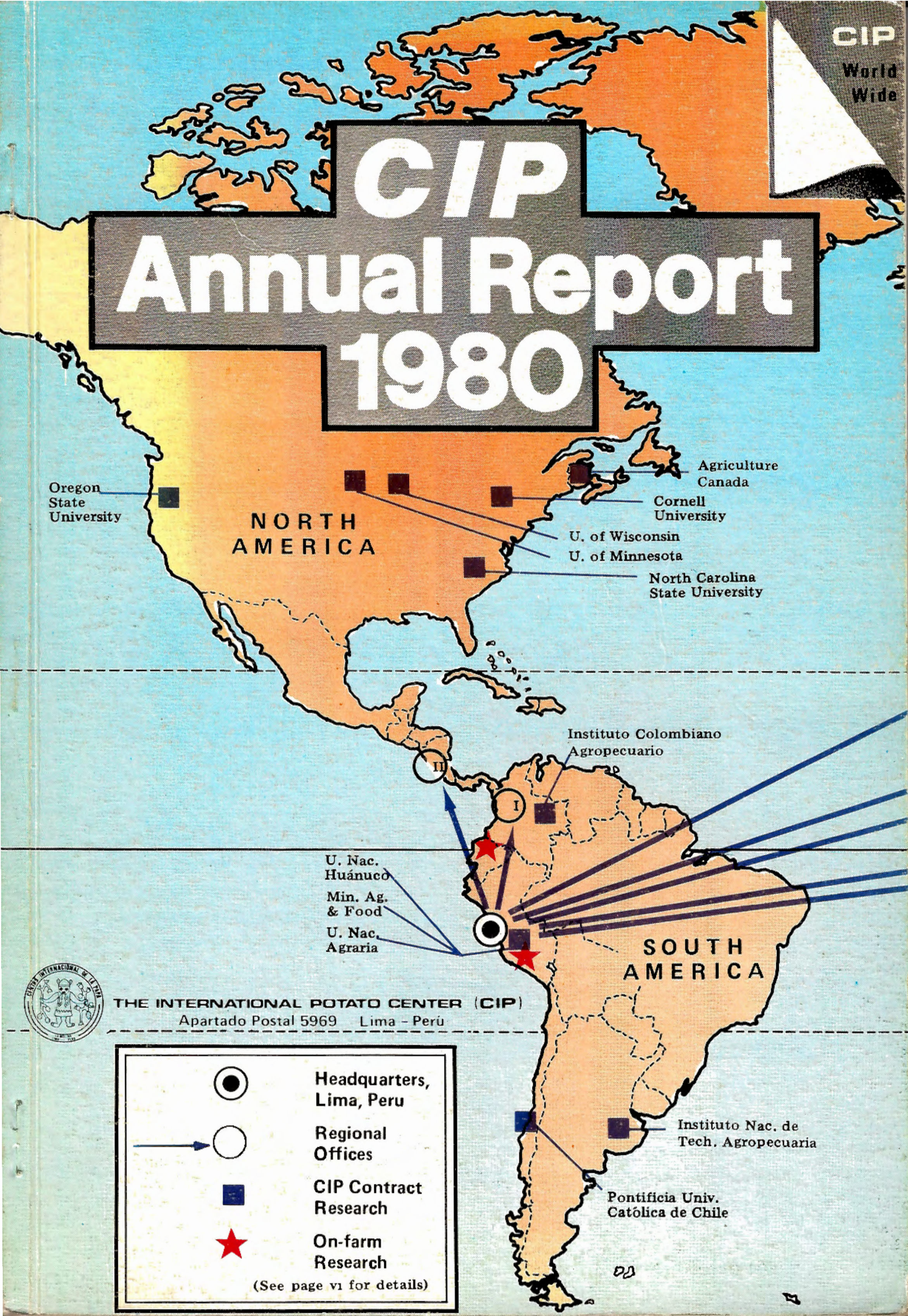
CIP Annual Report 1980



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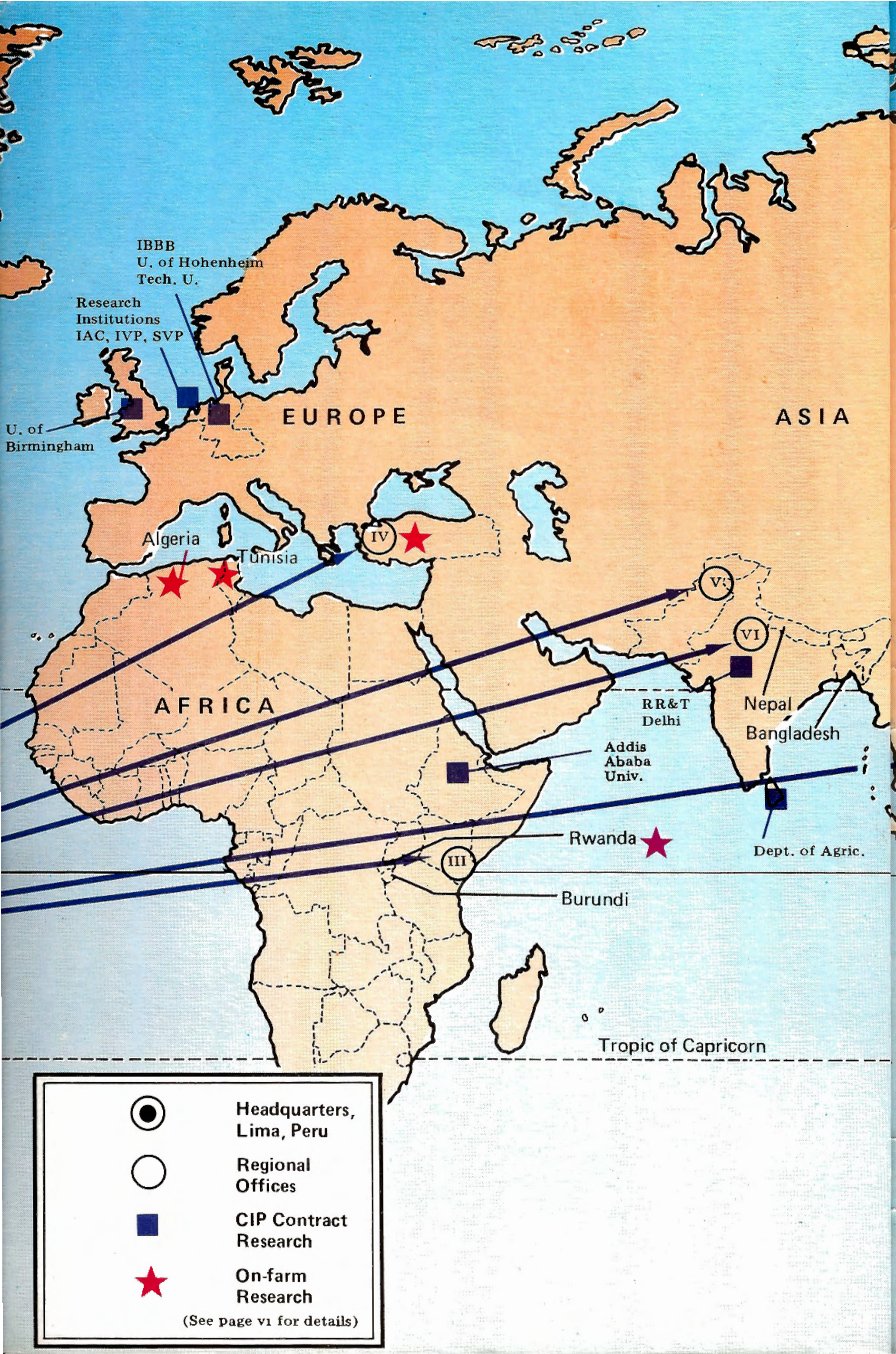

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CIP Contract
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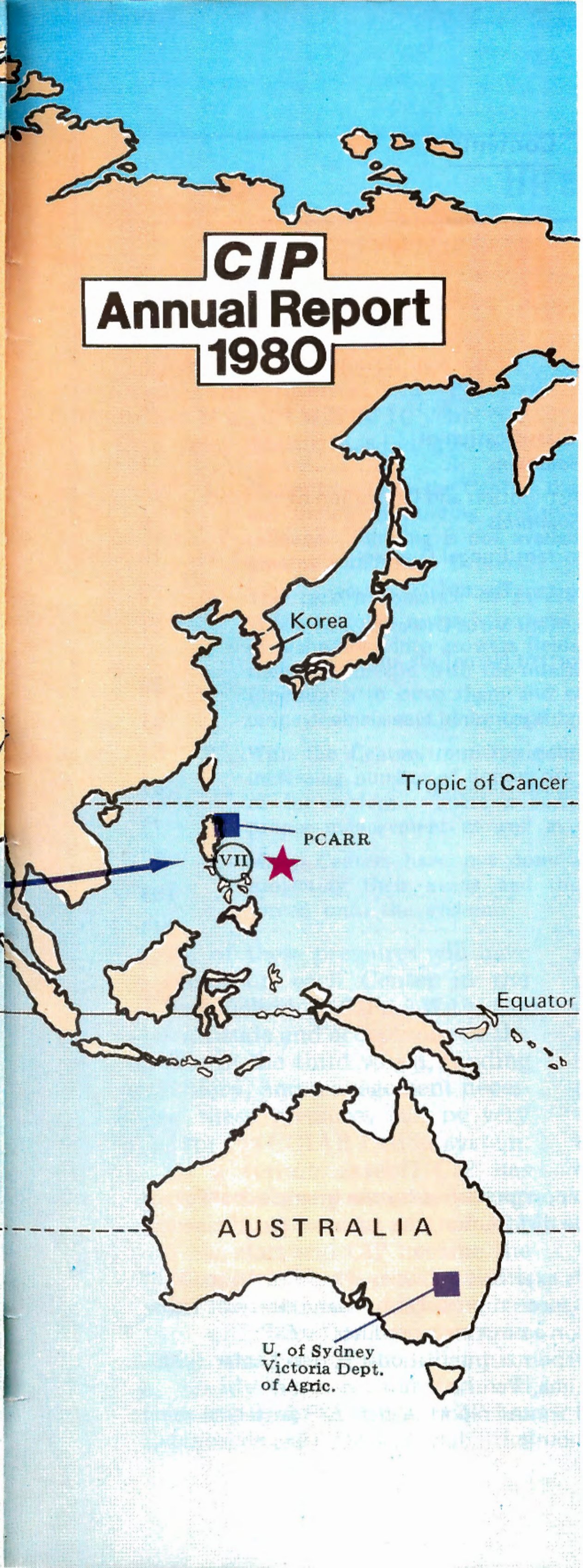
On-farm
Research
(See page vi for details)

CIP Annual Report 1980



Contents

This is the ninth annual report published by the International Potato Center. Printed for worldwide distribution, the report covers the period of calendar 1980.

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 Report

The CGIAR research system of which the International Potato Center is a part will be 10 years old next year. Maturity is being forced onto the system faster than expected by a number of pressures. Some of these pressures are:

1. Commitments to the Centers these past 2 years indicate there is not unlimited funding available for Centers of scientific excellence. Funding is not available for unlimited growth of the present established Centers.
2. The lack of balance of investments in international Centers versus national research systems is not providing a smooth flow of technology into growers fields. Nationals are thus questioning their relationship with the international Centers whose principal function is to serve them and wondering if Centers are getting money which should be coming to national research programs.
3. With the Centers receiving nearly US$ 150 million a year, an increasing number of donors are concerned with the informality of the system. There is correctly an increasing concern for proper management as well as scientific expertise.
4. Many Centers have not done a very good job of adequately projecting their needs and thus long-term planning is being forced onto the system.

All of these pressures will have an effect on each Center in the system including CIP. With the right attitude and acceptance of the realities in the third world, funding availability, and management necessities, these pressures can be very good for the CGIAR Center system.

To a certain extent, CIP has anticipated these pressures. Long-term planning was a part of CIP from the start and CIP became the first Center to develop and publish a plan for activities and involvement with developing countries through the year 2000. This plan has already been revised and will be revised again in 1982. CIP has developed very modest facilities so that there is not a continuing major expense in overhead and maintenance. A portion of CIP's priority research is accomplished by contracts which can be expanded or reduced in accordance with funding availability. From the start a similar investment has been placed in research transfer as in research. This included the development of specific strategies for the smooth transfer of relevant technology into growers fields in a way which would help creditable images emerge for national scientists.

In order to help protect the Center from the funding uncertainties which almost every donor faces at times, CIP has intentionally developed a broad base of relatively modest donors. Two new donors joined the list in 1980 and probably two more will join in 1981.

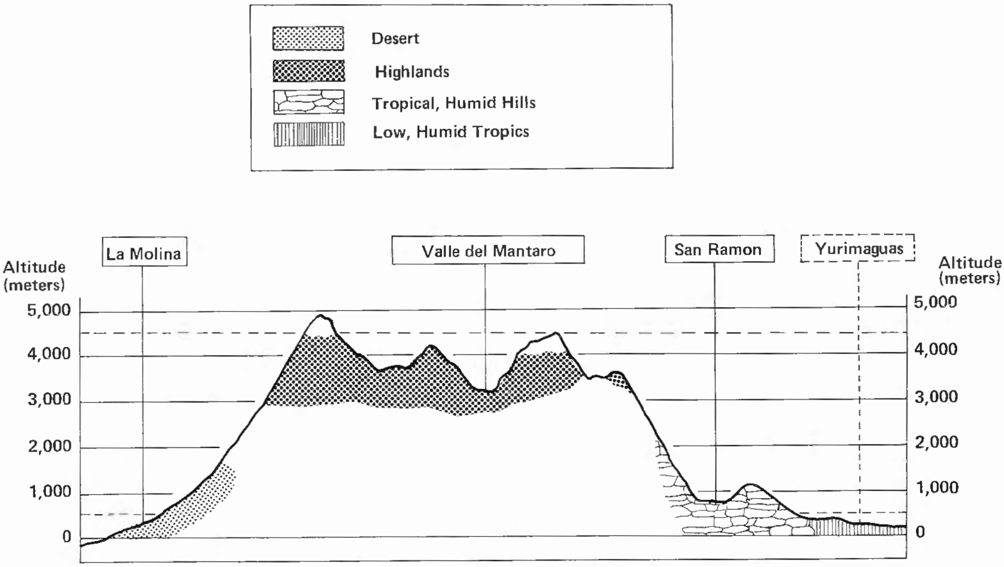
CIP has been management orientated from the start. Board members have been identified specifically for their management, training and experience. CIP's Deputy Director was sent to advance executive management training the year of his appointment and the Director of Regional Research was sent last year. A Department Head and the Head of Technology Transfer are scheduled to go for concentrated management training this year. Thus, management capabilities are being joined with senior scientific capabilities at several levels.

