vitro, plants were propagated from cultures and grown for one generation in the field to eliminate possible physiological differences that may have resulted from in vitro propagation. Tubers from the plants were planted in the field along with tubers of the same clone obtained from conventionally propagated plants. No morphological differences between plants of both origins were observed. The protein pattern of both types of tubers will be compared by polyacrylamide electrophoresis.

Selection for Salt Tolerance. More than 100 colonies of three clones were isolated from cell suspension cultures containing the following salts at two concentrations: 80 and 160 mM NaCl; 1.75 and 3.5 mM KCl; 5 and 10 mM $MgCl_2$. The final salt concentration in the growth medium was reached suddenly or gradually with time. Of the isolated colonies, from 10 percent to 30 percent continued to survive and grow in the salt media after several transfers, suggesting that such tolerance is perhaps genetically controlled. Plantlets from the tolerant colonies will undergo further evaluation to salt tolerance under greenhouse conditions.

Protoplast Culture. The following factors were investigated to improve procedures for isolation, yield and viability of protoplasts:

Source of tissue for protoplast preparation. Suspension cultures: The quality of protoplasts depended strongly on the phase of growth. Best protoplasts were obtained from fast growing suspensions in the middle part of the logarithmic phase.

Leaf mesophyll. In preliminary studies, excellent yields of protoplasts were obtained from plants of two wild species grown in the greenhouse in Huancayo. The protoplasts grew in size and were viable for at least 2 weeks but without sustained cell division. When leaves of in vitro plantlets were used for protoplast isolation best results were obtained from those plantlets which were in active growth in Murashige and Skoog medium enriched with coconut milk.

Isolation procedure. The separation of protoplasts from enzyme solution and debris is difficult. The best methods were: (a) sedimentation of the protoplasts by centrifugation for 2 min at 100 g followed by repeated washing with culture medium, or (b) centrifugation of protoplasts in 0.5-0.6 M sucrose solution, in which intact protoplasts may float. The latter method is gentle but its efficiency depends on the buoyant density of the protoplasts. When this method cannot be used, method (a) was modified using gradual Ficoll gradients (0.5-2 percent) in culture medium or sedimenting the protoplasts on a layer of 0.5 M sucrose.

The stability of the protoplasts was increased by diluting the protoplast suspension immediately after isolation with 1 volume of Murashige and Skoog, 1962, medium containing 320 mM NaCl and 20 mM $MgCl_2$.

Cultivation of Protoplasts. Additives such as glutamine (100 mg/l) to the protoplast culture medium was beneficial for survival. Replacement of a part of the medium by potato extract as used in other

species for protoplast and anther culture had no positive effect. Liquid media gave better results than semi-solidified media with agar.

Protoplast density. The optimal density for survival of protoplasts was in the range of 5.10^4 - 1.10^5 protoplasts per ml for several different clones.

Dilution of the original suspension. The time at which the suspension should be diluted is critical. When the suspension is diluted too early, the protoplasts, cell or colonies will die. In undiluted suspensions the polyphenol production may lead to cell death. No general rule can be stated, but the suspension has to be observed carefully to decide when to dilute it.

Reproducible procedures for protoplast preparations with sustained cell division could not be obtained. The reason for this may be related to the genotypes used. Therefore, further experiments will be carried out with clones which grow readily in tissue culture. Such clones have been identified through anther culture.

Anther culture. Anthers of two diploid (2x=24) breeding lines with bacterial wilt and nematode resistances produced callus from which a number of plantlets were regenerated with a tentative chromosome number of 25. Further studies are necessary to show if the regenerated plantlets are homozygous. During early stages of microspore development to plantlets a duplication of chromosome number occurred in 90 percent of the cases investigated. This leads to homozygous diploid plantlets. If the callus had grown from somatic tissue (anther wall or filament) the regenerated plantlets would be heterozygous. Homozygous plantlets carrying the resistance genes to bacterial wilt and nematodes would be useful for further breeding.

Ovule fertilization in vitro. The conditions for in vitro development of fertilized ovules were studied as a basis for later studies on in vitro fertilization. Flowers were taken at different times after pollination and ovules were cultured on different media. The two main problems were bacterial contamination and tissue browning as a result of polyphenol production. To overcome these problems, different antibiotics and chemicals incorporated in the medium are being evaluated. In total, 11 different combinations were used.

Effect of explant size on PSTV elimination by low temperature. PSTV infected plants were incubated at 10°C and 22°C for 6 months. Apical explants of different sizes were excised from buds and plantlets were regenerated in vitro. Extracts of such plantlets were tested by polyacrylamide gel electrophoresis for PSTV.

GERM PLASM MULTIPLICATION AND DISTRIBUTION

The in vitro collection contains 125 pathogen tested accessions

Table IX-9. Effect of explant size on PSTV eradication during incubation at two temperatures.

Explant*	Incubation temperature 10°C		22°C	
	Free	Infected	Free	Infected
Shoot tip	2	21	0	30
Meristem tip	8	35	0	19
Apical dome	9	4	–	–

* Shoot tip = apical dome + leaf primordia + leaflet(s)

Meristem tip = apical dome + 2 leaf primordia.

which are composed of CIP clones and cultivars, Mexican clones, cultivars important to national programs, standard European and North American cultivars, and cultivars important to the CIP breeding program. Pathogen tested materials were distributed in several forms to 41 countries in accordance with accepted quarantine regulations (Table IX-10).

The use of rapid multiplication techniques and fast evaluation methods made it possible to rapidly select advanced clones from tuber families for resistance to *Pseudomonas solanacearum* and *Globodera pallida*.

Low virus seed tubers were produced for CIP scientists from four planting dates in two locations. Advanced clones were planted in 25 hill plots for seed tuber increase and evaluation for plant vigor, tuber shape, color and yield, fruiting ability, and resistance to hail and frost. Selected clones are being multiplied further for adaptation studies with the objective of selecting advanced clones for pathogen clean up and export. Forty-four clones were evaluated in the early and late Huancayo plantings and 26 were kept for further multiplication.

Table IX-10. Export of pathogen tested potatoes.

Shipment	Number
Tubers of cultivars and advanced clones	8,632
In vitro plantlets	312
Tuber of TPS families	52,162
TPS	64,075

Regional Research and Training

Throughout this RR&T section of the 1981 annual report a number of acronyms are used for brevity. These stand for the following:

BARI — Bangladesh Agricultural Research Institute (Bangladesh).

BPI — Bureau of Plant Industry (Philippines).

EMBRAPA — Empresa Brasileira de Pesquisa Agropecuaria (Brasil).

IADS — International Agricultural Development Service.

IARI — Indian Agricultural Research Institute (India).

IBTA — Instituto Boliviano de Tecnologia Agropecuaria (Bolivia).

ICA — Instituto Colombiano Agropecuario (Colombia).

ICAR — Indian Council for Agricultural Research (India).

INIAP — Instituto Nacional de Investigaciones Agropecuarias (Ecuador).

PRECODEPA — Programa Regional Cooperativo de Papa (Central America).

SAPPRAD — Southeast Asia Program for Potato Research and Development.

Latin America for administrative and research activities now consists of two Regions. Region I headquarters remain in Bogota, Colombia and provide technical support to the Andean countries of Bolivia, Peru, Ecuador, Colombia and Venezuela. The non-Andean countries of South America — Brazil, Uruguay, Paraguay, Argentina and Chile — will constitute a new Region II to be supported temporarily from Lima until a permanent headquarters is established in Brasilia, Brasil. Central America, formerly Region II, is mainly self-supporting through PRECODEPA but individual countries may participate in activities organized by the two Regional Programs. PRECODEPA activities receive direct support from CIP-Lima scientists.

The Region III scientist visited Zimbabwe as, after independence, this country asked for help in its small but important potato program. The leader of the Ethiopian Potato Program, a long-time cooperator with CIP, is in Lima for 2 years as a visiting scientist and works in the Department of Breeding & Genetics.

The special project in Tunisia for seed production terminated during 1981; however, support continued under the new Region V, Francophone Africa. The formal agreement establishing the Region will be signed in 1982. The regional scientist-designate visited Togo and Ivory Coast at the request of the Conseil D'Entente to assess the situation for potato improvement. As a result of these impending changes, countries supported from CIP's regional base in Turkey will change. Region IV will now develop more activities in the Middle East zone and assume responsibility for support to Pakistan. A new special project was started in Region VI in the Kingdom of Bhutan. This Himalayan mountain country is ideal for growing both ware and seed potatoes. A scientist took up his post in the capital, Thimpu, in early 1981.

A major development in Region VII of Southeast Asia was the agreement to establish a new coopera-

tive research network, SAPPRAD. Australia funds this project and the current regional scientist becomes coordinator for 2 years. Actual research activities by the countries involved begin in 1982. A new regional scientist has been appointed.

Support for the Bangladesh program continued to be provided by a CIP specialist seconded to IADS, the agency working closely with the Bangladesh Agricultural Research Council. Additional help is provided by bilateral assistance of The Netherlands Government with an ex-CIP associate scientist, who previously worked in the Region III program in Kenya for 3 years.

In Ecuador, CIP supports the national program mainly in the fields of breeding and nematology. In 1982 it is anticipated a CIP scientist will take a bilaterally-funded post in Ecuador to accelerate efforts of the national program in these and other areas of potato technology.

This close linkage between the Regional Research Program and bilateral programs which is now a firm feature of CIP policy provides a multiplier effect to research efforts with national programs.

RESEARCH IN THE REGIONS

GERM PLASM EVALUATION AND DISTRIBUTION

Regions I and II. A wide range of germ plasm was tested in most Regional countries for adaptation to adverse environments and resistance to pests and disease. Major recipients of genetic materials were ICA in Colombia and EMBRAPA in Brazil. Frost resistant material was tested at the Tibaitata station of ICA. After four heavy frosts down to −7°C for 1 1/2 hr, 40 promising clones were selected out of 350. Five showed high resistance and good yields. Mild frost in other sites, notably in Bolivia, precluded good tests.

ICA also received 318 clones resistant to cyst nematode *Globodera pallida* of which 71 were selected for yield, adaptation and tuber quality and tested in an infected field. The nematology department of INIAP, Ecuador, has also regularly received similar material for evaluation. Of 94 clones tested, 54 had similar resistance ratings to those given by CIP, Lima, and 41 considered susceptible by CIP were rated resistant in Ecuador. Only two rated resistant by CIP were considered susceptible in Ecuador. In Bolivia, IBTA tested CIP germ plasm selections resistant to *Globodera rostochiensis* and identified some tolerant clones.

Virus resistant germ plasm, in particular resistance to leafroll virus, was of special interest to Argentina. Originally 606 plants were planted and after two seasons of intensive field infection 13 clones survived and were judged free of PLRV and PVY.

In general, adaptation trials in Brazil with a wide range of genetic material resulted in 186 clones selected; 85 percent yielded between 500 g and 1,500 g per plant in the low fertility soils of the Cerrado. Severe attack by *Meloidogyne javanica* indicates this nematode pest needs further study.

Since CIP does not have a priority breeding project for resistance to early blight, *Alternaria solani*, 879 clones were evaluated for this disease by EMBRAPA at the Brazilian experiment station. Most

were susceptible although 20 percent had useful degrees of resistance. Further selection may improve this proportion as many clones had high yield and good agronomic characters.

Joint research with ICA at the low altitude station of Medellin, Colombia, involves evaluation and selection of germ plasm for resistance to late blight, *Phytophthora infestans*, and resistance to bacterial wilt, *Pseudomonas solanacearum*.

Late blight tests screened more than 3,000 clones from which 7 percent of the plants were selected for further evaluation. Sixteen advanced clones tested under field conditions both with and without chemical protection were compared with seven standard varieties including Monserrate Roja, the preferred type. In nearly all cases the chemical protection enhanced yield even when resistant clones were compared. However, with most selected clones the unsprayed yield was significantly greater compared with the check varieties indicating good yield potential of CIP material under both high and low technology conditions.

Incidence of wilt on the station was low but three selected clones are being grown. Likewise, two other clones, one of which, BR63-65, selected as the Peruvian variety Molinera, are being multiplied in farmers' fields.

Region III. CIP's association with the Plant Quarantine Station of the Kenya Government continues to be one of the most productive projects for evaluating and distributing improved germ plasm through a Regional program. Kenya provides land and glasshouse facilities; CIP provides the screenhouse installations, labor and supplies and provides training in meristem culture and rapid multiplication to the Kenyan staff. All materials arriving from CIP or any other source are checked in the greenhouses by the government staff before being released for multiplication in the screenhouses under CIP control.

Three harvests per year are possible and in 1981 the March harvest produced 46 clones and varieties, June 122, and 52 in September under screenhouse quarantine conditions. Table RRT-1 details countries requesting material and the types of resistances in demand. Obviously resistance to late blight is still first priority followed by bacterial wilt. Of interest is the increasing demand from many countries for lowland tropic adaptation.

Promising clones from the multiplication system are evaluated at three sites at 3,000 m, 2,600 m and 1,700 m altitude. Both sprayed and unsprayed trials are used to assess overall yield potential and blight resistance under farm conditions. Generally, CIP clones performed better for late blight resistance than foreign commercial varieties. Yield was also good in most cases whereas tuber shape and size need improvement. Late blight resistance so far incorporated seems to be associated with late maturing varieties. However, four clones 800224, 720050, 573275 and 573079, selected by the Kenya Potato Program based on performance in national trials, are in the final stages of evaluation prior to naming as varieties. Elsewhere, in Mozambique one clone, 800169, has performed impressively compared with local varieties.