Because of the pressures on the system which are emerging, it is indeed fortunate that the CGIAR system is being reviewed during 1981. I am proud to have been chosen to be a part of the Review Committee. Having been a Center Director General since the beginning of the system in 1972, watching the pressures develop and knowing the many capable people working, planning and managing the system I am confident that strategies will be developed to ensure a continuation of this essential part of the world food production system. I am confident that strategies will be developed which will lead to a better peer relationship amongst Center scientists and national scientists of the third world. CIP must maintain flexibility in attitude and program and be able to continue to adjust to the changing pressures within the system and any new policies which may emerge from the review.

Richard L. Sawyer
Director General
International Potato Center

Board of Trustees

Cross Section, Central Andes
CIP Research Sites



Nearly two billion people live in the environmental zones represented by the four CIP field locations in Peru — desert, alpine and high and low jungle.

Although there are daylength limitations, the range of other physical environmental factors at CIP experimental sites is broad — a range of 3,000 meters altitude, 2,000 mm rainfall and -5° to 40° C in temperature.

Being a center of diversity of the potato, Peru is also a center of diversity 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.

CIP's long-term comparative advantages focus on the exploitation/distribution/utilization of the world potato collection maintained at Huancayo. Through breeding and genetic manipulations new combinations of genes are assembled from CIP's gene bank and screened for climatic adaptation, resistance to specific pests and diseases and stability of good yield.

Station	Latitude (S)	Altitude (m)	Temperature °C Max (mean)	Min (mean)	Mean	Rainfall (mm)	Daylength hr:min 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 1980

In 1972 only three donors were listed as contributing to the financial support of the International Potato Center. The donor list for 1980 is as follows:

	Core	Special Project
Australian Development Assistance Bureau	X	
Belgium Government	X	
Canadian International Development Agency (CIDA)	X	X
Danish International Development Agency (DANIDA)	X	
European Economic Community	X	
Federal German Government	X	X
Ford Foundation		X
French Government	X	
Inter-American Development Bank (IDB)	X	
International Development Research Centre (IDRC)		X
Netherlands Government	X	
Philippines Government	X	
Rockefeller Foundation	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

Data for Cover Maps

Research and Consultancy Contracts

Country	Total	Place
Peru	8	Universidad Nacional de Huánuco (1) Ministry of Agriculture and Food, La Molina (2) Universidad Nacional Agraria, La Molina (5)
United States	7	Cornell University (1) North Carolina State University (2) University of Wisconsin (2) Oregon State University (1) University of Minnesota (1)
Germany	3	Institut fur Biochemie Biologische Bundesanstalt, Braunschweig (1) University Hohenheim (LH) Stuttgart, Germany (1) Technical University of Berlin (1)
Netherlands	3	Wageningen (3)
Australia	2	University of Sydney (1) Victoria Department of Agriculture (1)
Ethiopia	2	Addis Ababa University, Dire-Dawa (2)
Sri Lanka	2	Department of Agriculture (2)
Argentina	1	Instituto Nacional de Tecnología Agropecuaria, Balcarce
Canada	1	Agriculture Canada, Fredericton
Chile	1	Pontificia Universidad Católica de Chile, Santiago
Colombia	1	Instituto Colombiano Agropecuario, Río Negro
England	1	University of Birmingham
Philippines	1	Philippine Council for Agriculture and Resources Research
India	1	R.R. & T. Delhi

CIP Regional Headquarters

Region I, South America — Bogotá, Colombia.
Region II, Central America, Mexico and the Caribbean — Turrialba, Costa Rica.
Region III, Tropical Africa — Nairobi, Kenya.
Region IV, Middle East and North Africa — Menemen, Izmir, Turkey.
Region V, Southwest Asia — Islamabad, Pakistan.
Region VI, India, Nepal and Bangladesh — New Delhi, India.
Region VII, Southeast Asia — Los Baños, Laguna, Philippines.

On-Farm Research

Region I — Peru, Ecuador
Region III — Rwanda
Region IV — Turkey, Tunisia, Algeria
Region VII — Philippines

CIP Research Summary

CIP Research Highlights – 1980

CIP's activities during 1980 centered in 52 projects in nine Thrusts, five in Social Science and 34 contracts in direct support of research. The research contracts were equally distributed between developing and developed country institutions. CIP sponsored three Planning Conferences to provide guidelines for future research in breeding, virus control and village level processing.

Thrust I – Collection and Classification of Tuber-Bearing *Solanums*

Three collecting expeditions to southern Peru, Colombia and south central Mexico were in the field for 6 months in search of wild potato species. In addition to three new species described during 1980, nine species near extinction were collected. Forty accessions, including about half of known Mexican species, were deposited with both INIA, Mexico and CIP. Electrophoretic protein patterns were used to identify 2,996 duplicates among 4,056 primitive cultivars.

Thrust II – Maintenance, Utilization and Distribution of Tuber-Bearing *Solanums*

A total of 7,618 primitive cultivated potatoes were planted in the field for routine maintenance and further study. Over 90,000 new descriptive data units were stored in CIP's data bank. About 1,500 stem cuttings were transferred to ICA, Colombia to establish a second site for germ plasm maintenance. Uniform hybrids

> The term "THRUST," as used at the International Potato Center, refers to the integration of research projects into units of common research activities. Each Thrust has a Coordinator responsible for the unification of project activities within a Thrust. Five research Departments serve as administrative units for grouping personnel according to their professional discipline and for allocating project funding. Through Thrusts the various research disciplines cooperate in developing technology for low income farmers.

from true seed yielded an average of 18 t/ha at CIP's 800 m site. In the Amazon basin two 5th cycle clones yielded 33 t/ha in 65 days. Excellent progress is being made in screening for leafroll and combined XY virus resistance; 16,000 of 36,900 resistant seedlings were retained for tuber production. A total of 150 putative tetraploids derived from diploid hybrid combinations of four Solanum species were selected in studies to maximize genetic variability. Selection year after year for resistance to frost has resulted in more than 50 percent survival rate of seedlings to -4°C and up to 22 percent survival at -5°C. Yields of 15 clones averaged more than 1.5 kg/plant grown at 3,700 m altitude where frost of -5°C was recorded. Success continued in the extraction of virus resistant haploids and bacterial wilt and nematode resistant haploids and bacterial wilt and nematode resistant diploids to produce pest and disease resistant hybrids. A total of 48,489 pathogen-tested tubers were sent to 22 developing country programs in addition to 20,400 true potato seeds sent to four selected developing and six developed countries.

Thrust III — Control of Important Fungal Diseases

A total of 33,520 seedlings were screened for resistance to late blight, a reduction in view of improved accuracy in screening and less emphasis on resistance under lowland tropical conditions where blight is of minor significance. The new field test site at Rio Negro, Colombia, is more convenient than the previous site at Toluca, Mexico, and approaches the complexity of indigenous pathotypes of the fungus encountered in Toluca. Efforts to eliminate specific gene resistance from breeding populations while increasing levels of field resistance is continuing: clones with dual resistance to both early and late blight have been identified and confirmed under field conditions. Field sprinkler equipment obtained in 1980 has improved field test conditions. Chemical control treatments for a range of soil-borne pathogens in experimental fields resulted in selection of useful fungicide combinations. Studies of Peruvian races of the potato wart fungus indicates a wider genetic spectrum than encountered in Europe.

Thrust IV — Control of Important Bacterial Diseases

Through the Wisconsin contract a new media permitting direct assay of *Pseudomonas* wilt bacteria is being used in studies of the presence and population dynamics of the bacteria in field soil samples. Routine tuber assay of latent infection following harvest was introduced during 1980. Seventeen diploid progenies involving combinations of three potato species were selected for resistance to four different races of *Pseudomonas*. Encouraging levels of resistance to the soft rot bacterium, *Erwinia chrysanthemi* have been identified. Isolation and distribution of three *Erwinia* species in Peru indicate restricted distribution of two species and lowland-highland-coast distribution of *E. carotovora* var. *carotovora*.

Thrust V — Control of Important Virus Diseases

New enzyme-conjugate procedures, simplified electrophoretic techniques and the identification of a new local lesion host have permitted more sensitive and accurate detection of key problem viruses and a viroid (PSTV). The potato spindle viroid has been eliminated from CIP breeding and export material. Any unfamiliar plant disease symptoms received expert diagnosis to detect potential novel infectious agents. Sticky hairs on leaves while effective in trapping insects do not preclude insect transmission of virus. A vigorous screening program for leafroll virus resistance has been pursued with increasing success; combined XY resistance is now routinely incorporated into breeding material. Sensitized latex to detect specific viruses as well as combinations of viruses was sent to 16 developing countries.

Thrust VI — Control of Important Nematode and Insect Pests

Nematodes. Extensive field trials in Peru continued to substantiate the practical effectiveness of a fungus which parasitizes the eggs and adult females of root-knot nematodes. High levels of resistance to root-knot nematodes in diploid populations has now been incorporated into limited tetraploid populations some also having virus and disease resistance. A space and labor saving closed container method of screening for cyst nematode resistance was initiated. Resistance to various pathotypes of cyst nematodes was identified in a number of wild potato species.

Insects. The first known resistance to the destructive tuber moth was found in studies of 3,000 clones from CIP's germplasm collection. It is considered that resistance is inherited in a relatively simple manner which will facilitate breeding. Avoidance of tuber moth by phased seasonal planting is a practical control measure under experimental field conditions.

Thrust VII — Physiologic and Agronomic Management of Potatoes

Extensive experiments under varying field conditions confirmed the superiority of transplanting nursery seedlings rather than direct sowing of true potato seed in the field. Reflectant soil mulch effectively reduced soil temperatures and significantly enhanced marketable yields; a promising screening method to select for early tuberization under high temperature stress (day/night 38/22°) has been developed. Rock phosphate was found effective under Amazon basin conditions of ameliorating aluminum toxicity and increasing yield more than ten-fold.

Thrust VIII — Development of Storage and Processing Technology

Economically practical amounts of edible dried potato and starch were produced by farmers using the village scale equipment built and installed by CIP in the Peruvian highlands. Additional farmer financed and constructed processing facilities are planned. Low radiation levels (approx. 3 watts/m^2) are adequate to control sprouting of seed tubers stored in inexpensive diffused light storages. Rapid acceptance of diffused light storage by farmers is noted for the Philippines, Guatemala and Peru.

Thrust IX – Tuber and True Seed Research

Thirty-three clones were added to the tissue culture collection of pathogen-tested clones for a total of 79 clones. A total of 45 different clones as plantlets in culture were shipped to eight countries. Cell suspension culture studies were started to obtain plants having increased tolerance to normally toxic levels of salts and aluminum. Techniques for the isolation of protoplasts and selection for variant colonies are under development. In studies of heat inhibition of true seed germination, seed of diploid species were significantly more tolerant than tetraploids. Tolerance of true potato seed to high temperature (90°C +) without significant loss in germinability has been observed in research to inactivate seed-borne viral agents. Seed tubers grown under heat stress conditions in the field yielded less than tubers of the same varieties grown under cool conditions.

Thrust I

Collection and Classification of Tuber-Bearing *Solanums*

I. Cultivated Group

A total of 4,056 accessions of the Germ Plasm Bank in seven series were analyzed in 1980 by both morphology and electrophoresis to determine identical clones or synonyms (Table I-1). Of these, 3,846 accessions representing 822 different morphotypes were identified as synonyms by both methods. About 95 percent of the samples were duplicates.

II. Wild Group

Three expeditions to collect wild potatoes were made during 1980. The first, February to April was in southern Peru; the second, August in Colombia, and the third, September to October in south central Mexico. In nearly all localities extensive genetic erosion was being caused, mainly by man. Many endemic species are disappearing and some are probably already extinct.

Southern Peru: Although the main objective in south Peru was to explore the Departments of Cusco and Apurimac, a few collections were made in some of the highest localities of the Department of Puno near Lake Titicaca (3,850 m), La Raya (4,200 m) and the route between Santa Rosa and Puno (4,000 m) where several accessions of *Solanum acaule*, *S. bukasovii*, *S. raphanifolium* and *S. leptophyes* were collected.

In the Department of Cusco field work concentrated in the Vilcanota river region, from La Raya to the neighborhood of

Table I-1. Morphologic (M) and electrophoretic (E) identification of cultivated synonyms.

Species	Total N° samples studied	Number of synonyms (M + E)	Number of synonyms (E)	Total N° morphotypes (M + E)	Total N° morphotypes (E)
CON	6	4	2	2	1
STN	94	89	5	17	2
CHA	520	489	31	41	8
JUZ	104	101	3	14	1
ADG	3029	2871	158	714	60
TUB	104	93	11	32	5
CUR	199	199	–	2	–
	4056	3846	210	822	77

Cusco where *S. sparsipilum*, *S. raphanifolium*, *S. leptophyes* and possibly *S. arac-papa* and *S. megistacrolobum* were found. The surroundings of Cusco — San Sebastian, Urubamba, Pisac and Paruro — were also explored and additional species, such as *S. marinasense*, *S. lignicaule* and *S. bukasovii*, were located. In other Provinces of Cusco, Paucartambo, La Convención and Urubamba, only limited material was observed because of an unusual dry season. However, in the Province of Urubamba *S. coelestispetalum* was rediscovered. A few small plants are being grown in the greenhouse to produce true seeds. Also, in Urubamba a long search resulted in collection of several living plants of *S. santolalla.*

On the other hand, the extremely rare species, *S. urubambae* and *S. buesii* reported from the Department of Cusco were not found although, fortunately, the habitat of *S. pillahuatense* was located in the Province of Paucartambo, Cusco. This latter species, found for the first time 35 years ago, was unknown in the living state. The few living plants and cuttings collected did not survive the long journey to Lima. No tubers or seed-balls were found at the time of collecting.

During the southern Peru expedition collections were also made in the Department of Apurimac, the most unknown and unexplored area in the Andean region. In the far Provinces of Cotabambas, Grau and part of Abancay and Antabamba several specimens were collected including the species *S. abancayense*, *S. marinasense*, *S. raphanifolium*, *S. bukasovii*, *S. leptophyes*, *S. acaule*, *S. coelestispetalum* as well as still undetermined species.

Colombia. Although the time collecting in Colombia was less than 2 weeks, three new wild tuber-bearing species were discovered, *Solanum cacetanum* Ochoa, *S. orocense* Ochoa and *S. sucubunense* Ochoa. The last two were in the National Herbarium of Colombia.

The explored regions were mainly in the Departments of Cundinamarca, Boyaca, Caldas, Tolima and very isolated regions of the Departments of Huila and Caqueta.

The main purpose in Colombia was to collect *S. flahaultii* and, if possible, the little known species *S. lobbianum*. Living material of *S. flahaultii* was found in its original type locality, San Francisco, and, after a long search, *S. lobbianum* was collected in the vicinity of Nevado del Ruiz, Cordillera Occidental. These findings are considered extremely valuable, especially the latter which has now been recovered in the living state. Both species have been determined to be tetraploids.

Besides these species collected several accessions of *S. colombianum* have been added to the CIP collection.

Mexico. Special attention was focused on the Mexican States of Oaxaca and Chiapas where the widespread *S. stoloniferum* and *S. bulbocastanum* and also a few samples of *S. iopetalum*, *S. reconditum* and *S. agrimonifolium* were collected.

An intensive search was made on Mt. Male, near El Porvenir, District of Motozintla in the State of Chiapas, to find the rare species, *S. clarum*. Unfortunately, the few areas of native forest are overgrazed by domestic animals and it was not possible to find *S. clarum*.

In the Central States field work was confined mainly to some regions of Puebla, Hidalgo, Mexico, Queretero, Michoacan, Jalisco and Colima. Several accessions of different species were collected including *S. demissum*, *S. cardiophyllum*, *S. bulbocastanum*, *S. verrucosum* and *S. pinnatissectum*. Other less common species were *S. hougasii*, *S. iopetalum*, *S. polyadenium*, *S. polytrichon* and other accessions still undetermined. In spite of great effort *S. stenophyllidium* was not found.

Toward the end of the expedition to Mexico it was decided to explore in the far northwest State of Chihuahua, Taraumaras.

In the mountains of Santa Eulalia near Chihuahua several accessions of the tetraploid *S. fendleri* were collected. One of the most important specimens collected during the expedition to Mexico was of the little known diploid species *S. brachistotrichum* which is near extinction.

Living specimens were divided between CIP and the Mexican Potato Program. Duplicate herbarium specimens were deposited at the National Mexican Herbarium by the Department of Biology, UNAM.

Thrust II

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

During the 1979-80 growing season, 7,618 accessions of primitive cultivated species were planted at Huancayo. A total of 490 duplicate accessions were identified and eliminated from vegetative maintenance and preserved as true seed.

Establishment of a second site for the clonal propagation of the collection has been with the collaboration of the Instituto Colombiano Agropecuario (ICA) of Colombia. Transfer of material from CIP (Lima) to ICA (Bogota) included about 1,500 unrooted stem cuttings of 52 primitive cultivars which have shown resistance to some pests and diseases. The systematic characterization of the collection continued. A total of 86,560 new descriptive data units on morphological characters were stored in the CIP computerized data bank. Furthermore, 5,464 data units on reactions to disease and pests and evaluations made at CIP have been obtained and are in process of incorporation into the data bank.

During 1980 breeding work has continued, concentrating on adaptation to abiotic stresses (heat and cold), combination of resistance to pests and diseases, and adaptation to propagation by true potato seed (TPS).

Abiotic Stresses (heat and cold)

In selecting for adaptation to abiotic stresses emphasis also was given to improving earliness. As a result 55 clones were selected at San Ramon with yields ranging from .6 to 1.1 kg/plant in 76 days. At Yurimaguas, from the 5th cycle population for the lowland tropics, two selected clones, CIP 377939.5 ($P_6 C_1$.16 x Maria Tropical) and CIP 377904.10 (R 245.4 x BR 63.65) yielded 35 and 32 t/ha, respectively, in 65 days. These clones will be cleaned and distributed to the regions.

Studies on inheritance of earliness were conducted utilizing a 11x11 diallel mating design. Out of the 11 clones, which had a wide

Table II-1. Narrow sense heritability (h^2) estimates for various tuber characters.

Average tuber character measured in the field	h^2
Number of days to tuber initiation (greenhouse)	.84
Percent tuberization 30 days after transplant	.65
Tuber yield (g/plant) at 60 days	.37
Tuber weight (g) at 60 days	.72
Tuber yield (g/plant) at 90 days	.45
Tuber weight (g) at 90 days	.37

Table II-2. Seedling screening in growth chamber at sub-zero temperatures in 1980.

Date	N° of families	N° seedlings evaluated	N° of resistant seedlings	Percent resistance*
June	20	3,356	1,433	43.0
July	20	3,337	190	5.6
August	39	3,976	172	4.3
Sept.	62	3,156	700	22.0
Nov-Dec.	137	12,800	2,099	16.4
Total	298	26,625	4,594	

* June evaluation was made at -4°C, July and August evaluation at -5.5°C and September, November-December at -5°C.

genetic background, six were early maturing, lowland tropic adapted, and five were medium late. Greenhouse and field replicated experiments assessed various responses. Narrow sense heritability estimates indicate that progress in selecting for earliness can be achieved using phenotypic recurrent selection (see Table II-1). Heritabilities for yield at 30, 60 and 90 days is around .40. This estimate is higher than reported previously and was obtained from materials with a narrower genetic background.

Advanced frost tolerant clones from continuous selection year after year were intercrossed to increase the frequency of frost tolerant genes in the population. Also, selected late blight, PVX, PVY, black wart and cyst nematode resistant clones were used for crosses to combine with frost tolerance. Results of screening are in Table II-2.

A variable number of frost tolerant selected clones was tested at two locations in Peru and two in Bolivia to confirm their frost tolerance as well as select for yield and other agronomical characters (Table II-3).

Table II-3. Yield performance of frost resistant clones at different locations during 1980.

	Locations and their altitude (meters)			
	Huancayo 3,200	Usibamba 3,700	Belen 3,900	Toralapa 3,800
N° of clones tested	60	288	114	102
N° of clones selected	26	156	62	33
N° of outstanding clones	13	15	20	10
Range of yield kg/plant	1.6-3.2	1.5-1.9	1.2-2.2	.65-.97

Combination of Resistances

A concentrated effort was made to produce a large number of crosses combining resistances to bacterial wilt (*Pseudomonas solanacearum*) and late blight (*Phytophthora infestans*) with tropical adaptation. A sample of 6,000 seedlings was screened for resistance to late blight and the survivors were inoculated with *P. solanacearum*; 151 survived. Fifteen percent of the progenies of two half sibs of the family CIP 377847 crossed to Maria Tropical were resistant to both diseases.

Selected tetraploids immune to PVX/PVY or PVY were pollinated by the diploid clone IVP 35, a haploid inducer. After two inoculations 78 haploids were found to be resistant to PVX/PVY and 409 to PVY. In another experiment, out of 800 haploid-like plants, extracted from selected tetraploids resistant to late blight and/or frost, 312 were retained to be checked for resistance. In screening for 2n pollen production in selected diploid populations, five of 92 clones with combined resistances to bacterial wilt and root-knot nematode produced 2n-pollen. Also, extensive 2n-pollen was produced by a glandular trichome population originating from *S. berthaultii* x *S. phureja* crosses. Eleven plants examined for mechanism of 2n-pollen formation all had parallel spindles (First Division Restitution).

A population of 10,815 diploid seedlings was evaluated in a growth chamber for resistance to late blight. This population was formed by 42 progenies resulting from the crosses, on a partial diallel mating design, of four groups of clones of *S. stenotomum* with a varying degree of resistance to late blight. Data are presented in Table II-4.

A field experiment is evaluating correlations berween the growth chamber and field tests as well as to gain more information about the type of gene action in the control of the stable or field resistance to late blight.

About 34,000 seedlings were screened in incorporating virus resistance into lowland and highland populations. Out of 7,000 seedlings screened for PLRV resistance, 2,850 apparently healthy seedlings were returned for field evaluation. For combined PVY-late blight resistance a total of 4,092 seedlings was inoculated

Table II-4. Percent late blight resistance observed in various crosses.

Cross	% Resistance
Susceptible x Susceptible	.62
Susceptible x Moderately resistant	.68
Susceptible x Resistant	.96
Susceptible x Highly resistant	1.12
Moderately resistant x Moderately resistant	7.24
Moderately resistant x Resistant	10.29
Moderately resistant x Highly resistant	10.79
Resistant x Resistant	9.87
Resistant x Highly resistant	14.92
Highly resistant x Highly resistant	14.70

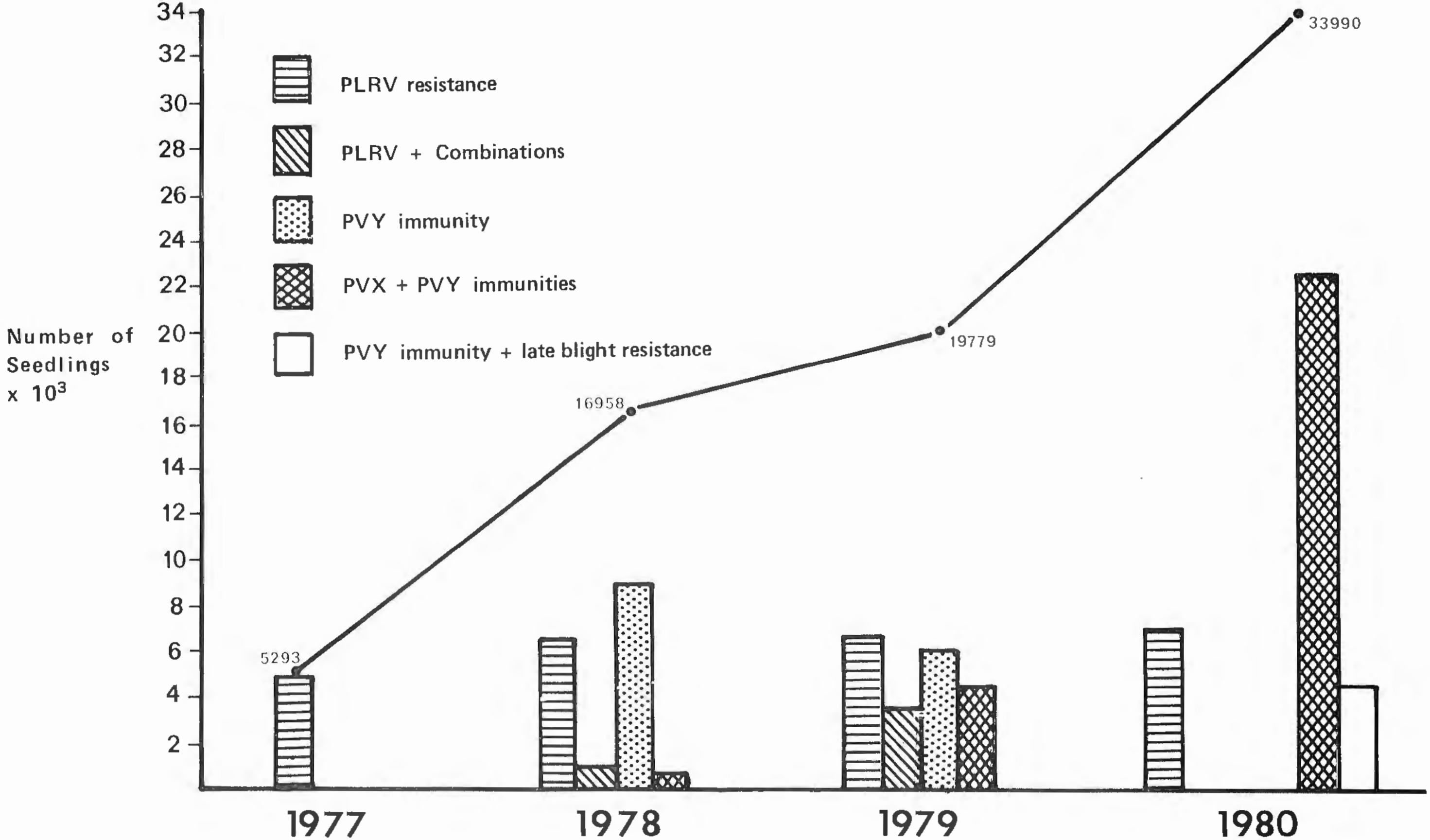


Figure II-1. Changes in emphasis for the type of material screened for virus resistance.

with both pathogens. Of these, 1,378 resistant seedlings were retained for tuber production. A total of 22,898 seedlings screened for combination of PVY and PVX immunities resulted in 11,799 seedlings being retained for tuber production. The seedling test is proving to be effective in eliminating susceptible genotypes very early in the life cycle of the plants followed by field selection for other traits of economic importance (Fig. II-1).