Rwanda, assisted by two CIP scientists, screened large numbers of clones to evaluate late blight and bacterial wilt resistance, priority requirements for the country. After four evaluations of 1,575 clones originally imported in 1979, only 12 were retained. In September

1980 a total of 3,054 tubers were imported and after two evaluations only seven were retained. An additional 1,958 clones and tubers were imported in 1981 and after the first evaluation 63 were retained. The average retention of clones after one evaluation is approximately 5 percent and after two or more evaluations less than 1 percent. This extremely high rate of attrition either reflects severe disease conditions or the high standards set by the scientists. The third alternative that the materials are unsuitable for Rwanda climate seems to be less valid as many of the tuber families show good potential in neighboring Kenya.

A number of clones were retained for further evaluation in Burundi and five local varieties from Rwanda were introduced to Zaire and compared with local varieties. In two of the three testing sites the introduced material was far superior to local varieties for yield and especially late blight resistance.

Region IV. Germ plasm importation increased in 1981 and CIP breeders sent families suitable for the latitude of Turkey (37°C). Approximately 19,500 tubers were planted plus 27,000 TPS. In tuber families, selection varied from 0 to 23 percent with an average of 5 percent. In general, the selected clones show improvement over germ plasm received in previous years. They are now being multiplied at Ezerum to avoid infection by virus which occurred when clones were maintained on the Aegean coast at Menemen. Tubers from this multiplication will go forward for large scale trials.

Thirteen clones were tested in Turkey against local races of tuber

Table RRT-1. Resistant germ plasm distributed from Kenya.

Country	Resistance type				
	Late blight	Bacterial wilt	Virus	Lowland tropics	General adaptation
Botswana	5	2	1	3	5
Cameroon	7	1	1	3	
Guinea		2	1	4	4
Kenya	10	18	1	5	
Malawi	10	2	1	2	1
Malagasy	8	2			
Mozambique	15			10	4
Nigeria	14	10		20	20
Rwanda		3			
Sierra Leone	3		11	9	3
Somalia	13	9	25	21	7
Sudan	8	3		16	6
Tanzania	10	2	1		
Togo	5	2	1	4	5
Uganda	11	3	1		
Zambia	7	6			19
Zimbabwe	12	7			6
Non-African					
Bangladesh		4		32	
North Yemen	2	1		1	
Sri Lanka				5	
CIP Lima			3	5	

moth, *Phthorimaea operculella*, to confirm that the insect's resistance in some wild potato species tested in Lima was not race specific. As these clones were mostly *Solanum andigena*, only seven tuberized of which four were classified as resistant. These clones will be considered in CIP-Lima's breeding program as resistant parents.

Region V. In the continued evaluation of germ plasm for resistance to leafroll (PLRV), the principal virus problem of Pakistan, 944 tubers were planted in the Punjab. PLRV infector plants were not adequately selected although populations of aphids, *Myzus persicae*, were high and natural spread was rapid. Late in the growing season some plants were symptomless and have been retained for subsequent evaluation.

Region VI. Large amounts of true seed of CIP selections resistant to cyst nematodes and root-knot nematode were supplied to ICAR, New Delhi, India. Twenty varieties, 14 clones and 11 tuber families with heat tolerance were sent to the Andaman Islands for evaluation. Nineteen other clones and six clones with resistance to charcoal rot were also supplied. A major bottleneck for testing germ plasm in India is the time required for imported clones to pass quarantine and be released to scientists. As a result of these delays the most recent germ plasm evaluated refers to material supplied in 1978 and 1979. It is now considered that the more recent germ plasm as a result of the recurrent selection program in CIP is infinitely superior to that of the earlier years.

In Bangladesh, germ plasm has been imported from CIP direct or via Kenya, India and Europe. Some 1,770 tubers were supplied directly from CIP and 591 were selected. In another test, 1,173 tubers were tested and 864 showed tolerance and resistance to PLRV and PVY respectively.

From 103 genotypes screened in 1979-80, four showed varietal potential of which CIP 800224 and 800225, also favored in Kenya are the most promising together with a Kenyan variety, Roslin Gucha. In view of the large number of clones now available in Bangladesh, it will be necessary to drastically reduce these before embarking on another major importation of germ plasm.

In Bhutan the CIP scientist assumed his post recently. The first priority will be to screen existing clones and varieties for bacterial wilt, late blight resistance, and to improve the earliness of the present crop.

Region VII. The first priority of this region headquartered in the Philippines has been to establish a multiplication site with relatively hygenic conditions for propagation of imported germ plasm to provide adequate tubers for testing. A new site was identified and 2 hectares of land rented at Sta. Lucia (Mt. Banahaw) which has been fenced and a screenhouse erected. Shortly before completion of the screenhouse a typhoon hit the area and the construction was 60 percent destroyed. The facilities are now being reconstructed at the same site but in a less exposed position. Meanwhile the Region is relying on tubers supplied by the Victoria Seed Unit in Australia where CIP has a contract for multiplication of selected CIP germ plasm and distribution to countries needing it.

TPS regional research mainly concerns evaluation of agronomic practices for proper establishment of seedlings and production of the tuber crop. Selection of improved genetic families specially suited to this technology is only beginning. Some promising hybrid populations are being distributed and these will be increased as capability for producing disease-free botanical seed of breeders' selections in Lima is strengthened.

Region I. Colombia. ICA achieved more than 90 percent germination of TPS and high survival rate with seed sown in organic soil mixed with well decomposed chicken manure. Analysis of the manure indicated it contributed the equivalent of 10-27-6 kg NPK per ha. Several open-pollinated and hybrid TPS progenies yielded more than 500 g tubers per plant. They were of acceptahle uniformity and high specific gravity. The mid-elevation station of La Selva, Medellin was the main experimental site.

Region II. Brazil. TPS hybrid progenies were evaluated at Vicosa University. On an experimental basis yields up to 25 tons per ha were obtained under field conditions and generally hybrid progenies outyielded those from open-pollinated seed. This corroborates experience in CIP/Lima. Additional experiments showed that several seedlings per hill give higher yields than single seedlings. In this experiment three seedlings were the optimum number (see Table RRT-2).

Table RRT-2. TPS — Number of seedlings per hill, Vicosa, Brazil.

No. seedlings	Yield ton/ha
1	18.1
2	22.6
3	26.0
4	24.8

Region III. Rwanda. Open-pollinated TPS of the local variety, Montsama, were dried and stored for different periods to determine the probable storage period required for farmers who lacked access to GA_3. It was concluded that ordinary farmers can use their own seed and expect adequate germination after 2 months storage.

A number of seed bed mixtures, both sterilized and unsterilized, were tested for seed germination. Sterilized volcanic soil and sand were superior to unsterilized. In all cases volcanic soil was a better seed bed medium giving up to 84 percent germination when sterilized. Farmers using unsterilized soil could expect approximately 65 percent germination.

Table RRT-3. Yields from Rwandan true potato seed.

Variety	ton/ha	Size of tuber (mm) percent			
		<20	20-30	30-45	>45
Sangema	20.3	8	23	50	19
Montsama	20.0	12	33	48	7
Bujumbira	8.0	14	41	41	4

In an experiment using open-pollinated seed of three local varieties up to 20 tons per ha of tubers were obtained. Varieties Sangema and Montsama yielded best. Results in Table RRT-3 used three transplants per hill, 30 square meter plot, harvest 127 days after transplanting.

To test feasibility of using TPS technology as an alternative tuber seed production system, yields were compared of tubers produced clonally and from TPS. Yields were identical in both systems but seed size was greater from clonally-produced seed although more tubers were harvested from TPS-produced tubers. Details are in Table RRT-4.

Region IV. In Turkey a trial was made of various transplanting methods for using TPS seedlings. Using a tobacco nursery technique (soil mixed with sieved sheep manure) an excellent seedling crop of the variety DTO-33 was obtained within 6 weeks. A major difficulty was initiation of tuberization before the seedlings had been transplanted. This is probably related to the rising temperature at the time of transplanting when the average maximum was 29°C. Efforts will be made to overcome this detrimental effect next season.

Region VI. India. Collaboration with agronomists of IARI started in 1979. In October 1980, studies included: methods of raising seedlings and transplanting; direct sowing; direct sowing using seed pelletized in clay and uncoated. Preliminary indications are that coated seed is inferior to uncoated seed and that sowing should not be delayed beyond September 20 because of potential frost damage to seedlings. Students are conducting agronomic trials and studying the effect of seed size and homogeneity within progenies for selected embryo types promoting vigorous growth. Some crosses and varieties of TPS contain a high percentage of superior embryos.

Bangladesh. Agronomic studies of raising TPS seedlings show that light shading during the main part of the day was essential to ensure good germination. Seedlings transplanted from plastic cups with roots covered by soil showed less transplant shock than other methods. In the heavy soil of the BARI station, 25 percent sand incorporated in the ridges provided better seedling establishment and 11 percent higher yield. In general, this first season results have underlined the need to transplant before November 15. Later plantings are affected by extreme heat stress during the bulking period.

Table RRT-4. Yield comparison from tubers produced by true potato seed and clonally (variety Atzimba).

Seed source	Seed rate t/ha	Yield t/ha	Tuber weight (9)	Tuber /plant
20 g tub. TPS	1	13	24	14
20 g tub. TPS	2	17	25	12
20 g tub. clonal	1	12	54	6
40 g tub. clonal	2	17	64	7

Region I. Colombia. A trial of tropically adapted clones was carried out by ICA scientists in Los Llanos station (300 m). A succession of problems including heavy rainfall, soil insects and delayed sprouting produced equivocal results. However, compared with the local check variety, ICA Purace, heat tolerant CIP clones LT-1, LT-2, and DTO-2 produced higher marketable yields.

Brazil. Trials were planted at Manaus on the Amazon in 1980 and 1981 under severe stress conditions. A number of factors contributed to the poor yields but seed with extreme· aplical dominance was the principal factor. Improved soil drainage and planting in June rather than November is planned in 1982 using the best sprouted seed obtainable. Various Brazilian scientists collaborating in experiments at Manaus and Belen have visited CIP to see at first hand techniques used by CIP at Yurimaguas, in the Amazon basin, Peru.

Region III. Kenya. Experiments were conducted at the Coastal Agricultural Research Station, Mtwapa. A number of clones produced in Nairobi were screened for tolerance to the hot coastal conditions. Emergence was erratic due to high soil temperatures (up to 36°C at 5 cm) together with water-logging. Eleven clones are worthy of further evaluation; three of these were derived from the Kenyan breeding program.

Agronomic experiments were in collaboration with a student in Wageningen University on the Magarini Settlement Scheme. Yields were low, although applying mulch to the soil greatly increased yield, shade from coconut trees was also advantageous.

In a second trial at Kilifi clone Y-67-20-40 gave a higher yield than Désirée or Siro. A severe attack of a fungal pathogen identified as *Colletotrichum* spp. destroyed the crop 8 weeks after planting.

Region VII. Philippines. Two agronomic trials were conducted in the Cagayan de Oro Valley, one on clay-loam soil after rice harvest and the other on a rainfed, sandy, coastal soil. The yield of locally available cultivars was highest on the sandy soil giving a mean yield of 33 tons per ha of which 21 tons were marketable size. On the clay-loam the yield dropped to 19 tons per ha with only 10.5 tons of marketable tubers.

Claveria (1,000 m) on Mindanao in the southern Philippines is a mid-elevation site suitable to study problems likely to be encountered in extending potato production into a new region. Replicated plots were planted on five farms and at the BPI experimental station. Seed tubers of the variety Red Pontiac imported from Australia were planted. Pests and diseases were relatively unimportant except for bacterial wilt which was present on all sites. Tubers from apparently healthy plants were subsequently replanted along with freshly imported seed of the same variety. Checks during the second season showed infection by bacterial wilt in the second season seed was 10 percent to 25 percent at 7 weeks and 5 percent in the newly imported seed. Further degeneration rate studies are planned for 1982; however, it is obvious that bacterial wilt is a problem in these mid-elevation areas.

The initial success in this technology transfer was with the diffused light storage technique for maintaining seed tubers in optimum physical and physiological condition. This technology is receiving widespread farmer acceptance. Nonrefrigerated storage of ware potatoes has become a major problem of lower elevations. Adequate storage methods exist in the cool highlands. Processing, another part of CIP research until recently, is still being explored in the Regions.

Region I. Colombia. Diffused light stores were built at several rural institute sites and also in farmers' fields. Conclusions were that seed potatoes from the diffused light stores were in much better physical condition than those from traditional farm stores. The important economic factor is that seed of these stores gave 5.5 ton per ha more yield than the farmers' seed. That difference alone would, at prevailing low prices, have paid for the stores in the first season. Extension services in Colombia are now ready to promote the technology and provide loans for construction although current low farm prices deter farmers from making substantial investments.

Region III. Kenya. Major effort has been testing feasible designs of ware potato storage. Under highland conditions, natural ventilated stores showed weight losses but a type of adapted African store also provided low weight loss. The average loss was only 8 percent to 10 percent after 5 months storage, which is satisfactory. The economic value of using sprout depressants is being determined. Experiments revealed that when supressants are used the quantities and stacking of potatoes must be carefully considered. In some designs resistance to air movement was so low within the stored potatoes that vapor of the supressant rapidly diffused out and had little positive effect. The extension phase of the technology is being taken up by the Ministry and although farmer interest is evident, the financial committment is unclear.