Although resistance to PVY and PVX is controlled by major genes, the frequency of occurrence of resistant seedlings appears to be affected by general PVY resistance and the genetic background of the cross. An experiment with three replications designed to study this, involved two XY immune parents and five susceptible ones. Data are presented in Table II-5.

Clone 376913.4 produces more resistant progenies than clone 376921.1 regardless of the presence of immunity genes.

A sample of advanced clonal selections, originally screened as seedlings for various virus resistance combinations, received a second field evaluation in multiple hill plots. Thirty-one selections were made from 176 clones tested; four XY immune, three XY immune + PLRV resistant, three X immune + PLRV resistant, and 21 PLRV resistant.

Adaptation to Propagation by True Seed

Since this is a rather new area of research it was necessary to design experiments to gain basic genetic information to support a breeding program. A North Carolina mating Design I was developed using 15 randomly selected male clones each crossed to a random sample of four females. All the clones were from a Neo-tuberosum population. Field trials were at two sites with 60 families evaluated for 16 characters. Only in 10 characters additive genetic variance was greater than the standard error of their estimated heritabilities (Table II-6).

The heritability estimates in Table II-6 indicate enough additive genetic variability for the traits noted to expect rapid improvement in many of these characters. Yield was not considered due to the lack of additive genetic variance for this character in the population where most of the genetic variability was of a non-additive nature.

A trial compared yield potential of F_1 hybrid seedlings, tuber

Table II-5. Influence of genetic background on combined resistance to PVY and PVX expressed as percent healthy plants in progeny after seedling screening.

Susceptible Parents	Immune Parents		Mean
	14XY.4	7XY.1	
376913.4	51.7	71.7	61.7 a
BR 69.50	38.0	67.7	52.8 ab
BR 63.74	44.3	61.3	52.8 ab
375318.2	30.0	59.3	44.7 b
376921.1	29.3	43.0	36.2 b
Mean	38.7	60.6	49.6

Table II-6. Narrow sense heritability (h^2) estimates for several traits in potatoes propagated by TPS.

Character	h^2 (FS)
Germination percentage	.53
Transplant survival	.30
Nursery vigor	.56
Nursery uniformity	.33
Resistance to Rhizoctonia	.55
Days to maturity	.57
Nº of berries	.58
Tuber number	.60
Tuber size	.79
Depth eyes	.57

families from full sibs of the hybrid seedling and open pollinated (OP) seedlings from full sibs of the F_1 seedlings. Twenty progenies of each of the family types were grown at San Ramon and La Molina (Table II-7).

Yields of F_1 seedlings and F_1 tuber propagation were superior to that of OP seedlings. This is probably an effect of inbreeding depression if one considers that 80-85 percent of the open pollinated seed is produced by selfing. In La Molina trials during the summer, loss of transplants was high, consequently, the error mean square was high and influenced significance. It is also noticeable that tuber size tended to be larger in F_1 tuber propagated than in the seedlings either F_1 or OP. Seedlings usually produce a large number of secondary stems by a profuse branching and in consequence produce larger number of tubers of smaller size. However, the heritability estimate for tuber size (Table II-6) was .79 indicative that selection can significantly increase tuber size.

Table II-7. Mean comparisons for traits measured in F_1 seedlings, open-pollinated (OP) seedlings and F_1 tuber propagated plants.

	Yield (g/plant)		Tuber size (g/tuber)	
	San Ramon	La Molina	San Ramon	La Molina
F_1 seedlings	499 a	313 a	34.0 ab	25.2 b
OP seedlings	315 b	229 a	28.7 b	25.9 b
F_1 propagated tuber	424 a	400 a	44.6 a	45.3 a

Table II-8. Yield of representative hybrid families at San Ramon.

Group	Pedigree	Yield (ton/ha)
Very uniform	DTO-2 x 7XY-1	20.0
	DTO-2 x 575059	19.0
	83.118 SRLL x M. Tropical	16.0
Uniform	68.3 LV x 377904.10	20.8
	377838.4 x CGN 60.1	17.0
	377935.64 x M. Tropical	15.0
Not uniform	DTO-28 x 14XY-4	26.0
	104.121 SRLL x 377904.10	20.2
	41.135 SRLL x Tbr Yuri.	17.8

A North Carolina mating Design II was used to obtain more information about genetic parameters using CIP selected and breeding clones as a widely diverse base population. In this case a heritability estimate $h^2(FS) = .53$ was obtained for tuber yield.

A sample of 295 families from the lowland tropic adaptation program was evaluated in replicated trials at San Ramon. The goal was to select uniform and high yielding progenies. The growing period was 80 days from transplanting to harvest (Table II-8).

About 15 families have been identified as very uniform. This type of material will be used in the near future at various locations in the regions.

Contract Research

Cornell University

The Cornell contract continued in 1980 to develop a broadly based population of *S. tuberosum* spp. *andigena* clones with good yield, wide adaptation and with disease and pest resistance. More than 125,000 seedlings were screened.

Field screening of seventh cycle andigena selections were in Peru, Newfoundland and at three sites in New York state. Of 58 clones selected for parents of the eighth cycle, 47 were resistant to PVY, 45 to PVX and 22 were resistant to wart. Approximately 200 of 2,800 andigena seedlings selected for combined PVY resistance and heat tolerance were sent to an Amazon basin site in Peru for further testing.

Early maturity is one desired characteristic of varieties for the warm tropics. Field studies of tuberization of cuttings provided a better index of maturity than the evaluation of dry matter partitioning among the leaves, stems and tubers of whole plants having known maturity.

Studies of resistance to four species of root-knot nematodes, *Meloidogyne incognita, M. javanica, M. arenaria* and *M. hapla*, indicate that *S. sparsipilum* is a superior source of combined resistance to the first three species of *Meloidogyne* while resistance to *M. hapla* is greater in *S. tuberosum* spp. *andigena*. Twenty-eight clones were selected from 693 seedlings for study during 1981. These clones were derived from crosses having various resistance to PLRV, PVY, PVX and bacterial wilt as well as resistance to root-knot nematodes.

In a program to combine insect resistance from glandular trichomes, clones with large droplets, high trichome densities and a high level of resistance to aphids have been recovered in the F_2 generation of "Hudson" x *S. berthaultii* crosses. Present evidence suggests complementary interactions in trapping insects between the tetralobulate (Type A) and the simple (Type B) trichomes of *S. berthaultii*. Polyphenol oxidase and peroxidase activity of the trichome exudates has been established. Experiments are underway to determine the relative importance of the enzyme-mediated browning reaction versus other components of trichome resistance.

High levels of general resistance to the late blight fungus *Phytophthora infestans* have been identified in the Cornell Breeding Program. This resistance has been found in tuberosum, andigena, andigena x tuberosum and andigena x phureja x tuberosum material. Advanced methods of testing in the greenhouse, growth-cabinets and the field has resulted in the selection of clones NY59, NY61 (Rosa) and NY63 with valuable levels of general or field resistance. These clones have also shown high levels of resistance to early blight, *Alternaria solani.* In addition NY59 is highly resistant to *Verticillium* spp.

In studies of potato spindle tuber viroid (PSTV), 4,200 samples were tested for PSTV using electrophoresis. Field studies during 2 years on transmission of PSTV showed 50 percent occurred on tractor wheels. While plant to plant transmission could not be demonstrated, 15 percent random transmission in field plots set up in such a way as to minimize or elimiminate human interference.

University of Wisconsin

The major objective of the contract is to use species germ plasm, haploids and meiotic mutants to increase yield and broaden the genetic base of the cultivated potato. In the production of true potato seed, two cultivars, three advanced breeding lines and five experimental tetraploids were identified that produced from 10,000 to 50,000 open pollinated seed per plant. A quantitative method to estimate the amount of selfing in open pollinated seed was developed using the "parallel spindles" alleles as a marker gene. The frequency of selfing varied from 60 to 90 percent. True seed from this research was supplied to CIP and cooperating scientists in seven countries.

A new hypothesis proposes that Endosperm Balance Number (EBN) is a major component to explain endosperm development. Thus EBN is more important than the actual chromosome number in predicting the success of crosses and the ploidy levels of progeny. Studies indicate that the EBN number may be under qualitative genetic control.

Male sterility results from the interaction of dominant genes from the cultivated diploids with haploid tuberosum cytoplasm when the haploid is used as the female. In studies involving 56 cultivars crossed with a male fertile phureja-haploid hybrid (heterozygous for a dominant gene for male sterility), the presence of 1, 2, or 3 dominant male fertility restorer genes was indicated by the recombinant ratios. The findings facilitates the use of Tuberosum haploids and hybrids in breeding and germ plasm transfer.

Agricultural University, Wageningen

The contract is concerned with use of Mexican wild *Solanum* spp. *S. bulbocastanum* has been made available to breeding by using complex tetraploids as a bridge. The resulting hybrids are crossable with *Longipedicellata* spp. (*fen, sto, plt*). The presence of *tbr*-genes in the hybrids suggests that crossability with varieties and FDR clones will be reasonably good.

Many new hybrids have been produced between *Etuberosa* spp. (*etb, brd* and *frn*) x *S. pinnatisectum*, the chromosome number being doubled through explant culture. Doubled F_1 hybrids were crossed with selected species (*sto* and *plt*) or haploid *tbr* x *ver* backcrossed with *ver.* The progeny were hybrids. These are promising possibilities of incorporating valuable *Etuberosa* genes in advanced material.

The contract provided advanced clones for India with PVX, PVY immunity in combination with late blight resistance.

Biologische Bundesanstalt, Braunschweig

The germ plasm collection at CIP contains many potential duplicates as judged by visual characteristics. The Braunschweig contract examines electrophoretic protein patterns from tubers to verify morphologic groupings of accessions. In 1980, about 1,200 primitive cultivars were examined by one-dimensional gel electrophoresis, pH 8.9 and 7.9 for proteins and for multiple forms of esterases. In some cases peroxidase patterns were examined by two-dimensional separations, focusing in the range pH 4 to 8 followed by electrophoretic separation at pH 8.9. During 3 years the biochemical classification has been reliable.

Canada Agriculture, Fredericton

The CDA contract is aimed at demonstrating the feasibility of establishing a biometrical model for predicting performances of potato clones in distant global areas. A small group of "controls" are sent to diverse environments to obtain productivity data — an environmental index. Clones to be tested are sent to a few chosen environments and the average yield data for each clone are regressed on the environmental indices (of the "controls") to establish a regression equation. This equation is then used to predict the performance of the clones in "untested" regions.

Yield data of an international series of trials sponsored by CIP-CDA were used for testing the prediction model. Using seven of 15 cultivars in a total of six trials as "controls," the correlation between predicted and actual yields of the remaining eight cultivars in three hypothetical "untested" trials was 0.81.

Thrust III

Control of Important Fungal Diseases

Late Blight
(*Phytophthora infestans*)

A field screening program began in 1980 at Rio Negro, Colombia in cooperation with the Instituto Colombiano Agropecuario. Natural infection of a series of 11 race differential hosts planted at the new site confirmed that a wide spectrum of pathogenic variability exists in the endemic inoculum. In addition 15 CIP clones and 14 ICA clones were evaluated in replicated plots of five plants each (Table III-1).

Initial trials at Rio Negro evaluated under field conditions 27 tuber families containing 2,081 (continued)

Table III-1. Late blight rating and yield of clones evaluated in Rio Negro, Colombia.

Clone or variety	Infection rate[1]	Yield kg/plant
A. Late blight differentials		
R1	.05	.38
R4	.12	.35
R7	.12	.38
R3	.14	.33
r	.17	.26
R10	.17	.58
R5	.20	.23
R1 R2 R3	.27	.13
R2 R3	.37	.63
R2	.43	.31
R2 R4	.60	.23
B. CIP clones and varieties		
ASN-69-1	0	.56
Atzimba	0	1.25
CGN-69-1	0	1.38
Monserrate	.02	.77
DGV-33	.03	.14
DIA-71	.03	.83
CEX-69-1	.07	.81
BR-69-84	.07	.84
Murca	.07	1.45
BR-63-5	.07	.91
Loman	.07	.79
Utatlan	.09	.19
CFK-69-1	.13	.76
Wanseon	.14	.28
Kennebec	.18	.42

(continued)

(continued)

Clone or variety	Infection rate[1]	Yield kg/plant
C. ICA clones and varieties		
Monserrate-rojo	.01	1.08
74-789-10	.04	.67
75-786-2	.04	.37
Tequendama	.04	.75
75-786-15	.05	.32
San Jorge	.05	.36
73-632-6	.06	.44
75-786-3	.07	.27
74-789-14	.07	.64
Puracee	.07	.74
75-850-11	.09	.74
Guantiva	.09	.04
Sirena	.12	.82
Picacho	.14	.28

[1] Clones and varieties were evaluated during five consecutive weeks on a blight rating scale of 1 (no blight) to 9 (100% of foliage destroyed). Infection rates were the regression coefficients of blight rate over time (in days). The mentioned blight scale is based on a logit transformation of percentage foliar infection by blight.

potential clones originally screened for blight resistance as seedlings. A total of 124 clones representing 24 families were retained for further evaluation. As part of the field trial, the infection rate of 250 randomly selected clones was determined and averaged per family. These values were compared with the seedling screening data previously recorded for each family. The significant correlation coefficient, 0.528, Figure III-1, is indicative that seedling and field resistance may be correlated.

Improvement and standardization of seedling screening procedures for late blight continued. A total of 33,520 seedlings were screened in a growth chamber (Table III-2). Heavy infection developed in another series of seedling screenings in a plastic greenhouse with a steam misting installation (Fig. III-2). An average of 3.3 percent of 30,240 6-week-old seedlings from three source programs survived the rigorous screening with

Figure III-1. Relation of percentage seedlings eliminated (S) and infection rate (r) of selected clones in Río Negro, Colombia. Tubers from selections obtained in seedling tests during 1978 and 1979 were planted in Río Negro during the first blight epidemic 1980. Infection rates (r, see Table III-1) were determined and compared with percent seedlings eliminated (S) of the same crosses (families). (R is correlation coefficient).

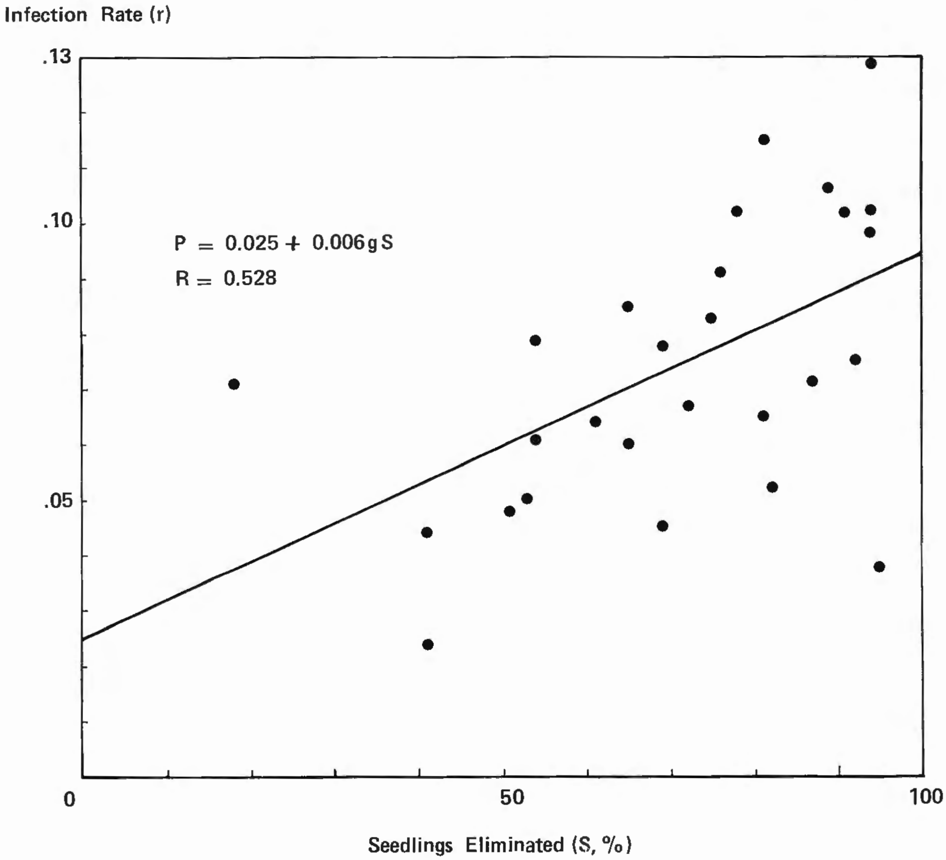


Table III-2. Growth chamber seedling test for late blight resistance.

Program source of families	Families tested	Seedlings tested	Percent seedlings selected
Highland tropics	157	21,498	30
Germ plasm collection	28	2,550	2
Bacterial wilt resistance	37	6,484	30
Virus resistance	27	2,988	46
Total	249	33,520	

a mixed inoculum of 30 late blight isolates which had been maintained on potato leaves (Table III-3). None of 2,200 open-pollinated Renacimiento control seedlings could be selected. It is anticipated that the greenhouse mist chamber will permit simultaneous screening of 60,000 seedlings. The installation of an overhead sprinkler system provided a favorable blight environment during winter months for field screening at La Molina, Peru, under coastal desert conditions (infection rate of 0.17 per day). Unfortunately, a concurrent heavy seasonal attack by leaf miner fly larvae (*Liriomyza huidobrensis*) forced early termination of the experiment.

Figure III-2. A sequence showing seedling tests for late blight in a greenhouse at Huancayo in Peru's highlands. Greenhouse temperatures in Huancayo throughout the year range between 8° and 24°C, which includes the optimal temperature range for late blight development. Humidity of the air is the principal limiting factor. A misting device, based upon steam introduction, was installed at one end of the greenhouse. The steam valve nozzle, shown here, controlled the mist. Turn the page to see what happens after the nozzle is opened.

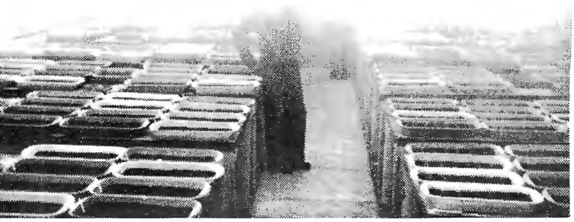
Soil Borne Pathogens

Previous experimental soil treatments with fumigants to control pink rot caused by *Phytophthora erythroseptica* increased potato yields in susceptible clones but did not reduce disease incidence.

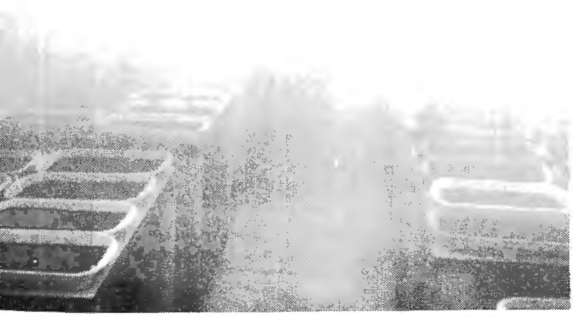
In recent field trials at a highland location (3,300 m) fumigants were applied singly or in combination with Ridomil, a systemic fungicide with specific activity against *Phycomycetes*. Application of either Dazomet, or methyl bromide 30 days before planting and then covering with plastic for 10 days, followed by in-furrow application of Ridomil at planting, gave highly

Within minutes the greenhouse is filled with a dense and persistent fog as revealed in this photo sequence. The nozzle, just below this bench, is opened . . .

. . . 5 minutes later . . .



. . . 10 minutes later . . .



. . . 15 minutes later.

Results one week after inoculation show in this tray of seedlings from open pollinated Renacimiento seed (the control).

An overview of the evaluation activity.

Table III-3. Seedlings tested for late blight resistance in greenhouse equipped with misting installation.

Program source of families	Families tested	Seedlings tested	Seedlings selected (%)
Root-knot nematode resistance	33	2,635	2.88
Highland tropics (advanced selection)	133	25,792	7.45
Highland tropics (primitive)	2	1,664	2.76
Renacimiento (open pollinated control)	1	2,200	0
	169	30,246	

increased yields and minimized disease incidence. Results of one representative experiment are in Table III-4. Tuber disinfection with sodium hypochlorite prior to planting did not give consistent yield improvement.

Significant reduction in the incidence of smut (*Angiosorus* = *Thecaphora solani*) and increased yield of potatoes cv. Yungay was achieved in field experiments following application of methyl bromide (750 kg/ha) or Dazomet 98 percent (400 kg/ha) 30 days before planting and then covering with plastic (Table III-5).

Table III-4. Yield and pink rot incidence on Ticahuasi potatoes as influence by soil treatment.

Treatments*	Average weight (kg) per 24 m^2 plot	
	Diseased tubers	Healthy tubers
Dazomet 98% 500 kg/ha + Ridomil 5-G 40 kg/ha	0.36 b	121.84 a
Dazomet 98% 500 kg/ha	18.2 a	54.35 b
Ridomil 5-G 40 kg/ha	1.44 b	66.78 b
Control	5.62 b	16.8 c

* Dazomet was applied broadcast 30 days before planting and covered with plastic for 10 days. Ridomil was applied in the furrow at planting.

Figures followed by the same letter are not significantly different ($P < 0.05$).

Table III-5. Yield and smut incidence on Yungay potatoes as influenced by various chemical treatments of infected soil.

Treatments [1]	Average of treatments		
	Smut-infected tubers as % of total yield	Yield of healthy in kg per plot	Weight of commercial size tubers in kg per plot
Benlate 2 g/1000 cm^3	30.2 c	12.46 b	10.60 bc
Methyl bromide 750 kg/ha	1.6 ab	34.10 a	31.36 a
Dazomet 98% 400 kg/ha	0.5 a	31.02 a	28.66 a
Ridomil 5-G 40 kg/ha	38.4 c	8.90 ab	7.28 c
Sicarol 41/ha	53.1 c	8.02 bc	6.18 c
Control	43.2 bc	5.46 c	4.58 c

[1] Benlate, Ridomil and Sicarol were applied to the furrow at planting and methyl bromide and Danzomet 30 days before planting.

Figures followed by the same letter are not significantly different ($P < 0.05$).

Two of nine potato varieties, Desiree and Rosita, had superior tolerance to *Sclerotium rolfsii* inoculated artificially into soil. Both varieties had a higher yield than the other varieties which correlated with the number of healthy stems 10 days after inoculation ($r = 0.79$, significant at the 5 percent level) as well as the number of stems at time of inoculation ($r = 0.76$, significant at the 5 percent level). Incidence of *S. rolfsii* is widespread in San Ramon.

A collection of *Verticillium* isolates from coastal and mountain fields in Peru all were identified as *V. dahliae*. Thirteen European differentials were all susceptible to 14 collections of *Synchytrium endobioticum* (wart) from Peru as determined by the Spieckerman method. None of the Peruvian isolates were similar to any single European wart race.

A scientist from India, temporarily working at CIP, found immunity to *Macrophomina phaseolina*, the causal agent of charcoal rot, in 22 clones of root-knot nematode resistant material derived from *Solanum chacoense*. High and intermediate resistance was also identified in 40 andigena clones and a small number of interspecific hybrids among 2,500 accessions evaluated.

Thrust IV

Control of Important Bacterial Diseases

Development of tuber families with resistance to bacterial wilt and late blight and their distribution and field evaluation received major emphasis in 1980. New families were produced and evaluated, together with promising clones selected the previous year. Field evaluation of latent tuber infection was introduced as a routine. In this way, promising clones without tuber or vascular infection were retained. The development through the Wisconsin contract of a new medium to detect *P. solanacearum* in the soil allowed study of the population dynamics of bacteria in infected fields. The first diploid progenies of crosses involving *S. sparsipilum*, *S. chacoense* and *S. phureja* were also evaluated.

Screening for resistance to soft rot caused by *Erwinia chrysanthemi* continued; several very resistant clones were identified. Surveys in Peru isolated *E. carotovora* var. *carotovora* from potatoes in the lowlands, highlands and coast. *E. carotovora* var. *atroseptica* has been isolated only in the highlands while *E. chrysanthemi* has been found only in the lowlands.

Bacterial Wilt

Six field trials evaluated clones previously reported to have bacterial wilt resistance as well as new clones selected in 1979.

In the Huanuco area bacterial wilt and late blight resistance were tested at Umari (2,400 m), and a similar control trial was also planted at the University field (1900 m) where both diseases are absent. Of 141 clones planted in the Umari bacterial wilt plots 31 showed neither vine nor tuber infection. Late blight in bacterial wilt plots was controlled by two applications of Ridomil. In late blight plots, 138 clones were evaluated with only 23 having a disease reading of 4 or less (scale 1-9). At the University Experiment Station yields of 106 of the clones planted at Umari were evaluated. Yields of 30 clones exceeded 800 g/plant and 14 exceeded 1,000 g/plant (15 tubers in 3 reps). Some of the highest yielding clones were: MB 37.3 (1850 g/plant), P-11 (14070), MB 53.29 (1340), MS 36.19 (1270). The University goal is to release a variety for that area.

At San Ramon (La Chincana field, 1,100 m), 148 clones were evaluated for bacterial wilt during the rainy season. Only 10 clones lacked tuber infection (MS 63.12, MB 5.39, MB 6.6, MB 14.8, MB 30.2, MB 34.47, MB 37.37, MB 44.37, MB 47.4 and PSP 30.10).

Yield trials under coastal irrigated conditions included 156 clones at El Asesor with 43 clones yielding more than 500 g/plant and five above 1,000 g/plant. At La Molina six of 177 clones yielded above 1,000 g/plant.

Continued evaluation of the 36

best clones from the bacterial wilt and late blight resistance project started in 1979 included six field trials and one greenhouse test. In field trials resistance to bacterial wilt and late blight, yield, and adaptation to different conditions were evaluated while resistance to three tropical isolates of *P. solanacearum* was studied under greenhouse conditions.

Preliminary data indicate that only five clones showed neither vine, nor tuber infection (MS 35.9, MB 6.1, BR 62.5, BR 63.15 and Cruza 148). The highest average yield of a resistant clone at five locations was 848 g/plant. No single clones performed well at all locations because of either poor soil fertility or heat stress. In the greenhouse, 10 plants/clone were inoculated with a suspension of 1×10^8 cells/ml, 40 ml/plot, with each of three bacterial isolates (112, 122, 165). Despite the high inoculum level a few clones were resistant to two isolates (MS 42.3) or one isolate (MS 1C-2, MB 5.24, MB 6.1, MB 6.13, MB 34.22, BR 62.5) (Table IV-1). Late blight ratings at Umari, Peru, are also included.

Of 11,000 seedlings in 27 families screened for resistance to bacterial wilt and late blight for distribution to CIP Regions, 1,846 seedlings were late blight resistant and 152 were resistant to race 1 and 3 of *P. solanacearum*.

The presence and distribution of *P. solanacearum* at three soil depths (0-30; 30-60 and 60-90 cm) was studied in two naturally infested potato fields in the tropics of Peru (Huanuco, 2,400 m and San Ramon 1,100 m) at harvest time and 140 days after fallow. Bacterial wilt incidence after flowering was 36 percent and 67 percent at San Ramon and Huanuco, respectively. Potatoes cv. Ticahuasi, tomatoes cv. Huando and a new selective medium developed through the Wisconsin contract were used to

Table IV-1. Reaction of the best 12 of 36 clones to 3 isolates of *Pseudomonas solanacearum* (race 3) under greenhouse conditions (26-31°C) and to *Phytophthora infestans* under field conditions.