Rwanda. An unusual situation exists in Rwanda with respect to storage of seed potatoes. Conditions permitting the planting of potatoes at nearly any time of the year puts high priority on keeping dormancy as short as possible. It has been observed that storage of tubers in diffused light lengthens the dormancy period. Thus, potential for this technique is relatively low. Despite this, the initial three demonstration stores constructed of local materials in 1980 led to keen interest on the part of farmers. Ten more stores with capacities ranging from 6 to 20 tons were constructed by the farmers and average cost was only US$10 per ton capacity. Below 1,600 m altitude tuber moth was a problem but this was resolved by dipping the seed potatoes in insecticide. Comparisons with farmers traditional bulk storage methods show little difference with respect to weight loss after 3 months but the slightly higher temperature of traditional storage (1.5°C to 2.0°C) reduces the dormant period.

Burundi. In constrast to Rwanda, where planting the entire year is possible, Burundi has only two distinct seasons. Seed must be stored for considerable periods and diffused light storage is quite feasible. CIP scientists supervised construction of only one store in 1980. It

was copied by the Research Institute and the Department of Agriculture and at least 13 more were built. This has drastically changed the prospect for seed storage in Burundi and the concept, adapted to smaller scale stores, has been taken up by farmers.

Region IV. Tunisia. Preliminary observations were made to test the feasibility of providing seed tubers for the following early February planting of June-harvested tubers stored throughout the hot summer without cold storage. The plan was to use traditional storage under straw until the end of September, then placing seed tubers in trays in diffused light until planting. Physical appearance of the tubers was slightly dessicated with firm green sprouts. Yield was only slightly below that of imported tubers. However, as 24 varieties are on the official recommended list, possible variety differences must be investigated before final conclusions are made.

Turkey. Preliminary experiments were made in Menemen concerning levels of tuber moth infection of tubers stored in light and dark. First results suggest that high levels of infection are more rapid in the light than in the dark. Thirty days after storage only 4 percent of dark-stored tubers were infected compared to 12 percent of those stored in light. By 45 days these values were 43 percent in dark and 76 percent in light. Under conditions where tuber moth infestation can be severe, extra care must be taken with diffused light stores.

Region VII. Regional testing and adapting of the diffused light concept for highland potato storage in the Philippines is an excellent example of a technology which fills a particular need and expands throughout the farming community by its own momentum. During the season a more detailed investigation was conducted on the major economic benefits of the technique. Farmers' trials comparing traditional dark storage with improved farmers' stores incorporating the diffused light technique resulted in harvested yield increase by about 1 ton per hectare. Other trials included an improved custom-built store as an additional treatment. Average yield increases were 2 ton/ha for the farmer-modified store and 3 ton/ha for the custom-built store. There was an indication that variety played a part in determining the net benefit, as mentioned in the trials of Region IV. Conchita has a longer dormancy period than Isola, the other favored local variety. As such, the benefits of light storage are more apparent in Isola.

The following conclusions were drawn from an economic analysis of on-farm trials: Out of 10 trials, seven showed an increase in net income with the improved store. In five cases the benefit was from a reduction in costs due to lower losses during storage and thus less seed required initially. All seven showed an increase in total yield or improved quality. In five other trials comparison was made of seed from refrigerated stores and the farmers' dark storage. There was a reduction in costs in one case associated with refrigerated stores due to lower losses from dry rot but in only one case was the Benefit/Cost ratio greater than 1.5, the arbitrary value used to determine acceptability of the technique.

Seed Multiplication and Dormancy

Region III. Rwanda. The main problem in northern Rwanda where year-long planting is possible is not storage of potatoes but short dormancy. A simple method of treating potatoes in a trench to increase heating and breaking dormancy was devised. The potatoes were stored in a trench 0.5 m deep and wide, covered with wood ash, dry grass and soil to a depth of 0.25 m. Potatoes were placed in the trench at various times after harvest and periodically checked for germination. The results are given in Table RRT-5. Dormancy can be reduced by 30 to 45 days using this technique; an appropriate recommendation has been made.

Table RRT-5. Breaking dormancy by underground trench treatment (in days).

Time in trench after harvest	> 90% germination	Harvest to planting
30	42	72
45	42	87
60	35	95
75	28	103
90	21	111
105	14	119

Region IV. Tunisia. Locally-produced improved seed was compared with farmers' seed for the autumn crop and imported seed for the winter crop (Table RRT-6 and RRT-7). A cold store with uniform temperature could not be found

Table RRT-6. Comparison of local improved seed and farmer seed of the variety Claustar.

Site	Yield, t/ha	
	Farmers' seed	Improved seed
Dahmani	2.5	5.3
Sidi Bouz	8.0	8.0
Sfax	15.3	12.2
Nahdia	18.5	20.5
Jendouba	45.0	42.5
Siliana	0.0	11.1
Zaghouan	12.0	15.0
Korba	10.0	11.0
Kelibia	6.0	9.0
Bizerte	6.7	15.0

for the improved local seed; the available store had temperatures fluctuating between 2°C and 15°C. Thus, the physiological condition of the local improved seed was probably inferior to that of the imported seed.

Table RRT-7. Comparison of improved local seed and imported seed, Winter 1980/1981, variety Spunta.

Site	Yield, t/ha	
	Improved seed	Imported seed
Bizerte	26.6	28.2
Sfax	7.8	9.9
Takelba	37.7	42.1
Soliman	44.4	32.9
Beni Khaled	35.0	36.0
Beni Khiar	18.0	17.0
Mahdia	15.5	17.0
Sousse	27.0	24.0
Gabes	15.6	13.0

INSECT CONTROL

The two main projects of insect control concerned tuber moth in Region IV and V and thrips in Region VII.

Region IV and V.

Survey of PTM in farms and stores	Infection Percent
Tunisia:	
Experimental plots at harvest	17-40
Farmers' fields	22-37
Farmer's store two weeks after harvest . .	54
Cold store after one culling	16
Cyprus:	
4 to 6 weeks storage dusted with Sevin . . .	9-56
Vegetable market of potatoes Sevin dusted	39
Syria:	
Farmers' fields 10 days before harvest . .	13-18
Jordan:	
Experimental field at harvest	54

The high levels of infection at harvest can be attributed to shallow planting, poor ridging and cracked soil before harvest due to irregular irrigation. A trial in Menemen, Izmir, Turkey, with improved ridging did not give conclusive results. Further investigations of control by improved cultural practices are necessary.

Region VII. Philippines Thrip Control. A survey of thrip populations during 1980/1981 showed population build-up was late during the season and as a result the effect of the pest on yield levels was relatively light in most areas. Chemical control in Benguet Province did not increase yield.

A trial on a farmer's field at Loo tested timing of insecticide on yield of marketable tubers. Regardless of when the insecticide was applied there was little difference in yield between treatments. However, all treatments gave improved yield between 4.5 and 7.8 tons/ha over the unsprayed control. No further trials on chemical control are planned but the available information has been given to the Extension Service.

Social Science Department

Interdisciplinary approaches to problem identification, technology generation, and transfer are now used in CIP's key research areas and regional programs. An economic model has been developed for analysis of conventional seed certification programs. Interdisciplinary research helps establish priorities for refining true potato seed technology. Adoption of post-harvest technology and impact is being monitored. Studies of potato consumption and marketing contribute to understanding potential demand for use in developing countries.

CIP's social scientists work directly with biological research scientists in problem identification, design, and transfer of improved potato technology. They apply social science theories and techniques to potato agriculture in developing countries. And they bring social science perspectives to regional and national programs.

Work in social sciences relates to CIP's major research areas: seed systems, post-harvest technology, expanding potato production in lowland areas, and developing and distributing improved germ plasm. The central objective is to increase the effectiveness of CIP's global program to exploit the potential of the potato as a world food crop.

Selected 1981 research activities are outlined under two headings:

- Interdisciplinary team research.
- Potato consumption and marketing studies.

INTERDISCIPLINARY TEAM RESEARCH

Interdisciplinary research experience with biological scientists has led to formulation of two complementary approaches to problem identification, technology generation, and transfer: the "Farmer-Back-To-Farmer" model and that of "Optimizing Potato Productivity (OPP)." The Farmer-Back-To-Farmer model represents a general philosophy of the total research process, including problem identification, technology design, testing, and evaluation. OPP integrates into this model as an intermediate step between technology generation and dissemination.

Farmer-Back-To-Farmer

The Farmer-Back-To-Farmer model, formulated with CIP's post-harvest Thrust, is based on the principle that applied agricultural research and transfer of acceptable technology should begin and end with the farmer, and involve interdisciplinary teamwork in all phases of a continuous research/transfer process. The model was developed during adaptation of seed storage principles to the requirements of resource-poor farmers and is equally applicable to any area of applied agricultural research.

The model is a series of *goals* aimed at achieving acceptable solutions for farmer's problems and linked in a circular form by a number of *activities* (labelled 1 to 4 on Figure SSD-1).

A proper diagnosis of problems (activity 1) provides efficient use of research resources. Initially, this may require social and biological scientists to make independent observations and studies. Subsequently, through a process of interdisciplinary dialogue and interaction with farmers, often characterized by debate and "constructive conflict," the different diagnoses of social and technological perspectives are brought together to arrive, with the farmer, at a common definition of the farmer's problem. During this phase, team members begin interdisciplinary team research (activity 2) to develop potential solutions to the farmer's problem.

Armed with a potential solution, the interdisciplinary team proceeds to testing and adaptation (activity 3) usually started at the research station and followed by on-farm testing. In coooperation with the farmer, potential solutions are compared against existing farming practices. It may be necessary to recycle stages 2 and 3 (research, testing, and adaptation) to arrive at a solution better adapted to the farmer's problem.

The farmer, in cooperation with scientific team members, makes a final evaluation (activity 4) of the technology under existing farm conditions using his or her own resources and management. Eventually the farmer accepts or rejects the technology. If rejected, further research determines why and finds ways to improve performance and acceptability of the technology.

If new technology is not used by farmers, the entire applied research effort is fruitless and research findings are destined to science archives. If technology is accepted and used by farmers, scientists must monitor the impact of the technology to determine if it is beneficial not only for small farmers but also for poor consumers.

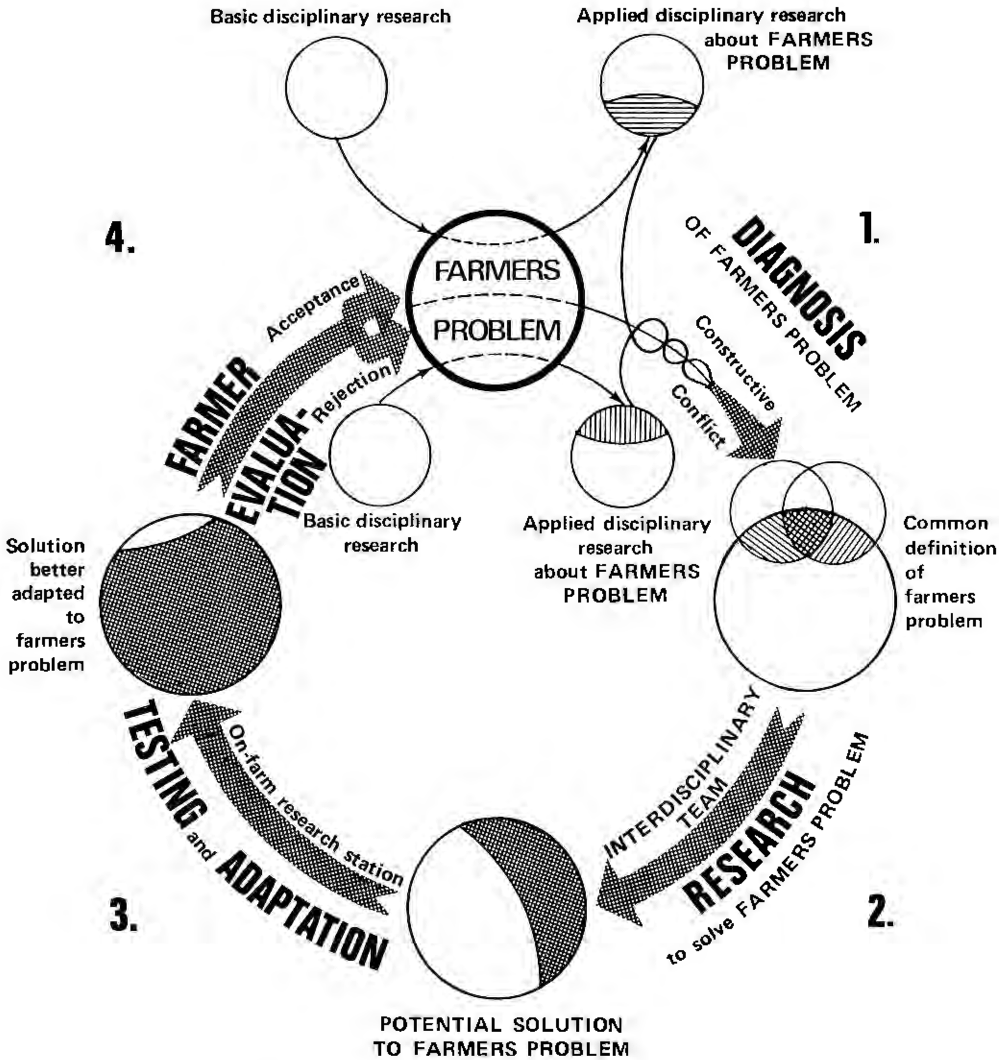
Optimizing Potato Productivity

This was the final year a fulltime staff member coordinated on-farm potato research in regional and national programs. CIP mainly has performed a backstopping role, giving the lead to national potato workers often supported through bilateral projects. Ten country programs conducted on-farm potato research in 1981 in collaboration with CIP: Bangladesh, Cyprus, Ecuador, Nepal, Pakistan, the Philippines, Korea, Rwanda, Tunisia, and Turkey. Department personnel collaborated with CIP's regional scientists and national counterparts in planning research and/or interpreting results bringing experience in three fields: understanding farmers' situations and problems, planning trials to test new technologies, and socioeconomic analysis of results.