Clone	% Wilted plants			Late blight reaction at
	Isolate 112 (Nepal)	Isolate 122 (Rwanda)	Isolate 165 (Sri Lanka)	Umari, Peru
MS 1C-2	40	0	60	2
MS 1E-7	20	20	40	3
MS 42.3	40	0	0	3
MS 82.60	60	60	40	1
MB 5.24	60	40	0	4
MB 6.1	0	20	20	8
MB 6.11	60	60	60	8
MB 6.13	80	0	40	6
MB 34.22	80	60	0	9
MB 34.99	40	40	–	9
BR 62.5	0	40	20	2
PSY 89.43	40	20	80	4
Ticahuasi	100	100	100	9

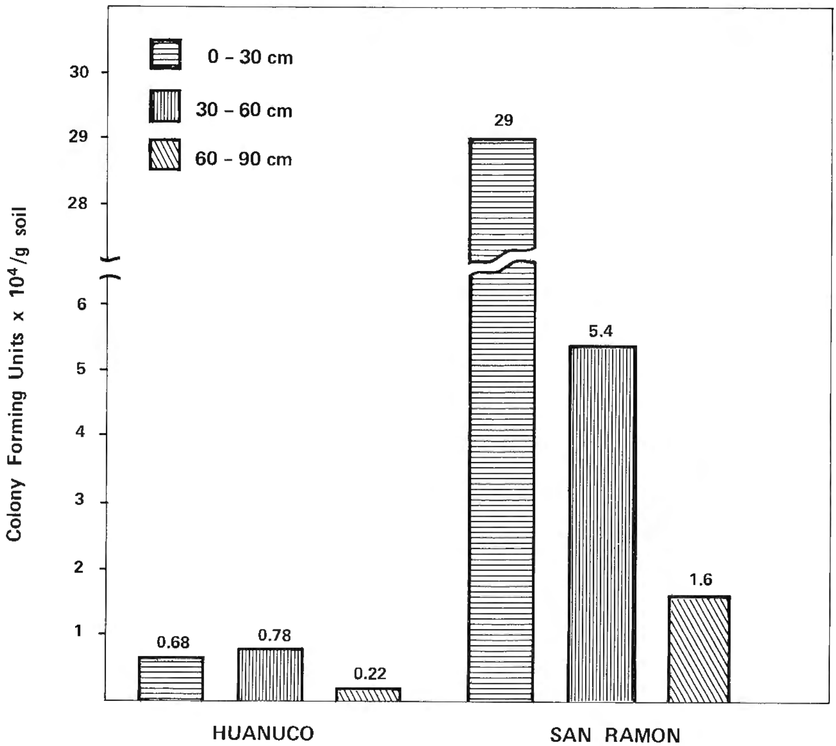
assay bacterial populations. The selective medium from soils collected at harvest time indicated that *P. solanacearum* was present at all three depths at both locations.

However, populations of bacteria were much greater at 0-30 cm and 30-60 cm at San Ramon than at Huanuco (Figure IV-1). These results agree partially with host plant response because at San Ramon tomato was readily infected from 0 to 60 cm depth but not at 60-90 cm, and potato failed to demonstrate bacteria at 30-90 cm depths.

Figure IV-1. Initial bacterial populations of *Pseudomonas solanacearum* at two locations and three soil depths in Peru. Samples taken at harvest April 1980.

On the other hand, at Huanuco potato demonstrated the presence of bacteria at all three depths (Figure IV-2). Populations of *P. solanacearum* were markedly decreased at all depths after 140 days of fallow at both locations (Table IV-2). Bacteria were not detected in soil collected at the 0-30 cm layer in Huanuco.

Screening of *Solanum* wild species for resistance to *P. solanacearum* continued. Most seedlings screened were derived from crosses involving *S. sparsipilum*, *S. chacoense* and *S. phureja* (MBN families). After screening to four different isolates: 013 (race 3, Peru), 003 (race 1, Peru), 048 (race 3 Costa Rica) and 052 (race 1, Taiwan), only 17 clones from 8 families were



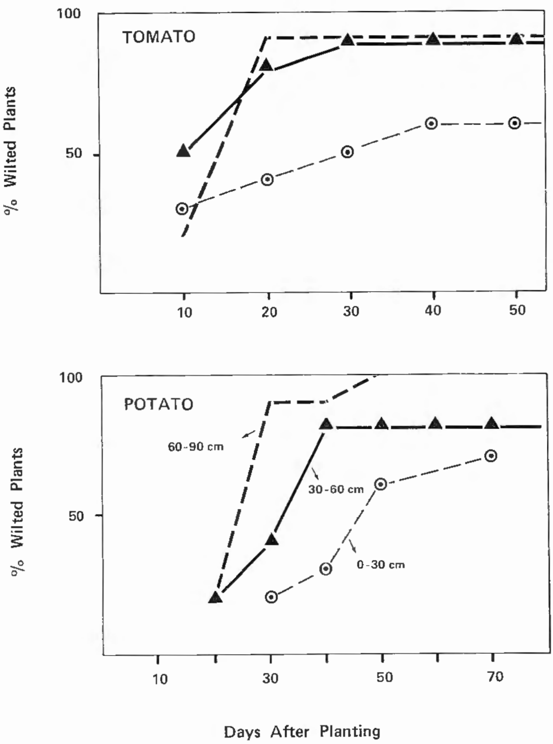


Figure IV-2. Percent wilted tomato and potato plants, planted in soil collected at three depths in Huanuco (Peru). Test conducted under greenhouse conditions at 26°-31°C.

resistant to all isolates. Fifty clones were resistant to three isolates and 111 clones were resistant to two isolates only. The best 17 diploid clones will be crossed to other resistant clones to concentrate in a single population most genes for resistance, especially to obtain good levels of resistance for the lowland tropics.

Erwinia Diseases

Resistance to *Erwinia chrysanthemi* of better yielding clones having resistance to other organisms was determined by the infectivity titration method (ITM) during 1980. In the first trial only one of 16 clones highly resistant to *Globodera pallida* was also moderately resistant to *E. chrysanthemi.* In another test, of 137 clones developed for resistance to bacterial wilt and late blight, only five clones were rated as resistant (R) and 10 as moderately resistant (MR) to *E. chrysanthemi.* Similarly, one clone was very resistant (VR), four were R, and 21 were MR to *E. chrysanthemi* of 147 clones resistant to frost and the late blight.

In studies on the distribution of the *Erwinias* in Peru, *E. carotovora* var. *carotovora* (Ecc) has been isolated from potatoes grown in the lowlands, highlands and coast.

E. carotovora var. *atroseptica* has been isolated only in the highlands and *E. chrysanthemi* (Ecy) has been isolated only from the lowlands. These results correlate

Table IV-2. *Pseudomonas solancearum* populations at Huanuco (2,400m) and San Ramon (1,150m) at three soil depths at harvest time and 140 days after fallow as determined by planting on a selective medium.

Soil Depths (cm)	Cells x 10^4 g/soil			
	Huanuco		San Ramon	
	At harvest	After 140 days	At harvest	After 140 days
0-30	0.68	0.00	29.99	6.15
30-60	0.78	0.22	5.40	0.65
60-90	0.22	0.08	1.60	0.23

well with the optima temperatures for each isolate. Ecc and Ecy have been isolated in the lowland region from plants grown from true seed which were then transplanted to the field.

Contract Research

University of Wisconsin

The project to determine relative importance of pectolytic strains of *Clostridium* in the decay of potato tubers in storage is approaching completion. Work progresses to determine correct species designation for the clostridial strains isolated from decaying potato tubers. The studies indicate for the first time the prevalence of clostridia in storage decay and the potential of these bacteria for causing rapid decay of tubers when temperatures rise above 20° C.

The project emphasis has shifted to studies on relationship of carbohydrate balance and mineral nutrition to the susceptibility of potato tubers to bacterial soft rot. Direct correlation between high levels of reducing sugars and increased susceptibility to *Erwinia carotovora* has been reported by several investigators. However, in our studies of this relationship no significant differences in decay severity were noted among commercial lots of tubers with different concentrations of reducing sugars. Glucose was shown to inhibit production of pectic lyase in vitro and delay initial onset of tissue breakdown when infiltrated directly into tuber tissue. Field trials to determine influence of different sources and levels of nitrogen on susceptibility of tubers to bacterial soft rot have been completed. These indicate a possible effect of Ca on bacterial soft rot susceptibility. In laboratory studies potato tubers were infiltrated with different concentrations of $Ca(NO_3)_2$ under vacuum and inoculated with *Erwinia carotovora*; treated tubers were then placed in a mist chamber to provide optimal conditions for bacterial decay. The percent of tuber tissue decayed decreased from 88.1 percent in the control series to 0 percent at 0.4M $Ca(NO_3)_2$. Decay severity with other N sources such as KNO_3 was not affected to the same degree. Work is in progress to determine the factors which are involved in this possible relationship between calcium levels and nitrogen source as well as other cultural practices that may affect tuber susceptibility.

Grant-in-Aid: Control of Bacterial Pathogens

Development of a selective medium for *Pseudomonas solanacearum*. A selective medium that allows excellent recovery of *P. solanacearum* (80-100 percent) from soil, while eliminating over 90 percent of other soil bacteria, has been thoroughly tested. It is prepared by adding to Kelman's tetrazolium medium (TZC) crystal violet (0.005 percent), merthiolate (0.005 percent), polymyxin B sulfate (100 ppm), tyrothricin (20 ppm), and chloromycetin (5 ppm). This medium represents a substantial improvement over those reported previously. The medium has a plating efficiency which is considerably better than that of several ordinary laboratory media. It has been used for the isolation of *P. solanacearum* from field soil samples received from Florida, Georgia, North Carolina, and Costa Rica. The medium is also being tested, with good results, at CIP headquarters in Peru as well as by collaborators in Japan, Costa Rica, Honduras, and Mexico. Recent tests with samples from Costa Rica indicate that minor adjustments in the content of antibiotics in the medium must be made when soil contains large numbers of certain groups of bacteria. Final composition of the medium must be adjusted specifically for each sample when the soil contains large amounts of decomposing organic matter.

Survival of *P. solanacearum* in the rhizosphere of nonhosts. The selective medium has been used to determine survival of *P. solanacearum* in the rhizospheres of pepper and castor bean plants. Seedlings were inoculated initially by a root-dipping technique. In the greenhouse, survival of *P. solanacearum* in the rhizosphere of these two plants could not be detected beyond 10 to 14 weeks. When long-term survival was detected, plants invariably showed internal colonization of the tissues. Pepper, in particular, could be colonized internally by several strains of the pathogen, although the plants remained symptomless. General conclusion of these studies in the greenhouse is that *P. solanacearum* survives by actively invading the roots of many plants that act as carriers, rather than by multiplying in the rhizosphere in competition with other bacteria.

Relationship of resistance to the multiplication and spread of *P. solanacearum* in potato stems. Work was completed on a long-term project to determine the kinetics of multiplication of *P. solanacearum* in susceptible and resistant potato plants. The results of infectivity titrations indicated that this is a highly sensitive system to detect differences in resistance of potato clones. Linear regression was used to estimate the ED_{50} values (dosage required to wilt 50 percent of the population) for each seven potato clones. Most hybrid clones (*S. phureja* x *S. tuberosum*) had intermediate ED_{50} values (310-1,000 CFU) when inoculated with our most pathogenic isolate (276, from Mexico). The most susceptible was Katahdin (ED_{50}: 3.00); the most resistant was *S. phureja* 1386.15 (ED_{50} : 2.09×10^6). On Russet Burbank, use of infectivity titrations indicated that strain 276 was more virulent than our standard strain (K60) by about three orders of magnitude. The resistance to strain 276, identified by infectivity titration, should be very useful in breeding programs.

As in previous investigations, it was determined that incompatible strains of *P. solanacearum* (an avirulent variant, a strain from banana, or virulent strains inoculated in highly resistant potato plants) multiplied extensively in the stem tissues, but at lower rates than in the compatible combinations. A major difference was the inability of the incompatible bacteria to move above the site of inoculation.

Extensive histological examination of the various compatible and incompatible interactions revealed no marked differences in the response of the tissues. In the incompatible interactions, vessels were plugged by masses of bacteria less frequently, but tyloses formed more frequently than in compatible interactions. However, the histopathologies of compatible and incompatible interactions were not strikingly different. The factors that restrict the upward movement and the multiplication of incompatible bacteria must be of rather subtle physiological origin.

Chemical nature of resistance in potato to bacterial wilt. Further work was carried out to determine the possible role of agglutinins (lectins) in resistance of potato clones to *P. solanacearum*. Emphasis was given to the study of the interactions of *P. solanacearum* cell surface polysaccharides and potato lectin. We reported previously that the binding interaction between potato lectin and the lipopolysaccharide (LPS) and extracellular polysaccharide (EPS) of the bacterium was reversible by oligomers of N-acetyl-D-glucosamine. We now suspect that the presumed "hapten" activity of our preparation resides in an unidentified polyanionic contaminant. Preparations of chitin oligomers free of this component do not prevent or reverse potato agglutinin-LPS or -EPS precipitation. The evidence thus far points toward a charge-charge interaction between positively charged groups on the agglutinin and negatively charged groups on the LPS and EPS. It is conceivable that differences in charge interactions, and, therefore, in agglutination of *P. solanacearum*, may account for differences in multiplication of the bacterium in resistant and susceptible potato cultivars. These possibilities are being examined.

Thrust V

Control of Important Virus Diseases

Potato Leafroll Virus (PLRV)

From native cultivars and wild species of potato 32 isolates of PLRV were collected from several sources and maintained on *Physalis floridana*. Symptom severity and type were essentially similar with all isolates. All were readily transferred with five *Myzus persicae* non-winged aphids suggesting no marked differences in aphid transmissibility.

New enzyme-conjugates prepared using two sources of antisera, reacted similarly and detected PLRV from leaf sap diluted up to 1/40. Incubation of samples at 32° C for 2 hours before loading the plates routinely produced the lowest absorbance values (A 405nm) in healthy controls and the highest with infected samples. Since there are still some problems in detecting low concentration of PLRV, studies are comparing immunosorbent electron microscopy with infectivity tests.

Potato Spindle Tuber Viroid (PSTV)

Electrophoretic detection of PSTV-RNA was facilitated using the Pfannestiel et al 1980 method of extraction. Sensitivity of the test is at least two-fold greater than the earlier method with only half the amount of tissue required for assay.

A local lesion host for PSTV is highly desirable. *Solanum acaule* (accession OCH 11705) has some potential in such an assay and a shrub from Peru may also be of use. Both plants are under further tests.

Studies on development of a potential serological test for PSTV were directed toward identification and resolution of the distinctive antigen found in previous experiments.

Following velocity sedimentation, the bulk of the antigen was left in the supernatant after centrifugation at 3,000 rpm for 30 min and in the material pelleted at 60,000 rpm for 2 hours. Attempts to produce antibodies to partially purified PSTV-RNA infected with polyacrylamide gel as adjuvant were not successful. Therefore, the major effort is now directed towards isolation of the distinctive protein from foliage, tubers, and seeds of PSTV-infected plants.

Analysis of total proteins from infected plants by electrophoresis suggested existence of a "protein band" not present in healthy plants. This protein seems to be very labile and occurs in extremely low concentration in plants infected with PSTV but does not occur in those infected with PVX, PVY, APMV, and PVS. In a few patterns it was possible to distinguish the protein in infected potato and in tomatoes. The band from potatoes migrated slightly faster than that from tomatoes suggesting that its production is host-dependent.

PVY Isolates

PVY isolates were collected from widely separated fields in Ecuador. Six Ecuadorian isolates induced necrotic local lesions on detached leaves of potato clone A6, but did not infect cultivars of *Capsicum annuum* and differed from Peruvian isolates in the milder symptoms induced on *Nicotiana tabacum* "White Burley." Three were aphid transmitted and placed in the PVY group while the other three were not aphid transmitted and are tentatively considered as members of the PVY^C group. Strains of PVY^C have been reported previously only from Europe, India and Australia.

In agar double diffusion serological tests with sodium dodecyl sulfate, Peruvian and USA PVY^O isolates reacted identically with a Peruvian PVY^O isolate and its homologous antiserum (Table V-1). PVY^N isolates from Peru and PVY^C (tentative identification) from Ecuador reacted with partial identity. The Peru tomato virus (PTV), a related potyvirus, did not react.

In reciprocal tests with PTV and its homologous antiserum, Peruvian PVY^O and PVY^N and USA PVY^O gave a reaction of partial identity. The Ecuadorian PVY^O and PVY^C did not react. Differences of this type as observed among potyvirus strains in double diffusion tests have been reported previously only for turnip mosaic virus.

Two Peruvian isolates of the PVY^O group did not produce necrotic local lesions on detached leaves of potato clone A6. A similar deviating strain has been reported previously only in Europe.

Fields 400-800 meters above sea level were extensively surveyed in northwest Argentina. Seed in this region is believed to be representative of most of that grown in Argentina. No virus disease symptoms were observed in half of the 22 fields surveyed. The incidence of mosaic and potato leafroll diseased plants were essentially similar.

Mosaic diseased (57 samples) and 34 apparently healthy plant samples were collected. They were checked by the latex serological test for PVY, PVX, PVS, andean potato latent virus (APLV), and andean

Table V-1. Serological reactions of Ecuadorian PVY isolates when compared with a Peruvian PVY^N isolate and its homologous antiserum, in sodium dodecyl sulfate-agar double diffusion.

Reaction			
Identity		Partial Identity	
Number of isolates and strain group	Origin	Number of isolates and strain group	Origin
2 PVY^O	Peru, La Molina	9 PVY^N	Peru, Cuzco
4 PVY^O	Peru, Cañete	2 PVY^N	Peru, Huanuco
1 PVY^O	Peru, San Ramon	3 PVY^O	Ecuador
1 PVY^O	Peru, Cajamarca	3 PVY^{C*}	Ecuador
2 PVY^O	U.S.A.		

* Tentative classification of this group of isolates.

Table V-2. Relative prevalence of potato viruses detected in northwest Argentina in mosaic diseased and apparently healthy plants as determined by the latex serological test for PVX, PVS, APLV and APMV and the microprecipitin drop test for PVY.

Virus	Plants with mosaic symptoms (%)*	Apparently healthy plants (%)**
Potato virus X	28	15
Potato virus Y	19	0
Potato virus S	21	5
Andean potato latent virus	0	0
Andean potato mottle virus	0	0

* From a total of 57 plants assayed.
** From a total of 34 plants assayed.

potato mottle virus (APMV). The microprecipitation drop test was also used for detection of PVY (Table V-2). The natural virus infection levels detected in these tests had resulted from only two field multiplications of imported certified seed.

Novel Viruses

A virus coded SB-10 was obtained from cv DTO-33 during routine host range testing. SB-10 does not produce symptoms in DTO-33 but a mild mosaic in Kennebec and Tomasa Condemayta. Symptoms induced in other solanaceous hosts are mild mosaic, leaf deformation, stunting and sometimes vein necrosis. The virus causes systemic infection in *Chenopodium quinoa*, *C. amaranticolor*, *C. murale* and *Gomphrena globosa*. Purified preparations show isometric particles ca. 30nm in diameter. The virus seems to have its genome encapsidated in two different particles. Protein preparations from purified virus show the presence of two polypeptides but they do not occur in equimolar quantities. The polypeptide in higher concentration has M.W. of 32,000 daltons.

UF Virus

This has been isolated from a Peruvian potato cultivar. This virus is mechanically transmitted to indicator hosts and to some wild potatoes and cultivars. When grafted onto several potato cultivars it induces chlorotic spots starting on the leaf margins which may fuse and produce large chlorotic areas and leaf crinkling. It resembles PVY but does not produce local lesions in clone A6 and does not react serologically against antiserum to normal PVY. It is transmitted by aphids in a non-persistent manner and has elongated flexuous particles about 730 nm, typical of the potyviruses. Studies are underway to compare it by symptomatology and serology to three strains of PVY, PVA, Peru tomato virus and wild potato mosaic.

Studies were continued to characterize three novel diseases of possible virus origin: a deforming mosaic, a yellow vein disease and the tentatively name P78 disease.

Electron Microscope (EM)

The electron microscope facility is now fully operative including the ultramicrotome. The EM work involves routine examination of potato leaf samples for virus identification, purified virus preparations, ultra thin tissue sections and to a lesser extent immunosorbent electron microscopy. The EM facility is being used to a limited extent for collaboration with research institutions in Peru. Members of the CIP virology thrust actively participated in the First National Course in Electron Microscopy organized by the Peruvian Association of Pathologists.

Antiserum for Virus Detection

Sensitized latex for detecting potato viruses by the latex agglutination test has been distributed to National Potato Programs in 15 different countries throughout the world. Amounts distributed vary between 2 to 30 ml, enough for 250 to 3,600 tests (Table V-3). Polivalent latex to detect PVX, PVS, and PVY simultaneously was also prepared and sent to two countries. An instruction sheet is sent with all samples and a slide set has been prepared with the CIP Communications Department depicting the procedure step by step.

Sensitized latex has also been sent for virus testing in CIP seed program and for testing resistance to PVX and/or PVY in the following amounts: PVX, 118 ml (14,160 tests); PVY, 222 ml (26,640 tests); PVS, 314 ml (37,680 tests); APLV, 96 ml (11,520 tests) and APMV 161 ml (19,320 tests). Requests for pure antiserum for microprecipitation or other tests have been received from 6 countries.

In order to increase sensitivity of the latex agglutination test, eight buffer systems were compared with the Tris-HCl buffer system presently in use. None were superior. Sensitivity of tests was not increased using protein A for latex sensitization. EM observations have been used to determine the nature of latex particle aggregation in positive reactions.

PVY Resistance

Potato seedlings from 244 families were inoculated with either PVY^{O} (isolate T), PVX (isolate C), or simultaneously with both. Three

Table V-3. Distribution of antibody sensitized materials to different countries*.

Number of countries	PVX	PVY	PVS	APLV	APMV
South America					
6	32	32	32	14	14
Africa					
1	7	7	7	–	–
Asia					
5	52	52	52	18	18
Other					
4	11	11	11	4	4

* Amounts in ml (1 ml = 120 tests).

Table V-4. Susceptibility of selected families to PVX, PVY, or PVX + PVY when seedlings were spray gun inoculated in flats before transplanting.

Crosses		Inoculum	Plants inoculated Nº	Healthy plants Obtained %	Healthy plants Expected %
B1 61.74.167 x (X + Y Resistant)	B1 54.121 (susceptible)	PVX	135	84	
		PVY	146	50	
		PVX + PVY	119	50	42
XY 15.7 x (X + Y Resistant)	Maria Tropical (susceptible)	PVX	55	44	
		PVY	43	42	
		PVX + PVY	64	45	
Ccompis (open pollinated (susceptible)		PVX	114	22	
		PVY	116	16	
		PVX + PVY	62	2	3
		Total	866	42	

weeks later, symptomless plants were reinoculated mechanically with a 2 percent w/v inoculum concentration of each virus. Plants with mosaic symptoms or with necrotic local lesions were discarded. From a total of 34,381 seedlings inoculated, plants were selected as potentially "immune" to PVY (1965 plants), to PVX (512 plants) or to both PVY and PVX (13,795 plants).

Previous tests suggested some interference between PVX and PVY inocula when mixed together as the percentage of apparently healthy plants surviving the test was higher than expected. Three families (Table V-4) were inoculated at a 5 percent w/v concentration with each virus. The number of healthy plants obtained from simultaneous inoculation with PVY and PVX was slightly higher with B1 61.74.167 X B1 54.121 than expected and with XY 15.7 X Maria Tropical the percentage of apparently resistant plants was considerably higher than expected. However, the percentage of healthy "escapes" in a susceptible progeny was apparently unaffected. Attempts will be made to avoid this interference by modifying the inoculum preparation.

Simultaneous inoculation of PVY and PVX was synergistic on potato seedlings similar to that reported for tobacco. Doubly infected plants exhibited more severe symptoms of rugose mosaic and growth reduction than those singly infected with either virus.

From diploid *Solanum phureja* and *stenotonum* intercrosses tested for PVY resistance, three clones showed resistance after mechanical inoculation and some resistance to aphid inoculation, but were susceptible after graft transmission. Resistance in these three clones is polygenically inherited and broken by high temperatures. Stem cuttings from these clones were mechanically inoculated with isolates of three Peruvian PVY strains. Except for clone P 1-1 inoculated with isolates CC5 and T, all the other potato plants remained symptomless. Clone P4 was resistant to isolates T and CC5.

These same three Peruvian PVY isolates, plus isolate 16-1, a mild necrotic strain, have been grafted on seven sources of "immunity" to PVY used as scions. So far all these resistant sources react as "immune" to the four strains. Tuber progenies from the "immune" scions are presently under study to detect virus infections. Also 9 Peruvian isolates (four PVY^O and five PVY^N) collected in four locations in Peru have been grafted on PVY immune clones XY 14.7 and 377967.4. These clones behave also as "immune" to the 9 isolates.

PLRV Resistance

Seedling plants grown from true potato seed (TPS), obtained from PLRV resistant parents were inoculated by shaking PLRV-carrying aphids (*Myzus persicae*) onto seedling plants growing in trays.

Aphids were permitted to feed for one week and then were killed by an insecticide. Plants without PLRV symptoms were transplanted to "Jiffy" pots and grown until tubers had developed. Tubers of plants without symptoms were saved for further observations (Table V-5).

To the present, 30 families (CIP numbers 379611 to 379640) with high PLRV resistance were identified and selected before the first tuber generation. Tuber sets of 14 families have been distributed to Pakistan, Turkey, and Argentina under CIP numbers 379037-40 and 379325-34. These progenies were previously field evaluated in Peru.

In a new screening protocol, three tuber sets are made from the symptomless individuals surviving the seedling screening test. The largest tuber of each plant is placed in set A, the next largest in set B, etc. Sets A, B, and C are grown in the screenhouse and plants with secondary PLRV symptoms are recorded. Set A is transplanted to the field where natural PLRV spread is expected. The frequency of primary PLRV symptoms is recorded. The best plants are selected for type and yield. Set B is planted in the screenhouse and incidence of tuber borne PLRV determined. These plants are then exposed to a second aphid inoculation. Set C is grown without further inoculation and secondary symptoms are observed during the period of growth.

During 1980, 5,610 tubers of set A (symptomless survivors from five different PLRV seedling screening experiments) from 76 families were planted in the field for further PLRV and agronomic evaluation. Presently, another group of 29 families with over 2,000 symptomless survivors of PLRV seedling screening tests is in the final stage of tuberization in the screenhouse.

Table V-5. PLRV resistance-seedling evaluation in screenhouses at La Molina.

Program	1979-80 N°	1980 N°
Experiments	4	3
Families screened	78	60
Seedlings inoculated	8,730	7,315
Symptomless survivors	6,470	6,235
Tubers for field tests	2,533	4,449

PLRV Germ Plasm Screening

After field screening of 1,100 accessions from CIP's germ plasm collection to identify new sources of resistance to PLRV, 27 selections were made during 1979. These selections were interplanted in the field in 1980 with PLRV infected carrier plants. Three outstanding clones CUP-199, 703232 and 701752 have been selected with high potential for PLRV resistance and suitable plant type. Further screenhouse tests are underway to determine the PLRV resistance level of each clone.

Trichomes and PLRV

Five *M. persicae* aphids were placed on two accessions of *Solanum berthaultii* namely PI-310971 (with 4-lobed trichomes only) and PI-265858 (with both simple sticky and 4-lobed trichomes) multiplied to an average of 31 and 8.4 aphids per plant, respectively, within seven days. Four of five seedlings of each accession became infected with PLRV in the screenhouse. From PI-310971 in PLRV field exposure trials, 84 percent of the tubers became infected with PLRV. Similar tests are underway to determine the percent of PLRV present in the field harvested tubers of PI-265858 by using back inoculations to *Physalis floriana* and by ELISA serology. Both of these accessions are also highly susceptible of PVY.