More attention was given to identification of yield constraints and careful planning of trials than in previous years. Experimental designs were simplified to allow use of larger plots and more trials in each area. Greater emphasis was on ensuring adequate farmer control treatment in the trials.

Farmer Adoption of Rustic Seed Stores

A comparative study of farmer acceptance of low-cost seed stores has begun in collaboration with Thrust VIII (post-harvest technology) with 1981 case studies in the Philippines, Peru, and Colombia. This study's objectives:



	Activities	Goals
1	Diagnosis of farmer's problem	Common definition of problem by farmers and scientists
2	Interdisciplinary team research to solve farmer's problem	Identify and develop a potential solution to the problem
3	On-farm testing and adaptation	Better adapt the proposed solution to farmer's conditions
4	Farmer evaluation	Understanding farmer acceptance or rejection of solution

Figure SSD-1. Farmer-back-to-farmer — a model for generating acceptable technology.

- understand farmer response in order to improve the technology,
- explore ways to reduce time between initial research and ultimate use by farmers,
- identify contexts where technology has a greater chance of success, and,
- evaluate methods for facilitating transfer of CIP technology.

The process of farmer adoption in the three countries has shown striking similarities. In each case technology was first introduced by national programs through demonstrations and field days. Demonstrated storage principles were then adopted for small quantities of seed by one or two farmers, generally community leaders. The remainder of the community adopted a wait-and-see attitude. If storage demonstrations or farmers' experiments showed an improvement in seed quality, other farmers began experimenting on their own. Although important, production increase in the field was not the only criteria for adoption. Farmers often began investing in new stores or altering traditional stores before seeing field results. Farmer innovations ranged from simply spreading potatoes in diffused light to construction of new stores. Acceptance of the new technology was more rapid in small, closely-knit communities actively involved in seed improvement programs than in larger, more dispersed areas with no seed improvement program.

Table SSD-1 reports the number of known adopters of the simple storages as of late 1981.

Table SSD-1. Reported adopters of simple diffused light seed storage principles, 1981.

Country	Number
Philippines	130
Peru	42
Guatemala	15
Honduras	43
Colombia	6
Sri Lanka	20
	256

Economics of Seed Certification

Institutional schemes for potato seed certification that operate successfully in North America and Western Europe have not performed well in Andean countries. Few potato producers in highland areas use certified seed. Research completed in 1981, in collaboration with national programs in Colombia, Ecuador, and Peru, identified and analyzed factors limiting use of certified seed, particularly in highland Andean areas.

An economic model developed for this research indicates that farmers will find it profitable to use certified seed only if the following condition is met:

$$\frac{Yc - Yf}{S} > \frac{Pc - Pf}{P}$$

where:

Yc and Yf = yield resulting from use of certified and non-certified seed, respectively,

S = seeding rate,

Pc and Pf = price of certified and non-certified seed, respectively,

P = price of potatoes produced.

Socioeconomic surveys and farm-level experiments generated data for economic analysis of certified seed in five Andean locations (Table SSD-2). Results indicate that use of presently available certified

Table SSD-2. Cost and revenue estimates for potato producers, rural assemblers, trucklers, and wholesalers in central Peru 1979 (US$/t).

	Total revenue	Total cost	Net revenue
1. Producers			
Coast			
Small farmers	100	58	42
Med/large farmers	108	67	41
Prodn. Coops.	129	80	49
Highlands			
Small farmers	78	129	–51
Medium farmers	81	97	–16
Large farmers	103	84	19
2. Coastal Rural Assemblers*	19	15	
3. Truckers			
Coast			
Gasoline	6	8	–2
Diesel	8	8	0
Highlands			
Gasoline	18	22	–4
Diesel	22	15	7
4. Lima Wholesalers	9	4	5

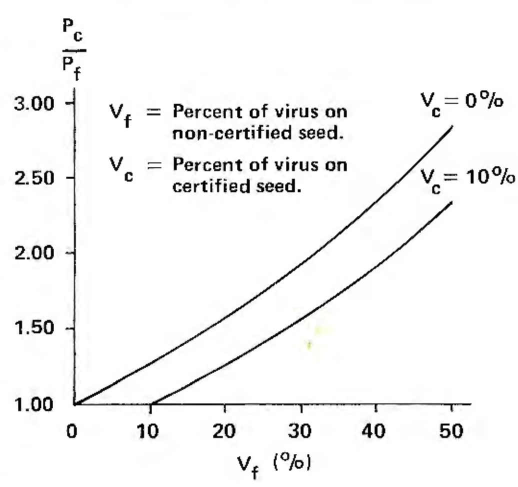
* Not a major marketing agent for highland potatoes shipped to Lima. Total revenue excludes cost of potatoes.

seed would be profitable in only one of the five locations: Cañete, an irrigated coastal valley in Peru. Low yielding capacity of certified seed presently available in highland locations appears to be the major factor limiting its use.

Based on previous work by Reestman (1946) De Wit (1962) and van der Zaag (1972) a formula was developed to estimate the maximum percent virus infection which can be tolerated in a self-sustaining, economically viable seed potato certification program. Other things equal, this level depends upon the amount of virus disease in non-certified seed and the ratio of prices of certified and farmer seed (Pc/Pf).

Figure SSD-2 illustrates application of the model. Assuming that farmer seed has 30 percent secondary leafroll virus, certified seed with 10 percent virus infection could be sold at a maximum price of about 57 percent above the price of non-certified seed. Given the same assumption, certified seed with zero virus infection could be sold for about 83 percent above the price of non-certified seed.

Figure SSD-2. Maximum allowable price ratio for certified and non-certified seed.



True Potato Seed (TPS)

True potato seed (TPS) has emerged as a promising new technology for developing countries. Interdisciplinary research by the Social Science Department and Thrust VII and IX contributes to development of TPS technology and analysis of its potential adoption. The research objectives are to:

- identify technical and socioeconomic factors influencing potential use and impact of TPS,
- establish priorities for refining the technology and adapting it to farmer conditions.

As a first step, an interdisciplinary framework has been developed for macro- and micro-level research on the technology itself, areas of potential adoption, and its possible impact.

To gain experience and relevant information, agroeconomic research was conducted on CIP La Molina experimental facilities during the main crop season, June-October 1981. Experimental treatments simulated production of consumption potatoes using conventional tuber seed and TPS transplants. During the same period two on-farm trials were conducted in Cañete (coastal Peru).

These trials allow comparison of cost levels and structures and help researchers identify priority areas for future TPS research. Unadapted DTO-33 progenies were used. Hence, results should be considered preliminary. As superior progenies become available costs are expected to change. Results indicate that seedbed substrate used by CIP researchers produced transplants with better emergence, vigor, and uniformity than the unfertilized substrate commonly used by farmers producing vegetable crops. Transplanting method from nursery to field and the associated "transplant shock" were found to be critical determinants of plant survival and production. Potential cost savings from use of TPS were partially offset by increases in labor, pesticides, and fertilizer costs. Tuber seed yielded significantly more than transplants and produced a larger proportion of larger tubers.

Findings highlight the need to develop and make available higher yielding progenies, improve transplanting methods, and reduce dependence upon pesticides. Where labor is abundant, labor absorption may be an asset of TPS technology; where labor is scarce and costly, labor-saving technology may be advantageous.

Farming systems research on TPS is underway in Tarma, a vegetable growing area in highland Peru. Principales and procedures are being developed for identifying world areas of high potential adoption and for evaluating TPS systems and component technologies under their conditions.

POTATO CONSUMPTION AND MARKETING STUDIES

Consumption

CIP's research on potato consumption and human nutrition focuses on tropical developing countries with low income levels and nutritional inadequacies. The objectives are to determine:

- the current role of the potato in representative diets,
- whether greater potato availability could improve the diet, and,
- obstacles to greater potato consumption.

A typology of potato consumption patterns serves as the study framework. In 1980 case studies were conducted in Peru and Rwanda — where the potato is a dietary staple and average per capita consumption exceeds 60 kg per year. In 1981 studies were in Guatemala, Philippines and Indonesia — areas of low consumption (reported to be less than 5 kg per person per year). Emphasis was on determining how potato consumption patterns relate to agroecological zone, rural vs. urban residence and socioeconomic status to identify target populations with the greatest potential and need to increase potato consumption. Two widely held myths were disproven: (1) that potato producers in Central America and South East Asia do not eat potatoes, and, (2) that only wealthy urban residents consume potatoes.

The *Guatemala* study was in collaboration with the Institute of Nutrition of Central America and Panama (INCAP) and the Guatemala Institute of Agricultural Science and Technology (ICTA). In farm surveys, all potato producers consumed potatoes, often in amounts exceeding 75 kg per year. Consumption is seasonal, following each harvest. Often three crops are harvested per year. Within the rural population, potato producers have the highest levels of potato consumption. INCAP nutrition surveys of the mid-1960's and mid-1970's reported consumption levels of twice the official rate of 4.5 kg per capita per year. An informal survey of current potato consumption in the capital city showed that potato consumption is positively correlated with income. Nevertheless, even among poor people, potatoes are consumed frequently.

The plastic packaging of these potatoes (center) in the Baguio, Philippines municipal market indicates their "high status" position among other vegetables. In this area, potatoes are a luxury food, eaten only on special occasions. Most are trucked to Manila markets.

In a market on the island of Mindanao, Philippines potatoes are displayed more casually and in larger quantity than in the Baguio market on the island of Luzon. In this market, customers select from a range of prices based on size and quality. Potatoes are consumed regularly in this area as a supplementary vegetable.

The *Philippines* study was in collaboration with the Philippine Potato Program, the Bureau of Plant Industry, the University of the Philippines and Mountain State Agricultural College. Consumption among most persons interviewed was higher than the reported national average of less than 1 kg per year. Middle and upper income families consumed potatoes an average of once a week at a rate of about 26 kg per familiy per year. Low income families consumed potatoes only on special occasions — one to three times a year. In general, potatoes are considered as a vegetable in diet, eaten in small amounts as a complement to rice, or rice/corn mixtures. Potato consumption levels are highest during May festivities and the Christmas season. Color preferences for either white or red skinned potatoes are strong and vary across locations. Numerous misconceptions exist concerning the potato's nutritional value. Many people consider it harmful to consume potatoes frequently or in large amounts. Poor and middle income groups cite price as the major barrier to greater consumption. Lowering potato prices would apparently result in more frequent use of the potato as a vegetable, but little change in the quantity consumed each meal unless educational strategies are implemented to change current usage patterns.

The *Indonesia* study was in collaboration with the Indonesian Agency for Agricultural Research and Development (AARO), BALITTAN-Lembang Vegetable Research Station, the International Agricultural Development Service (IADS), the Jakarta Marketing Board, the Netherlands Techni-

This Indonesian girl holds a deep-eyed (purple) potato and an elongated (reddish) tuber traditionally grown and consumed in central Java. Farmers also grow round, white-skinned, yellow-fleshed varieties to satisfy the demands and preferences of urban consumers.

Indonesian children from the highlands of central Java surround a bowl-full of fried potatoes which will complement their evening meal of rice and other vegetables.

cal Assistance Project Indonesia QTA-28. Indonesia is the largest potato producing country in South East Asia, reporting over 20,000 ha harvested and 233,298 tons produced in 1980. Although a small portion is exported to Singapore, most potatoes are consumed domestically. Food balance sheets indicate an average per capita consumption rate of only 1.5 kg per year. However, existing surveys and nutritional studies for Java indicate that per capita consumption ranges from up to 50 kg, depending on agroecological zone, socioeconomic status, ethnic background, and rural or urban residence. For most people potatoes are an expensive vegetable consumed only on special occasions. There is a tendency for consumption studies in Indonesia to overlook potatoes for several reasons. Often, informants who claim not to eat potatoes will actually consume them weekly. Because potatoes are generally not considered a "food," but rather "trimming," or "garnishing" for rice, many people consume them regularly but do not automatically report it as food consumed. Hence, annual per capita consumption may be considerably higher than officially reported. Regularity and frequency of consumption is reflected in year-round availability of potatoes in urban and rural markets on the major islands.

Final case studies in *Bangladesh* and *Bhutan* and the project's comparative analysis will be completed in 1982.

Peruvian Potato Marketing

Potato is the most important food crop in Peru; hence potato marketing problems are matters of great public concern.

The present study, completed in 1981, describes and analyzes the production-distribution system linking coastal and highland producers to Lima wholesale markets and draws some conclusions of relevance to policymakers.

Three different potato marketing channels were identified and related to farm types. Most highland producers are small and subsistence-oriented. They sell a small share of their potatoes in local fairs and markets, frequently to consumers. In contrast, larger commercial highland producers tend to sell

Selecting small potatoes (about an inch in diameter) used especially for making *rendang*, a popular festive dish for weddings and other celebrations in west Sumatra. Larger potatoes (foreground) are commonly used for other dishes to accompany the staple fare of rice.

their potatoes in the field to Lima-based wholesalers. Most coastal potato producers are commercially-oriented; they sell to local assemblers who, in turn, ship to Lima wholesalers.

These potato marketing channels are complex and better functionning than generally believed. From a system's perspective, producer-to-wholesaler potato marketing was relatively well organized. In contrast to popular opinion, the study found potato wholesaling not to be concentrated in the hands of a few wholesalers in Lima. Nor was potato marketing characterized by numerous, unnecessary stages, as often believed. Net profits of rural assemblers, truckers, and wholesalers were lower than those of most commercial potato farmers. Government policies, and programs to regulate prices, restrict storage and organize marketing have probably reduced market efficiency rather than improved it.

Many small highland farmers lost money producing potatoes this year due to unusually low potato prices and inflated input prices.

Consumer Demand for Potatoes

The study of demand characteristics for potatoes in developing countries has been identified as the priority area for CIP's future marketing research. Available demand projections for potatoes in developing countries have proven to be highly inaccurate and of limited use to researchers and policy makers. Levels of potato consumption have increased far more rapidly than predicted. Research is underway to estimate national potato demand parameters for representative developing countries, regions and income groups.

Planning Conference

The second Social Science Planning Conference, September 1981, established the following priorities for the 1980's:

- Broaden the scope of interdisciplinary teamwork with CIP biological scientists.
- Consolidate and synthesize research findings to date, complete research on marketing and consumption, and expand research on acceptance and impact of new technologies.
- Expand socioeconomic work in the regions, through research and training links with local social scientists.

The planning group stressed the importance of strengthening national program social science capabilities through creation of opportunities for national social scientists to participate in interdisciplinary research on potatoes.

Training & Communications

The impact of CIP's research in the developing world depends largely on abilities of national researchers, extensionists, and educators to receive, use, and pass on to their clientele improved germ plasm and technologies to better potato production. The ability to communicate is an important role in this process. As such, CIP's training, communications, and library staffs as members of scientific interdisciplinary teams conduct training efforts directed at national programs.

TRAINING

A Training Committee, some members with regional experience, reviews training activities conducted at headquarters and in the regions quarterly as well as those planned for the future. Members insure that priorities are addressed and that potato workers from key areas of the world participate in training.

Regional Activities

Traditionally, regional activities have been production-oriented. As more extensionists have participated and scientific expertise has developed in some regions, the need for training in certain specialized areas has emerged. In nearly all regional activities participants are from surrounding countries and more national scientists are participating as instructors. In 1981, a total of 16 CIP headquarters scientists developed training plans, evaluated, or instructed in 17 different regional activities. Regions differ in activities because of differences in development and needs of the regions.

Region I. During 1981 this region was subdivided to form Regions I and II. National program personnel from both regions participated in activities reported here.

Two storage courses funded by a United Nations Development Program (UNDP) special training project were conducted in Colombia and Peru. Forty-three national scientists and extensionists participated in 16 days of training. A 5-day rapid multiplication technique course in Colombia had 11 participants. CIP provided financial support to five fertilizer courses organized by Peru's Agricultural University with additional support from the Ministry of Agriculture and various agro-businesses. A total of 230 researchers, extensionists, and farmers participated. Supporting Central America's Proyecto Regional de Papa (PRECODEPA) three CIP headquarters scientists instructed in two nematode courses and in a tuber moth workshop.

Region III. A 20-day production course in Tanzania was for 20 participants. CIP regional staff instructed in two storage courses sponsored by other agencies with 26 potato workers obtaining 12 days of training. Four researchers were trained in a joint CIP-Institute

for International Tropical Agriculture (IITA) tissue culture course at IITA funded by UNDP.

Rwanda. A 14-day on-farm research seminar, funded by UNDP, was conducted for 15 potato workers. Thirteen seed production researchers from Zaire and Rwanda received individual training of 2 to 4 weeks each. A total of 132 extensionists and farmers participated in three 2-day production workshops.

Burundi. Fifty-eight national researchers and extensionists took part in two 5-day production workshops and 14 completed a 5-day storage short course.

Region IV. Six national scientists attended a 14-day production course in English in Tunisia.

Tunisia. Fourteen national researchers and extensionists participated in a 28-day production course in French in Tunisia. Thirty-eight extensionists participated in three harvesting and storage field days.

Region V. In mid-1981, after 5 years of operation, the regional headquarters were transferred to North and West Africa allowing a bilateral project to collaborate more extensively with the Pakistani national program. During the first half year a 4-day on-farm research seminar was attended by 33 Pakistani researchers, extensionists, and farmers.

Region VI. Five national researchers attended a 20-day seed production course co-sponsored by CIP and the Central Potato Research Institute (CPRI). Four storage courses funded by UNDP and which totaled 20 days of training in Sri Lanka were attended by 204 researchers, extensionists, and farmers.

Bangladesh. CIP's consultant instructed a 3-day seed production and storage workshop for 35 extensionists, two 3-day production short courses for 100 extensionists, and a 2-day research workshop for 70 researchers, extensionists, and farmers.

Region VII. A 15-day production course had 15 researcher and extensionist participants. Ten national potato workers attended a 15-day storage course.

Participants in a seminar on optimizing potato production conducted in Rwanda.

Instructor (kneeling) and trainees in a germ plasm management course in Lima.

Headquarters Specialized Courses. Because of available expertise and facilities, courses in certain areas of specialization are better conducted at CIP headquarters in Peru. Intentions are to conduct these courses for a minimum of 2 years at headquarters before conducting them in the regions. This allows time to perfect course content, develop necessary training materials, and prepare personnel to conduct the training in the regions.

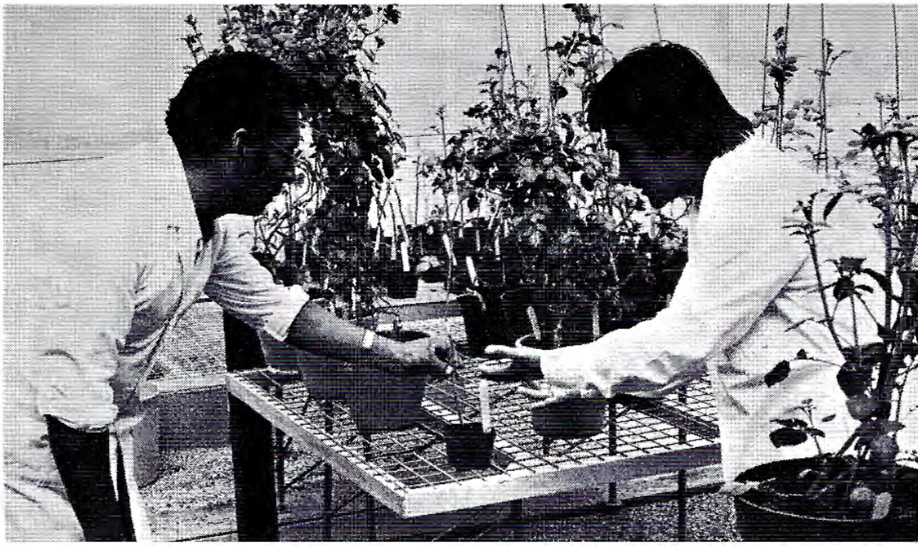
Three specialized courses were conducted at CIP headquarters in Peru. The first was a 28-day germ plasm management course in English for eight researchers from eight different countries. The second and third courses were 14-day field level virology courses, one in English and one in Spanish, attended by 16 researchers from 14 different countries. Two 5-day simple processing workshops were at CIP's highland station in Huancayo for 13 Peruvian researchers and extensionists.

Headquarters Individualized Training. Headquarters scientists sometimes accept national scientists on an individual basis for training tailored to meet national needs. It is primarily on-the-job experience.

Seven national scientists from five countries received individualized training in seed production, virus testing, and tissue culture during training periods of 1 to 4 months.

Scholarships. CIP has always recognized the need for advanced degree scholarships for particular areas of the world. It helps provide for promotion of the individual as well as priority research for the scholar's home country.

CIP sponsored, fully or partially, 13 doctoral and five masters scholarships for national program personnel



A mid-career trainee (right) from Bhutan with an instructor.

from eight countries. Five doctoral and three masters scholars completed studies. CIP sponsored 20 research assistantships for masters theses for Peruvian students, mainly from the Agricultural University and nine completed studies during the year. CIP also accepted nine students to perform 2- to 3-month practical experience periods as required by Peruvian universities.

Mid-career Training. Collaborative research at headquarters in Peru allows visiting scientists from national programs to conduct priority research for their countries and learn more about CIP. Headquarters scientists gain an opportunity to better understand country research needs. Three scientists from Argentina, Bangladesh, and Bhutan received from 3 to 6 months of this type of experience at headquarters.

CIP Staff Training. A total of 25 CIP staff members and wives received Spanish-language training while 76 technicians and employees received English-language training. Two senior staff members received advanced management training at Cornell University.

Training Materials. Development and preparation of training materials support CIP's training program. Selected methods are those that national programs are more likely to use: technical information bulletins, manuals, slide sets with printed guides, and flip charts. They are intended for use by national programs.

Efforts were directed at planning and preparing complete packages of training materials for teaching specific techniques. For example, all the materials necessary to train on rapid multiplication techniques at the regional level were completed, including evaluation. The series of technical information bulletins for production courses was expanded to 14 titles of which more than 23,000 were distributed worldwide.

Evaluation. A training activity evaluation system started in 1980 was refined in 1981 and was used in 13 training events. The system includes:

• a daily evaluation that provides immediate feedback to organizers and instructors, permitting adjustments as the event evolves and an analysis of effectiveness useful in future planning. It was used in seven courses, in English, Spanish, and French.

• a measurement of learning involving pre- and post-tests used in two courses.

• a final summary evaluation used in 11 courses.

• an evaluation of training materials with the intent of improvement.

Post Doctorals. Young Ph.D.'s conduct specific research over a predetermined period of time in an international setting with the possibility of beginning technical assistance careers. CIP had nine post doctoral positions.

COMMUNICATIONS

As CIP's research offers more technologies to improve potato production in the developing world, communications staff obtain information from scientists, prepare it with the intended receiver in mind, and produce it in an appropriate form for understanding.

To concentrate limited resources on the most important topics and media, a Publications and Audio-Visuals Committee reviews proposals for publications and audio-visuals and names scientific review boards for those approved. Table T&C-1 shows the distribution of work across three categories of support in 1980 and 1981: research, training, and administration. The increase in totals is attributed to an increase in support to research and training functions. Of the 124 publications, 20 were translated from English to Spanish.

The departmental staff also provided logistical support to 437 group gatherings in seminars, conferences, meetings, and courses. Included in these were 25 seminars conducted by CIP headquarters and regional scientists, visiting scientists, and scientists on research contracts. These provide an opportunity to discuss progress on on-going research and future plans.

LIBRARY

CIP's library is specialized to provide services mainly to scientists at headquarters, at its highland sta-

Portion of CIP's printing facilities.

Table T&C-1. Jobs processed in Communications, 1980/1981.

	PUBLICATIONS (annual reports, technical bulletins, circulars)				OTHER (visual aids, translations, graphs)				TOTAL
	Ad.	Res.	Tr.	Subtotal	Ad.	Res.	Tr.	Subtotal	
1980	14	48	46	108	154	114	155	384	531
(%)	2.6	9.0	9.0	20.6	29.0	21.4	29.2	79.6	100.0
1981	14	65	45	124	180	291	278	749	873
(%)	1.6	7.4	5.2	14.2	20.6	33.3	32.0	85.8	100.0

tion in Huancayo, and in its regional research and training network.

A Library Committee of senior scientists and directors reviews the services offered and purchases of all documents for the library. Items added to the collection showed an increase in technology transfer, training, multiple cropping, true potato seed, and several social sciences disciplines, Table T&C-2.

The library provided support to the three headquarters specialized courses by assisting in preparing bibliographics, reserving documents, and providing additional hours of service. Two library publications were: on the mention of potatoes in Peruvian documents from 1965 to 1980, and terminology used with potato diseases and pests. Both publications were exchanged with more than 70 libraries with exchange agreements.

SPECIAL PROJECTS

W. K. Kellogg Foundation granted a 3-year project to develop training materials starting in November 1979. It provides personal services, travel, and operational expenses. The objective is to prepare materials to support headquarters and regional scientists in training national researchers and extensionists.

In 1981 the project produced seven slide sets and guide-books in English, Spanish and French as well as a flip chart series in two languages. These materials comprise a complete training package on rapid multiplication techniques and virus testing.

United Nations Development Program since July 1980 has sponsored a collaborative project involving CIP, the Centro Internacional de

Table T&C-2. Accessions to library and major services provided.

	1980	1981	Total to date
Book collection additions	980	505	4,160
Journals by subscription	73	74	74
Periodicals	383	384	384
Annual reports	76	70	532
Loans to CIP staff and training program	4,084	4,830	na
Processed reprints	991	532	3,009
Interlibrary loans	428	482	na
International exchange (libraries in countries)	235 (56)	271 (66)	271 (66)

Agricultura Tropical (CIAT), and the International Institute for Tropical Agriculture (IITA) to transfer technology about potatoes and cassava.

CIP collaborated with a tissue culture course at IITA and independently conducted three storage courses in Colombia, Sri Lanka, and Peru and an on-farm research seminar in Rwanda. A total of 251 researchers, extensionists, and farmers participated in these activities. Details on these activities are in the regional section of this report.

This project's objective is to allow national program experts, some previously trained by CIP, to organize and conduct training activities for other researchers, extensionists, and farmers from their countries or surrounding countries. There are five joint and eight independent activities in this 2-year project.

Swiss Development Cooperation initially provided technical and operational support for an 8-month basic seed production training project beginning in September 1980. Since then, with CIP backstopping, the project has trained seven researchers from Peru's Instituto Nacional de Investigacion y Promocion Agropecuaria (INIPA) at three highland stations on the use of four rapid multiplication techniques and was extended in duration to include support for the INIPA experimental station at La Molina.

Publications by CIP Scientists

(For reprints please refer directly to main authors.)

Elango, F. and J. C. Lozano. 1981. Pathogenic variability of *Xanthomonas manihotis*, the causal agent of Cassava bacterial blight. Fitopatología Brasileira 6: 57-65.

Fernández-Northcote, E. N. and C. R. Brown. 1981. Resistance in diploid *Solanum phureja, S. stenotomum*, and *S. berthaultii* intercrosses to potato virus Y. Phytopathology 71: 873.

Franco, J. and A. Matos. 1981. Comportamiento de diez variedades comerciales de papa al ataque y multiplicación de *Globodera pallida* P_4A. Fitopatología 16 (2): 48-54.

Hooker, W. J. Editor. 1981. Compendium of Potato Diseases. American Phytopathological Society. St. Paul, Minnesota. 125 pages.

Hooker, W. J. primary collator. 1981. A proposed list of common names for diseases of potato (*Solanum tuberosum*). Plant Diseases 65: 524-525.

Horton, D. 1981. A plea for the potato. Ceres 79: 28-32.

Jatala, P., R. Salas, R. Kaltenbach and M. Bocángel. 1981. Multiple application and long term effect of *Paecilomyces lilacinus* in controlling *Meloidogyne incognita* under field conditions. J. Nematology 13: (abstract).

Martin, C., E. R. French and U. Nydegger. 1981. Bacterial wilt of potatoes in the Amazon Basin. Plant Disease 65: 246-248.

Ochoa, C. 1980. New tuber bearing Solanums from Colombia. Phytologia 46 (7): 495-497.

Ochoa, C. 1981. *Solanum calacalinum*, una nueva especie tuberífera ecuatoriana. Darwiniana 23 (1): 227-231.

Ochoa, C. 1981. *Solanum antacochense*, a new wild Peruvian species. Am. Pot. Journ. 58 (3): 127-129.

Ochoa, C. 1981. *Solanum irosinum*, a new Peruvian tuber-bearing species resistant to *Phytophthora infestans.* Am. Pot. Journ. 58 (3): 131-133.

Ochoa, C. 1981. *Solanum correllii*, a new tuber-bearing species from Ecuador. Am. Pot. Journ. 58 (5): 223-225.

Ochoa, C. 1981. Two new tuber-bearing Solanums from South America. Phytologia 48 (3): 229-232.

Ochoa, C. 1981. Colombian tuber-bearing Solanums in the Conicibaccata series. Phytologia 49: 485-487.

Ochoa, C. 1981. *Solanum sawyeri*, a new wild potato species from the Peruvian tropics. Am. Pot. Journ. 58 (12): 649-652.

Parker, B. L., R. H. Booth and C. P. Haines. 1981. Arthropods infesting stored cassava (*Manihot esculenta* Crantz) in peninsular Malaysia. Protection Ecology 3: 141-156.

Raman, K. V., M. Palacios and J. Alcázar. 1981. Progress of work on varietal resistance to potato insect pests at International Potato Center. Annual Plant Resistance to Insects Newsletter 7: 62-64.

Vander Zaag, P. and Fox, R. L. 1981. Field production of yams (*Dioscorea alata*) from stem cuttings. Trop. Agric. (Trinidad) 58 (2): 143-5.

Research and Consultancy Contracts

Breeding and Genetics Department

1. Cornell University. "The Utilization of *Solanum tuberosum* spp. *andigena* Germ Plasm in Potato Improvement and Adaptation." R. L. Plaisted, H. D. Thurston, W. M. Tingey, R. E. Anderson, B. B. Brodie, M. B. Harrison and E. E. Ewing.

2. North Carolina State University. "Breeding and Adaptation of Cultivated Diploid Potato Species." F. L. Haynes.

3. I. V. P. Agricultural University, Wageningen. "A Breeding Program to Utilize the Wild Solanum Species of Mexico." J. G. Th. Hermsen.

4. University of Wisconsin, Madison, U.S.A. "Potato Breeding Methods with Species, Haploids and 2n Gametes." S. J. Peloquin.

5. Instituto Nacional de Tecnología Agropecuaria, Argentina. "Programa de Utilización de Mayor Variabilidad Genética en el Plan de Mejoramiento de Papa." A. Mendiburu.

6. Agriculture Canada. "Response of Tuberosum Genotypes to Environmental Stress." D. A. Young.

7. Instituto Nacional de Investigación y Promoción Agropecuaria, INIPA, Perú. "Evaluación de Clones Avanzados del CIP y del Proyecto Nacional de Papa Peruana." M. Quijandría.

Pathology Department

8. Instituto Colombiano Agropecuario, Rionegro, Colombia. "Evaluación de la Resistencia de Material Genético de Papa a *Phytophthora infestans*." O. Pérez.

9. Universidad Nacional de Huamanga, Ayacucho, Perú. "Evaluación de Resistencia a *Synchytrium endobioticum* de clones de Papa en Condiciones de Campo." J. Valladolid Rivera.

10. University of Wisconsin, U.S.A. "Fundamental Research to Develop Control Measures for Bacterial Pathogens of the Potato." A. Kelman, L. Sequeira.

11. Instituto Colombiano Agropecuario, Rionegro, Colombia. "Evaluación de la Resistencia de Material Genético de Papa a *Pseudomonas solanacearum* y *Phytophthora infestans*." R. Navarro.

12. Department of Agriculture, Sri Lanka. "Development of Resistance and Control of Bacterial Wilt for the Mid and High Elevations of Sri Lanka." M. Velupillai.

13. Universidad Nacional "Hermilio Valdizán", Huánuco, Perú. "Evaluación de la Resistencia de Material Genético de Papa a *Pseudomonas solanacearum*, *Phytophthora infestans*, *Meloidogyne* sp., virus y otros Fitopatógenos en Huánuco." E. Torres.

14. National Agricultural Laboratories, Nairobi, Kenya. "The Reaction of Selected Potato Clones to Two Races of *Pseudomonas solanacearum* in Kenya." A. H. Ramos.

15. Swiss Federal Agricultural Research Station, Changins, Nyon, Switzerland. "Detection of PLRV through Antiserum Production and Improved Serological Techniques." P. Gugerli.

16. Universidad Nacional Agraria, La Molina, Peru. "Consultancy on the Production of Antisera Project in the Virus." C. Fribourg.

17. Universidad Nacional Agraria, La Molina, Perú. "Mejoramiento de la Resistencia al PVY." E. Fernández-Northcote.

Nematology and Entomology Department

18. Foundation for Agricultural Plant Breeding, Wageningen. "Resistance Breeding Against the Potato Eelworm, *Globodera rostochiensis*." C. A. Huijsman.

19. North Carolina State University. "Evaluation of Potato Lines for Resistance to the Major Species and Races of Root-knot Nematodes (*Meloidogyne* spp.)." J. N. Sasser.

20. Oregon State University, Corvallis, Oregon, U.S.A. "Chemical Protection of Potato Seed and Seed Pieces from Plant Parasitic Nematodes." H. J. Jensen.

21. Instituto Nacional de Investigación y Promoción Agropecuaria (INIPA), Perú. "Evaluación de Clones Resistentes al Nematodo del Quiste de la Papa, *Globodera pallida*." E. Herrera.

22. Instituto Nacional de Investigaciones Agropecuarias (INIAP), Ecuador. "Evaluación de Clones Resistentes al Nematodo del Quiste (*Globodera* spp.) en Ecuador. F. Muñoz, R. Equiguren.

23. Universidad Nacional Agraria, La Molina, Perú. "Fertilización de la Papa en Trópico Húmedo." S. Villagarcía.

24. Universidad Nacional Agraria, Peru. "Consultancy on Agronomy and Fertility for the Adaptation of the Potato to Tropical Conditions." S. Villagarcía.

25. Ministry of Agriculture, La Molina/Huancayo, Peru. "Development of Low Cost Storage Technology." A. Córdova (La Molina), O. Cuyubamba (Huancayo).

26. Instituto Colombiano Agropecuario, Colombia. "Potato Seed Storage with Diffuse Light in Colombia." A. Rodríguez, F. Moreno.

27. University of Glasgow, Scotland. "The Effect of Diffused Light on Potato Sprout Growth During Storage." H. Duncan.

28. Victoria Department of Agriculture, Australia. "Production of Pathogen-tested Potato Germ Plasm for South-East Asian and Pacific Countries." P. T. Jenkins.

Support Department

29. University of Birmingham, England. "Consultancy in Exploration, Taxonomy, Maintenance and Utilization of Potato Germ Plasm." J. Hawkes.

30. Universidad Nacional Agraria, La Molina, Peru. "Consultancy on Design, Statistics and Computer Processing of Research Experiments." L. Ramírez.

Training and Communications Department

31. International Agriculture Centre, Wageningen. "Consultancy on Potato Improvement in North Africa." H. P. Beukema.

Staff

(by Department and Region on December 31, 1981 or serving a major part of 1981)

Richard L. Sawyer, Ph. D.	Director General
Roger Rowe, Ph. D.	Deputy Director General
William A. Hamann, B. S.	Assistant to Director General

Research

Orville T. Page, Ph. D.	Director

Breeding and Genetics

Humberto Mendoza, Ph. D.	Head of Department
Zósimo Huamán, Ph. D.	Geneticist
Charles Brown, Ph. D.	Geneticist
Masaru Iwanaga, Ph. D.	Cytogeneticist
Peter Schmiediche, Ph. D.	Breeder
Juan Landeo, Ph. D.	Breeder
Haile Michael Kidane, Ph. D.	Breeder

Nematology and Entomology

Parviz Jatala, Ph. D.	Head of Department
Javier Franco, Ph. D.	Nematologist
María Scurrah, Ph. D.	Breeder-Nematologist
Severino A. Raymundo, Ph. D.	Plant Protection Specialist
K. V. Raman, Ph. D.	Entomologist
S. V. Rama Rao, Ph. D.	Entomologist (Region IV)
Luis Valencia, Ing. Agr.	Entomologist (study leave)
Bruce L. Parker, Ph. D.	Visiting Entomologist

Pathology

Edward R. French, Ph. D.	Head of Department
Carlos Martin, Ph. D.	Pathologist
William Hooker, Ph. D.	Virologist
Luis Salazar, Ph. D.	Virologist
Anwar Rizvi, Ph. D.	Virologist-Breeder
Jan Henfling, Ph. D.	Mycologist
Fritz Elango, Ph. D.	Mycologist

Physiology

Sidki Sadik, Ph. D.	Head of Department
Patricio Malagamba, Ph. D.	Physiologist
Robert Booth, Ph. D.	Physiologist
Lieselotte Schilde, Ph. D.	Physiologist
David Midmore, Ph. D.	Physiologist
Siert Wiersema, M. S.	Physiologist
Jeffrey White, Ph. D.	Physiologist
Roy Shaw, B. S.	Physiologist

Taxonomy

Carlos Ochoa, M. S.	Head of Department

Support Department

Orville T. Page, Ph. D.	Head of Department
Marco Soto, Ph. D.	Superintendent - Huancayo
César Paredes, Ing. Agr.	Field & Greenhouse Supervisor/Hyo
Dennis Cunliffe, Ing. Agr.	Field & Greenhouse Supervisor - Lima
Enrique Grande	Field Supervisor - San Ramon
Eduardo Belda, Ing. Agr.	Field Supervisor - Yurimaguas
Joseph K. Campbell, Ph. D.	Visiting Agr. Engineer

Regional Research

Headquarters

Kenneth J. Brown, Ph. D.	Director
Primo Accatino, Ph. D.	Coordinator, Research Transfer
James E. Bryan, M. S.	Senior Seed Prod. Spec.

Region I — Andean Latin America

Oscar Malamud, Ph. D.	Regional Representative

Region II — Non-Andean Latin America

Oscar Hidalgo, Ph. D.	Regional Representative

Region III — Tropical Africa

Sylvester Nganga, Ph. D.	Regional Representative
Peter Vander Zaag, Ph. D.	Research Scientist - Rwanda, Burundi
Andre Devaux, Ir.	Research Scientist - Rwanda, Burundi
Eisse Luitjens, Ir.	Assoc. Res. Scientist

Region IV — Near and Middle East

Marciano Morales Bermúdez, M. S.	Regional Representative
S. V. Rama Rao, Ph. D.	Entomologist
Anton Haverkort, Ir.	Associate Scientist, Turkey
Willem Shrage, Ir.	Research Scientist (Tunisia)

Region V — Southwest Asia

Garry Robertson, M. S.	Regional Representative (to June, 1981)

Region VI — South Asia

Mahesh Upadhya, Ph. D.	Regional Representative
Hari Kishore, Ph. D.	Consultant
Bharat L. Karmacharya, Ph. D.	Production Specialist, Bhutan Special Project

Region VII — Southeast Asia

Lindsay Harmsworth, B. Ag. Sc.	Regional Representative
Michael Potts, Ph. D.	Agronomist
Richarte Acasio, M. Sc.	Research Scientist

Social Science Department

Douglas Horton, Ph. D.	Head of Department
Roger Cortbaoui, Ph. D.	Agronomist/Economist
Aníbal Monares, Ph. D.	Agricultural Economist
Robert Rhoades, Ph. D.	Anthropologist
Susan Poats, Ph. D.	Anthropologist
Gregory Scott, Ph. D.	Agricultural Economist - Special Project

Training & Communications Department

Manuel Piña, Ph. D.	Head of Department
Garry Robertson, M. S.	Senior Training Officer
Rainer Zachmann, Ph. D.	Training Materials Officer
Carmen Siri, Ph. D.	Communications Specialist - Special Project
Frank Shideler, M. A.	Senior Editor
Hernán Rincón, Ph. D.	Spanish Editor
Carmen Podestá, M. A. Inf. Sc.	Librarian

Administration

Office of Executive Officer

Adrián Fajardo, M. S.	Executive Officer
Lucas Reaño, C. P. C.	Administrative Supervisor
Germán Rossani, M. D.	Medical Officer
Fernando Canalle, Ing. Civ.	Works Supervisor
Georgio De-Gasperi	Transportation Supervisor
Jacques Vandernotte	Pilot
Ana Dummett, B. S. Asist. Soc.	Social Assistant

Accounting

Leonardo Hussey	Controller
Oscar Gil, C. P. A.	Assistant Controller
Guillermo Romero	Head Accountant
Jorge Bautista, B. S.	Accountant
Blanca de Joo, C. P. A.	Accountant

Scientific Associates

Carmen Felipe Morales, Ph. D.	Agronomist
Enrique Fernández-Northcote, Ph. D.	Visiting Scientist
César Fribourg, M. S.	Visiting Scientist
Teresa Ames de Icochea, Ph. D.	Mycologist
Sven Villagarcía, Ph. D.	Agronomist

Scientific Assistants

Luis Calúa, Ing. Agr.	Breeding and Genetics
Walter Amorós, M. S.	Breeding and Genetics
Ricardo Wissar, M. S.	Breeding and Genetics
Luis Manrique, Ing. Agr.	Breeding and Genetics
Rosario Gálvez, Biol.	Breeding and Genetics
Renate Kaltenbach, B. B. A.	Nematology
Marcia Bocángel, B. S.	Nematology
María Palacios, Biol.	Nematology
Angela Matos, Ing. Agr.	Nematology
Jesús Alcázar, M. S.	Nematology
Lilian G. de Lindo, Ing. Agr.	Pathology
Ursula Nydegger, Tech. Dip.	Pathology
Carlos Chuquillanqui, B. S.	Pathology
Ernesto Velit, Biol.	Pathology
Josefina de Nakashima, Biol.	Pathology
Wilman Galíndez, Ing. Agr.	Pathology
Hans Pinedo, Ing. Agr.	Pathology
Jorge Abad, M. S.	Pathology
Charlotte Lizárraga, B. S.	Pathology
Hebert Torres, M. S.	Pathology
Nelly de Fong, M. S.	Physiology
Norma Gonzales, Q. F.	Physiology
Nelson Espinoza, Biol.	Physiology
Jorge Roca, Biol.	Physiology
Rolando Lizárraga, Ing. Agr.	Physiology
Alberto Yupanqui, M. S.	Physiology
Rolando Estrada, Biol.	Physiology
Rolando Cabello, Ing. Ag.	Physiology
Donald Berríos, Ing. Agr.	Physiology
Matilde Orrillo, Biol.	Taxonomy
Alberto Salas, B. S.	Taxonomy
María Isabel Benavides, B. S.	Social Science
Hugo Fano	Social Science
Jorge Alarcón, B. S.	Social Science
Jorge Recharte, Lic. Antrop.	Social Science
Nelson Meléndez, Tech. Dip.	Support
Lauro Gómez	Support
Martha Crosby, B. A.	Library
Miguel Quevedo, Ing. Agr.	Communications
María Boisset, B. A.	Communications

INTERNATIONAL POTATO CENTER - CIP

FINANCIAL STATEMENTS
DECEMBER 31, 1981 AND DECEMBER 31, 1980

SUPPLEMENTARY INFORMATION
DECEMBER 31, 1981

CONTENTS

US$ = United States dollar
S/. = Peruvian sol

Moreno Patiño y Asociados
ASOCIADOS CON PRICE WATERHOUSE

LAS BEGONIAS 441
APARTADO 2869
LIMA 27, PERU
TELEFONO 40-0555
TELEX 20008 PRIWATR

April 7, 1982

REPORT OF INDEPENDENT ACCOUNTANTS

To the Board of Trustees
International Potato Center - CIP

In our opinion, the accompanying balance sheets and related statements of source and application of funds present fairly the financial position of International Potato Center - CIP at December 31, 1981 and December 31, 1980 and the source and application of funds for the years then ended, in conformity with generally accepted accounting principles consistently applied. This opinion is based on an examination which was made by us 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.

Moreno, Patiño y Asociados

Countersigned by

------------------------------(partner)
Francisco J. Moreno
Peruvian Public Accountant
Registration No. 155

INTERNATIONAL POTATO CENTER - CIP

BALANCE SHEET (Note 1)

ASSETS

	At December 31, 1981 US$	At December 31, 1980 US$
CURRENT ASSETS		
Cash on hand and in banks	590,317	135,610
Short term investments	81,369	-
Accounts receivable		
Donors	633,174	461,169
Advances to principal and support staff	38,871	43,757
Loans due from principal and support staff-short term (Note 2)	182,128	78,764
Advances to third parties for research work	200,640	54,024
Other (Note 3)	147,263	202,781
	1,202,076	840,495
Inventories of laboratory, spares and other supplies	515,874	544,470
Prepaid expenses and other assets	57,992	79,241
Total current assets	2,447,628	1,599,816
LOANS DUE FROM PRINCIPAL AND SUPPORT STAFF - LONG TERM (Note 2)	688,512	374,905
FIXED ASSETS (Note 4)	6,013,603	4,705,702
	9,149,743	6,680,423

LIABILITIES, CAPITAL BALANCES AND UNEXPENDED FUNDS

	At December 31, 1981 US$	At December 31, 1980 US$
CURRENT LIABILITIES		
Bank loan and overdrafts (Note 2)	204,166	111,795
Other loan (Note 5)	-	100,747
Accounts payable to vendors and third parties	646,220	272,728
Other	48,700	44,126
Total current liabilities	899,086	529,396
GRANTS RECEIVED IN ADVANCE (Note 6)	389,887	139,736
PROVISION FOR SEVERANCE INDEMNITIES, net of advances of US$ 15,375 in 1981 and US$ 12,028 in 1980	167,923	135,291
LONG TERM DEBT		
Bank loan (Note 2)	679,757	362,373
CAPITAL BALANCES AND UNEXPENDED FUNDS		
Capital		
Capitalization of fixed assets	6,013,603	4,705,702
Unexpended funds		
Working funds	702,000	632,000
Core programs	2,806	121,487
Special projects	294,681	54,438
	999,487	807,925
	7,013,090	5,513,627
CONTINGENT LIABILITY (Note 7)		
GRANTS PLEDGED (Note 8)		
	9,149,743	6,680,423

INTERNATIONAL POTATO CENTER - CIP

STATEMENT OF SOURCE AND APPLICATION OF FUNDS (Note 1)

	For the year ended December 31, 1981 US$	1980 US$
SOURCE OF FUNDS		
Operating grants		
Unrestricted	3,804,203	3,530,832
Restricted	4,702,011	3,834,406
	8,506,214	7,365,238
Special project grants	712,387	477,534
Capital grants	545,765	329,306
Working fund grants	702,000	632,000
Other income, net	207,841	160,967
	10,674,207	8,965,045
APPLICATION OF FUNDS		
Core operating expenses		
Potato research program	2,139,377	2,117,039
Research support	860,158	676,293
Regional research and training	2,561,562	2,569,270
Library, documentation and information service	384,846	329,825
General administration	813,396	843,650
General operating costs	1,951,911	868,641
	8,711,250	7,404,718
Special projects	417,705	423,096
	9,128,955	7,827,814
Capital		
Additions to fixed assets	545,765	329,306
	9,674,720	8,157,120
UNEXPENDED FUNDS	999,487	807,925

INTERNATIONAL POTATO CENTER - CIP

NOTES TO FINANCIAL STATEMENTS
DECEMBER 31, 1981 AND DECEMBER 31, 1980

1 OPERATIONS AND SUMMARY OF ACCOUNTING POLICIES

The International Potato Center - CIP was constituted in 1972, in accordance with the Agreement for Scientific Cooperation between the Government of Peru and North Carolina State University, United States of America, signed in 1971 and expiring in the year 2,000.

The CIP is a non-profit organization, centered in Lima, Peru, with programs located throughout America, Europa, Asia and Africa. The 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, seminars and, other activities in accordance with its objectives.

In accordance with existing legislation and provisions of the Agreement described above, the CIP is exempt from income tax and other taxes.

The aforementioned Agreement provides that, if for any reason the CIP'S operations are terminated, all of its assets will be transferred to the Peruvian Ministry of Agriculture.

The CIP is authorized to maintain and utilize checking accounts in foreign currencies for all operations, subject to the provisions of the law in effect for international organizations.

The principal accounting policies are as follows:

a) The books and accounts are maintained in U.S. dollars. Transactions are mainly in U.S. dollars, and assets and liabilities that are denominated in currencies other than the U.S. dollar are translated at an exchange rate which approximates the official exchange rate at the year end. Translation gains and losses are included in the statement of source and application of funds as other income, net.

b) Grant transactions are accounted for on an accrual basis. Restricted operating grants and unrestricted grants are accounted for in the period stipulated by the donor. Expenditures for grants utilized by international programs are recorded on the basis of advices received.

In accordance with the instructions of the Consultative Group on International Agricultural Research, the unexpended fund balances at year end, if authorized by donors, are treated as a source of funds in the next year in order to absorb corresponding expenses, otherwise the unexpended balances are recorded as liabilities.

Special project grants are recorded in the year they are pledged and the related expenses are applied against the respective income when incurred.

Working capital grants are recorded in the year they are received.

c) Short-term investments are valued at cost and bear annual interest of approximately 13%.

d) The laboratory, spares and other materials are generally valued at estimated actual value, which approximate cost.

e) Fixed assets are recorded as applications of funds at the time of their acquisition and are simultaneously capitalized at their purchase cost.

It is not the policy of the CIP to reduce the net value of the fixed assets and the related capital account for depreciation. When assets are sold or retired their cost is removed from fixed assets and the related capital account.

Maintenance and repairs are recorded as operating costs.

f) Indemnities to local staff are accrued in full in accordance with Peruvian legislation.

2 LOANS TO PRINCIPAL AND SUPPORT STAFF

The balance of the loans granted to principal and support staff for home and vehicles purchases at December 31, is presented in the balance sheet as follows:

	1981 US$	1980 US$
Loan-current portion, including interest receivable of US$3,736 (US$4,765 in 1980)	182,128	78,764
Loan-long term portion	688,512	374,905

Substantially all loans to principal and support staff have been financed by a line of credit from Citibank N.A. New York totalling US$ 1,000,000 in favor of the CIP. Interest is charged at 1 1/2% per annum over the Citibank N.A., New York prime rate on the aggregate unpaid amount of used credit. Total outstanding credit at December 31, 1981 and 1980 is US$ 872,070 and US$ 447,871, respectively. Loans to qualifying principal and support staff are secured by first mortgages on properties acquired and payment terms extend to 10 years with interest charged at rates which absorb the related CIP liabitity to Citibank N.A., New York. Under the amortization program established, the current portion of payments on the outstanding credit total US$ 192,313 (US$ 85,498 in 1980) including accrued interest of US$ 12,501 (US$ 8,652 in 1980) is shown under current liabilities in Bank loan and overdrafts in the balance sheet.

3 ACCOUNTS RECEIVABLE - OTHER

This account comprises the following at December 31:

	1981 US$	1980 US$
Advance to contractors and others	29,009	50,904
Current account of "Proyecto Suelos Tropicales - Yurimaguas" of North Carolina State University	50,199	73,109
Travel advances and revolving funds to principal and support staff	65,113	62,501
Guarantee deposit (Note 7)	2,942	4,359
Others	-	11,908
	147,263	202,781

4 FIXED ASSETS

Fixed assets at December 31, comprise the following:

	1981 US$	1980 US$
Buildings and construction in progress	1,932,617	1,730,586
Research equipment	712,429	670,081
Vehicles and aircraft	1,538,951	776,560
Furniture, fixture and office equipment	458,516	441,346
Operating equipment	225,276	151,978
Installations	676,310	633,288
Site development	290,025	162,935
Communication equipment	107,140	71,415
Other	72,339	67,513
	6,013,603	4,705,702

Vehicles and other fixed assets replaced to be sold are transferred from the fixed asset and related capital account to a memorandum account. The balance of this memorandum account at December 31, 1981 is US$ 252,065 (US$ 116,502 in 1980).

5 OTHER LOAN

The 1980 loan balance from Proyecto Regional Cooperativo de la Papa (PRECODEPA) totalling US$ 100,747 (including US$ 747 of interest payable) bearing interest of 20.69% per annum, was paid in its entirety in 1981.

6 GRANTS RECEIVED IN ADVANCE

Donations received in advance to be utilized in the following year are as follows:

	1981 US$	1980 US$
Swiss government	381,553	-
French government	8,334	-
Federal German government	-	139,736
	389,887	139,736

7 CONTINGENT LIABILITY

A constructor has filed a lawsuit against the CIP claiming a payment of S/. 6,394,000 (approximately US$ 12,537) that includes S/. 5,000,000 (US$ 9,800) for damages. The CIP has deposited S/. 1,500,340 (US$ 2,942) in a local bank as guarantee (Note 3). It is the opinion of management and their legal advisor that no significant liability will arise from this contingency.

8 GRANTS PLEDGED

During 1981 the following donations were pledged to the CIP for special projects in 1982, 1983 and 1984:

	1982 US$	1983 US$	1984 US$
United Nations Development Program	85,000	-	-
W.K. Kellog Foundation	56,000	-	-
Swiss - Shakya	19,380	21,740	-
Swiss - Bhutan	100,000	100,000	20,000
German Agency for Technical Cooperation	10,000	12,000	12,000
	270,380	133,740	32,000

Moreno Patiño y Asociados
ASOCIADOS CON PRICE WATERHOUSE

LAS BEGONIAS 441
APARTADO 2869
LIMA 27, PERU
TELEFONO 40-0555
TELEX 20008 PRIWATR

April 7, 1982

REPORT OF INDEPENDENT ACCOUNTANTS

To the Board of Trustees
International Potato Center - CIP

In our opinion, the accompanying information, presented in Exhibit 1 to 4 is stated fairly in all material respects in relation to the financial statements, taken as a whole, of International Potato Center - CIP for the year 1981, which are covered by our report dated April 7, 1982 presented in the first section of this report. The accompanying information is presented as additional data and is not necessary for a fair presentation of the financial position and source and application of funds. Our examination, which was made primarily for the purpose of forming an opinion on the financial statements taken as a whole included such tests of the accounting records, from which the additional information was compiled, and such other auditing procedures as we considered necessary in the circumstances.

Moreno, Patiño y Asociados

Countersigned by

------------------------------(partner)
Francisco J. Moreno
Peruvian Public Accountant
Registration No. 155

Exhibit 1

INTERNATIONAL POTATO CENTER - CIP

ACCOUNTS RECEIVABLE - DONORS
DECEMBER 31, 1981

	US$
Rockefeller Foundation	954
International Development Research Center	6,565
Belgian Government	275,013
Swiss Government	38,030
Canadian International Development Agency	4,478
United Nations Development Program	109,466
Federal German Government	39,786
Commission of the European Communities	158,882
	633,174

Exhibit 2

INTERNATIONAL POTATO CENTER - CIP

FIXED ASSETS
DECEMBER 31, 1981

	Balance as of 1.1.81	Additions	Replacements		Balance as of 12.31.81
			Additions	Retirements	
	US$	US$	US$	US$	US$
Buildings, and construction in progress	1,730,586	201,555	1,476	1,000	1,932,617
Research equipment	670,081	46,955	2,693	7,300	712,429
Vehicles and aircraft	776,560	38,048	975,957	251,614	1,538,951
Furniture, fixture and office equipment	441,346	18,909	12,563	14,302	458,516
Operating equipment	151,978	66,519	8,432	1,653	225,276
Installations	633,288	32,577	15,610	5,165	676,310
Site development	162,935	127,090	-	-	290,025
Communication equipment	71,415	9,286	52,325	25,886	107,140
Other	67,513	4,826	-	-	72,339
	4,705,702	545,765	1,069,056	306,920	6,013,603

Exhibit 3

INTERNATIONAL POTATO CENTER - CIP

SOURCE OF FUNDS
DECEMBER 31, 1981

	US$	US$
CORE OPERATING GRANTS:		
Multi-purpose		
Danish International Development Agency, Denmark	367,813	
Swiss Development Cooperation, Switzerland	383,000	
International Technical Assistance, The Netherlands	300,000	
	1,050,813	
Less:		
Applied to capital	251,984	
Applied to working funds	70,000	
	728,829	
Core unrestricted grants		
Swedish Agency for Research Cooperation	810,959	
Overseas Development Administration, United Kingdom	542,007	
International Development Agency, Canada	623,325	
Federal German Government	503,272	
Australian Development Assistance Agency	219,864	
Mexican Government	100,000	
Spanish Government	25,000	
Philippine Government	50,000	
Belgian Government	87,495	
	2,961,922	
Plus:		
Balance from previous years	113,452	
	3,075,374	3,804,203
Core restricted grants		
Agency for International Development, USA	2,200,000	
International Fund for Agricultural Development	517,000	
Japan Economic Cooperation Bureau	200,000	
Interamerican Development Bank	860,000	
Belgian Government	163,737	
European Economic Community	653,239	
French Government	100,000	
	4,693,976	
Plus:		
Balance from previous years	8,035	4,702,011
		8,506,214
Carried forward:		8,506,214

Exhibit 3
Page 2

	US$	US$
Brought forward:		8,506,214
SPECIAL PROJECT GRANTS:		
Swiss Development Cooperation, Switzerland	202,180	
Federal German Government	154,457	
International Development Research Center	39,287	
International Development Agency, Canada	(3,085)	
United Nations Development Program	158,600	
Belgian Government	53,340	
W.K. Kellog Foundation	35,000	
Australian Development Assistance Bureau	18,170	
Balance from previous years:		
W.K. Kellog Foundation	1,665	
Swiss Development Cooperation, Switzerland	1,584	
International Development Agency, Canada	11,834	
United Nations Development Program	34,128	
Federal German Government	(34,078)	
International Development Research Center	34,403	
Ford Foundation	4,902	712,387
CAPITAL GRANTS:		
Transferred from multi-purpose funds	251,984	
Belgian Government	23,781	
International Development Association	270,000	545,765
WORKING FUNDS:		
Transferred from multi-purpose funds	70,000	
Balance from previous years	632,000	702,000
OTHER INCOME, net		207,841
		10,674,207

Exhibit 4

INTERNATIONAL POTATO CENTER - CIP

MOVEMENT OF SOURCE AND APPLICATION OF FUNDS OF SPECIAL PROJECTS
DECEMBER 31, 1981

Name of donors and projects	Funds provided US$	Disbursements: Prior years US$	Disbursements: This year US$	Disbursements: Total accumulated US$	Balance to date US$
Ford Foundation -					
Improve potato production	127,300	129,067	-	129,067	(1,767)
Training and research activities in Colombia and Ecuador	54,607	47,938	6,163	54,101	506
	181,907	177,005	6,163	183,168	(1,261)
Federal German Government -					
Potato marketing	42,214	-	17,733	17,733	24,481
Electrophoresis technique	40,815	-	-	-	40,815
Regional seed production specialist	149,391	112,040	23,637	135,677	13,744
	232,420	112,040	41,370	153,410	79,010
Swiss Development Cooperation, Switzerland -					
Potato improvement - Nepal (First Phase)	241,649	241,649	-	241,649	-
Potato improvement - Nepal (Second Phase)	234,830	182,556	36,329	218,885	15,945
Basic seed potato production training	35,000	4,181	18,072	22,253	12,747
PRECODEPA - Second Phase	25,000	14,330	2,420	16,750	8,250
Helvetas potato project - Bhutan	110,000	-	80,238	80,238	29,762
	646,479	442,716	137,059	579,775	66,704
International Development Agency, Canada -					
Potato improvement - Tunisia	272,352	263,604	26,406	290,010	(17,658)
United Nations Development program -					
Technology transfer on root and tubes crops	195,000	2,271	75,363	77,634	117,366
International Development Research Center -					
Agro-Economic research on potato production	248,556	216,010	32,331	248,341	215
Potato dehydration	61,132	19,988	25,299	45,287	15,845
	309,688	235,998	57,630	293,628	16,060
W.K. Kellog Foundation -					
Develop training material	70,000	33,335	41,682	75,017	(5,017)
Australian Development Assistance Bureau -					
Sapprad	18,170	-	32,033	32,033	(13,863)
Belgian Government -					
Rwanda	53,340	-	-	-	53,340
	1,979,356	1,266,969	417,706	1,684,675	294,681

THE INTERNATIONAL POTATO CENTER

Schedule 1: FUNDS PROVIDED AND COSTS
For the year ended December 31,1981
(Expressed in thousand of U.S. dollars)

	Total Funds Available	PROGRAM COSTS						% of Gral. Adm.& Operat. to Direct	Unex-pended Balance	Payable to Donors
		Fixed Assets	Total Research	Reg.Res. & Training	Library Doc. & Inf.	General Administ.	General Operating			
Unrestricted Core	(1) 3'966.6		1'388.1	605.3	233.4	401.6	1'380.8 (2)	45	(42.6)	Ø
Restricted Core										
USAID	2'200.0		829.9	708.7	106.5	225.1	329.8	33.7	-	
IFAD	517.0		-	517.0	-	-	-	-	-	
IDB	860.0		201.9	396.4	44.9	88.2	128.6	33.7	-	
Belgium	(3) 209.1		-	142.4	-	21.3	-	15	45.4	
E.E.C.	653.3		395.8	92.8	-	67.0	97.7	33.7	-	
French	100.0		74.8		-	10.2	15.0	33.7	-	
Japan	200.0		101.0	99.0	-	-	-	-	-	
Federal Germany	8.0		8.0	-	-	-	-	-	-	
Total Restricted Core	4'747.4		1'611.4	1'956.3	151.4	411.8	571.1		Ø	Ø
Total Operating Costs	8'714.0		2'999.5	2'561.6	384.8	813.4	1'951.9		2.8	
Capital Grants										
IBRD-IDA	270.0	270.0								
Belgium	23.8	23.8								
Transferred from multi-purpose	252.0	252.0								
Total Capital	545.8	545.8								
Special Projects										
Ford Foundation	4.9			5.3		0.8		14	(1.2)	
Federal Germany	120.4			36.5		4.9		13	79.0	
Swiss Dev. Coop.	193.1	16.2		111.6		6.9		15	58.4	
Swiss - PRECODEPA	10.7			2.4		-		-	8.3	
CIDA	8.7			23.4		3.0		14	(17.7)	
UNDP	192.7			63.6		11.7		15	117.4	
IDRC	73.7	6.6		46.8		4.2		14	16.1	
W.K. Kellog Foundation	36.7			41.7		-		-	(5.0)	
ADAB - SAPPRAD	18.2			32.1		-		-	(13.9)	
Belgian Government	53.3			-		-		-	53.3	
Total Special Projects	712.4	22.8	-	363.4	-	31.5	-		294.7	Ø
Working Funds										
Transferred from Multi-purpose	70.0									
Balance from previous year	632.0									
Total Working Funds	702.0								702.0	Ø
TOTAL FUNDS AND COSTS	10'674.2	568.6	2'999.5	2'925.0	384.8	844.9	1'951.9		999.5	Ø

1) Includes $162,454 from earned income.
2) Including the replacement of the aircraft.
3) Includes $45,387 from earned income.

THE INTERNATIONAL POTATO CENTER

Schedule 2: EARNED INCOME AND APPLICATIONS

For the year ended December 31, 1981

(Expressed in thousand of U.S. dollars)

	Approved Budget	Actual
Sources of Earned Income		
Interest on Deposits	50	74.0
Sale of Crops & Materials	10	16.0
Sale of Fixed Assets	110	138.9
Indirect Costs charges on Special Projects & Current Accounts	65	66.3
Adjustment prior year	-	(10.9)
Rate of Exchange adjustment	10	(34.4)
Other	-	6.3
Sub-Total	245	256.2
Less: Auxiliary Services Deficit	(45)	(48.4)
TOTAL	200	207.8
Application of Earned Income		
Applied to Core Operations	200	207.8

THE INTERNATIONAL POTATO CENTER

Schedule 3: COMPARATIVE STATEMENT OF ACTUAL EXPENSES

AND APPROVED BUDGET FOR THE YEAR ENDED DECEMBER 31, 1981

(Expressed in thousand of U.S. dollars)

	Operating Unrestricted		Operating Restricted		Capital	
	Budget	Actual	Budget	Actual	Budget	Actual
Programs						
Potato Research		1'388.1		1'611.4		
Regional Research & Training		605.3		1'956.3		
Library, Doc. & Info. Services		233.4		151.4		
General Administration		401.6 1)		411.8		
General Operating Costs		1'380.8 1)		571.1		
Contingencies		-		-		
	4'249.6	4'009.2	4'747.4	4'702.0		
Capital						
Operating Equipment					40.5	66.5
Research Equipment					34.5	47.0
Vehicles & Aircraft					21.6	38.0
Furniture, Fixtures & Off. Equip.					35.0	18.9
Installation & Utilities					15.0	32.6
Constructions & Buildings					145.1	201.6
Site Development					4.0	127.1
Communication Equipment					2.3	9.3
Other Equipment					2.0	4.8
					300.0	545.8
Analysis of Variances						
Budget Surpluses						
- Additional earned income	7.8					
- Grant shortfall	(45.0)					
- Transferred to Capital	(245.8)				245.8	
- Net surplus				45.4		
Deficits						
- Net Deficit	42.6					
TOTAL BUDGET VS EXPENSES AND APPLICATION OF VARIANCES	4'009.2	4'009.2	4'747.4	4'747.4	545.8	545.8

1) Includes the replacement of the aircraft.