Thrust VI

Control of Important Nematode and Insect Pests of Potatoes

Breeding and screening for resistance as well as biological and cultural practices in controlling nematode and insect pests received major attention during 1980. Sources of resistance to the potato cyst nematodes *Globodera pallida* and *G. rostochiensis*, to root-knot nematodes *Meloidogyne* species, to potato tuber moth *Phthorimaea operculella*, to Andean potato weevil *Premnotrypes suturicallus*, aphids and other foliar insects were used to develop resistant cultivars. Field applications of *Paecilomyces lilacinus* for controlling *Meloidogyne incognita* constituted a major effort in biological control studies.

NEMATOLOGY

Potato Cyst Nematodes (PCN)

In developing an efficient seedling screening method, seedlings of several crosses were inoculated with either cysts or nematode egg suspension. Inoculating seedlings with cysts 10-15 days after transplanting into small plastic cups was more practical than using the nematode egg suspension as inoculum. However, results indicate that seedling screening is much more laborious, time consuming and not as accurate as tuber screening. The use of an adequate soil mixture, fertilizer, water and temperature management have improved the accuracy of tuber test.

Greenhouse tests for identification of tolerance were conducted in Holland. The technique developed is efficient in identifying tolerance, although some greenhouse selected clones did not yield well under field conditions.

Results of pathotype identification of CIP's collection of potato cyst nematodes indicate predominance of *Globodera pallida* races P_4A and P_5A in the Andean countries (Table VI-1). *G. rostochiensis*

Table VI-1. Pathotype identification of potato cyst nematode populations (*Globodera* spp.) in 1980.

		Pathotypes									
Populations	Number	R_1A	R_1B	R_2A	R_3A	P_1B	P_2A	P_2B	P_3A	P_4A	P_5A
Bolivia	10	–	1	1	4	–	–	2	1	1	–
Peru	50	1	2	–	–	1	2	–	2	18	24
Ecuador	5	–	–	–	–	–	1	–	1	3	–
Colombia	4	–	–	–	–	–	1	–	1	2	–

was identified in samples from Costa Rica, Chile, India, Mexico and Panama. *G. pallida* was also identified in the cysts collected in India.

Resistance to *G. pallida* (races P_4A and P_5A) in CIP clones 702535 and 702698 was studied. Thirty cysts consisting of approximately 3,870 eggs were enclosed in muslin bags and inoculated in small pots containing tubers of these clones. A local susceptible cultivar "Renacimiento" was used as control. When plants matured new cysts and their number of eggs were counted, old cysts were recovered from muslin bags and the number of unhatched eggs were counted. An average of 1.4, 4.6 and 232.61 cysts were recovered from 702535, 702698 and Renacimiento, respectively (Table VI-2). There were no significant differences in number of unhatched eggs in cysts recovered from the resistant clones as compared to those of Renacimiento. Resistance is attributed to both an effective blocking system in the roots and hatching stimulus.

Table VI-2. Average number of new cysts and eggs formed in each clone.

	Clones		
	702535	702698	Renacimiento
New cysts	1.4	4.6	232.6
New eggs	181.5	596.5	30,163.6

A total of 2,804 clones from various sources were screened for resistance to *G. pallida* races P_4A and P_5A. Several clones resistant to both pathotypes are being retested prior to including them in the breeding program (Table VI-3).

Resistance to P_4A was confirmed in 21 accessions of *Solanum capsicibaccatum*, *S. megistacrolobum*, *S. sparsipilum* and *S. vernei*. Five clones of the 1978 Cornell Cyst Nematode Program representing intercrosses of wild and cultivated species were selected as resistant to P_5A population. From the 1979 Cornell contract, 37 clones were selected for resistance to three pathotypes (P_4A, P_5A and R_3A).

Results of tuber retest with material received as true seed from Holland indicate that 137 clones were resistant to P_4A. The clone AM 72-6368 has shown resistance to P_4A and P_5A pathotypes (multiplication rates 1.0 X and 2.6 X respectively). Resistance of 9 clones to P_4A, 11 to P_5A and 9 to R_3A

Table VI-3. Results on tuber screening for resistance to *Globodera pallida*.

Source	Number	Resistance to		
		P_4A	P_5A	P_4A + P_5A
Germ plasm	460	0	0	0
Meloidogyne resistants	134	52	18	14
CIP's breeding program	84*	1	–	–
Wild species	68	25	11	8
SVP contract	742*	109	–	–
Cornell contract	864	116	17	24
Wisconsin	196	21	–	–
Max Plank Institute	256	–	0	–

* Previously screened as seedlings.

Table VI-4. Reaction of selected new breeding material to two races of *Globodera pallida*.

	Number families	Number clones	Resistant clones* P_4A	P_5A	$P_4A + P_5A$
RP_5A x RP_4A	81	754	65	39	28
RP_5A x susceptible	31	388	0	47	0
RP_4 x susceptible	10	128	11	4	0
Total	122	1,270	76	90	28

* Root ball reading on 3 tubers/clone.

from the PCN breeding program have been confirmed by nematode cyst count. Only one showed resistance to three pathotypes.

Agronomic characteristics of several clones selected for resistance to *G. pallida* in previous years were evaluated. Twenty of these clones are being tested in three different locations in Peru to confirm their resistance to *G. pallida* races in those areas.

Seedlings from 122 families crossed during 1979 were screened for resistance under field conditions. Results of screening are given in Table VI-4. A high degree of specific combining ability has been noted and percent resistance recovered was lower than expected.

Studies of inheritance of resistance to *G. pallida* race P_4A in clones 702535 and 702698 indicate that the mechanism of resistance to race P_5A is inherited independently from the genes segregating for resistance to race P_4A. Percent resistance to race P_4A was the same if the clone resistant to P_4A was crossed with susceptible or resistant to race P_5A clone. It is postulated that the resistance is governed by several genes.

During several collection trips in southern highlands of Peru the past few years a white spherical female of an undescribed species was found on several crops in the vicinity of Lake Titicaca (15°-16° S latitude at 3,800 m). Laboratory observations confirmed that these white spherical females were not immature female nematodes of *Globodera*. Results of studies on the biology of this nematode indicate that it has more than one generation per growing season and mature females produce hundreds of larvae that hatch without a dormant period leaving a collapsed and disintegrated female. This characteristic has caused difficulty in establishing field identification on potatoes due to its extreme similarity with that of the females of the potato cyst nematode *Globodera* spp. Taxonomic studies indicate that this nematode is closely related to the genus *Thecavermiculatus*.

Root-Knot Nematodes

A total of 105 families consisting of the fifth cycle of recurrent selections for resistance to the root-knot nematodes were tested for resistance to *M. incognita*. These families were represented by 5,735 genotypes.

Segregating progenies immune and resistant to *M. incognita* consisted of 5.2 percent of the total

Table VI-5. Reaction of families consisting of the fifth cycle of recurrent selections for resistance to *Meloidogyne incognita.*

Families tested	Total N° seedlings	Root galling index* 1	2	3	4	5
105	5,735	35	210	1,586	3,724	130
		1.5%	3.7%	27.6%	64.9%	2.3%
		5.2%				

* 1 = no root galling and/or egg mass production to 5 = very severe root galling and/or a very high egg mass production.

populations tested (Table VI-5). In comparison with results on the fourth cycle of recurrent selection progenies, this is about a seven-fold drop in the level of resistance and immune material selected. This is basically attributed to development of a larger percent of tetraploid susceptible material in the fifth cycle of recurrent selection progenies. This drop in the level and frequency of resistance was expected due to apparent recessiveness of the resistance to the root-knot nematodes. Stem cuttings and tubers of the resistant material were obtained to multiply for future crosses and yield trial studies.

During 1978 some progenies of 4X-2X intercrosses, developed from the lowland tropic adapted clones were used as females crossed with bulk pollen of the intra- and interspecific-hybrid clones selected for both *Meloidogyne* and *Pseudomonas* resistance. Contributing species in these crosses were *Solanum sparsipilum*, *S. chacoense*, *S. microdontum*, *S. phureja* and *S. stenotomum*. In 1979 further intercrosses

Table VI-6. Reaction of the progenies of 4X – 2X intercrosses to *Meloidogyne incognita.*

Source	N° clones	N° plants	Root galling index* 1	2	3	4	5
4X - 2X intercrosses	345	1,157	11	35	794	304	13
			1%	3%	68.6%	26.2%	1.1%
			4%				
(4X-2X intercrosses) x (tropically adapted material)	197	334	31	20	181	97	5
			9.3%	6%	54.2%	29%	1.5%
			15.3%				

* 1 = no root galling and/or egg mass production to 5 = very severe root galling and/or a very high egg mass production.

of these materials were made in addition to crosses of 4X-2X intercrosses of 1978 backcrosses with tropically adapted clones. All material was planted in the field to select for good agronomic characteristics and for resistance to *M. incognita*.

A higher percent of immune and resistance clones were obtained from the crosses consisting of (4X-2X) X tropically adapted materials (Table VI-6). Some of the hybrid progenies also segregated for resistance to viruses X and Y as well as *Pseudomonas solanacearum* and *Phytophthora infestans*. All the resistant material from this cross and those of 4X-2X intercrosses are apparently tetraploid and are being multiplied for further test and use in the breeding programs.

A total of 69 clones of the germ plasm material previously reported as resistant to *M. incognita* were retested to confirm their resistance prior to use in the breeding program. Eleven immune and resistant selections have been added to the ongoing breeding program.

A total of 148 clones previously selected for resistance and high yielding capabilities were planted in a high jungle site (800 m) to further select for adaptability to hot, humid conditions. Thirty-three promising clones were selected and are being used in the breeding program. All 148 clones were also tested for resistance to *Macrophomina phaseoli* (charcoal rot). Nineteen clones were highly resistant and will provide a genetic base for obtaining resistance to charcoal rot organism.

Progenies of seven selected families of the fourth cycle of recurrent selection which segregated 70 percent or more for resistance to the Peruvian *M. incognita* population were tested at North Carolina State University. Each genotype was tested for resistance to four races of *M. incognita*, two races of *M. arenaria* and one race of *M. javanica*. Data indicate a high rate of segregation for resistance to these species (Table VI-7). Percent individuals resistant to all the races and species tested varied from 6 to 37. These results indicate the potential of combined resistance to other species and races

Table VI-7. Reaction of selected *Meloidogyne incognita* resistant families to several races and species of *Meloidogyne*.

	Percent segregation for high degree of resistance							
	M. incognita races				*M. arenaria* races		*M. javanica*	Combined resistance*
Family	1	2	3	4	1	2		
378857	100	82	90	100	87	50	40	14
378875	84	64	72	89	71	56	67	23
378908	87	67	68	79	84	48	86	20
378911	90	65	77	98	93	29	60	6
378916	56	46	39	69	49		51	13
378924	96	65	88	96	69		84	37
378930	83	67	60	69	46		70	23
378950	79	55	45	47	43		58	12

* To four races of *M. incognita*, two races of *M. arenaria* and one race of *M. javanica*.

of *Meloidogyne* in the material selected for resistance to Peruvian *M. incognita* race 3.

Feasibility of the use of chemicals in treatment of true potato seed and seed tubers for protecting plants from nematodes was investigated at Oregon State University. Preliminary results indicate a 1:1 mixture of acetone and Vydate (12 percent active ingredient) and 3:1 mixture of acetone and Mocap (17.4 percent active ingredient) had no effect upon germination and subsequent growth of potato seed in 2-16 minute soaks. Similar observations were also noted with pelleted seeds. Efficiency of these and other nematicides in controlling the nematodes is being tested.

Biological Control

Preliminary results in controlling *Meloidogyne incognita* under field conditions by the fungus *Paecilomyces lilacinus* were presented last year. To confirm those results and further determine the efficiency of this fungus control under different climatological conditions and different periods of field inoculation, experiments were conducted in Chincha and Cañete, Peru. The fungus was applied: (1) one month before planting, (2) at planting, (3) as a water suspension dip immediately before planting, (4) at hilling and (5) a non-inoculated control using a local Peruvian cultivar "Mariva". Normal field care was used throughout the growing season. Irrigation was restricted to prevent run off from entering other plots.

Roots and tubers were examined for nematode infection at harvest. A significant reduction of root and tuber galling was noted in all fungus-treated plots when compared with controls. Inoculation at planting was the most effective. Although no significant differences in total yields resulted from various treatments, more marketable potatoes as judged by less galling were produced in fungus-treated plots.

The use of *P. lilacinus* for experimental control of *M. incognita* was also done in farmers' fields in several locations in the coastal desert. Plots included (1) no treatment, (2) fungus treatment and (3) a commonly used nematicide Temik (at 10 percent granular formulation 25 kg/ha). Both nematicide and fungus were applied at planting. Normal field care was

Table VI-8. Effect of *Paecilomyces lilacinus* and Temik field application on *Meloidogyne incognita* on yield.

Cañete – Peru 1980				
Treatment		Kg. total yield/ $400m^2$ plot	Kg. infected tuber yield/$400m^2$ plot	Kg. non-infected tuber yield/ $400m^2$ plot
Control		814.61	691.92	122.57
Fungus		721.63	419.04	302.40
Temik 10% G (25 kg/ha)		656.88	509.76	171.00
LSD	0.05	104.62	27.60	85.10
	0.01	139.32	36.72	113.28

by the farmer. At harvest, roots and tubers were examined and indexed for nematode infection.

Results demonstrated the potential of biological control. There was a significant reduction of tuber and root galling in the fungus- and nematicide-treated plots compared with controls. Yield of total marketable potatoes (non-infected tubers) was highest in fungus-treated plots (Table VI-8).

ENTOMOLOGY

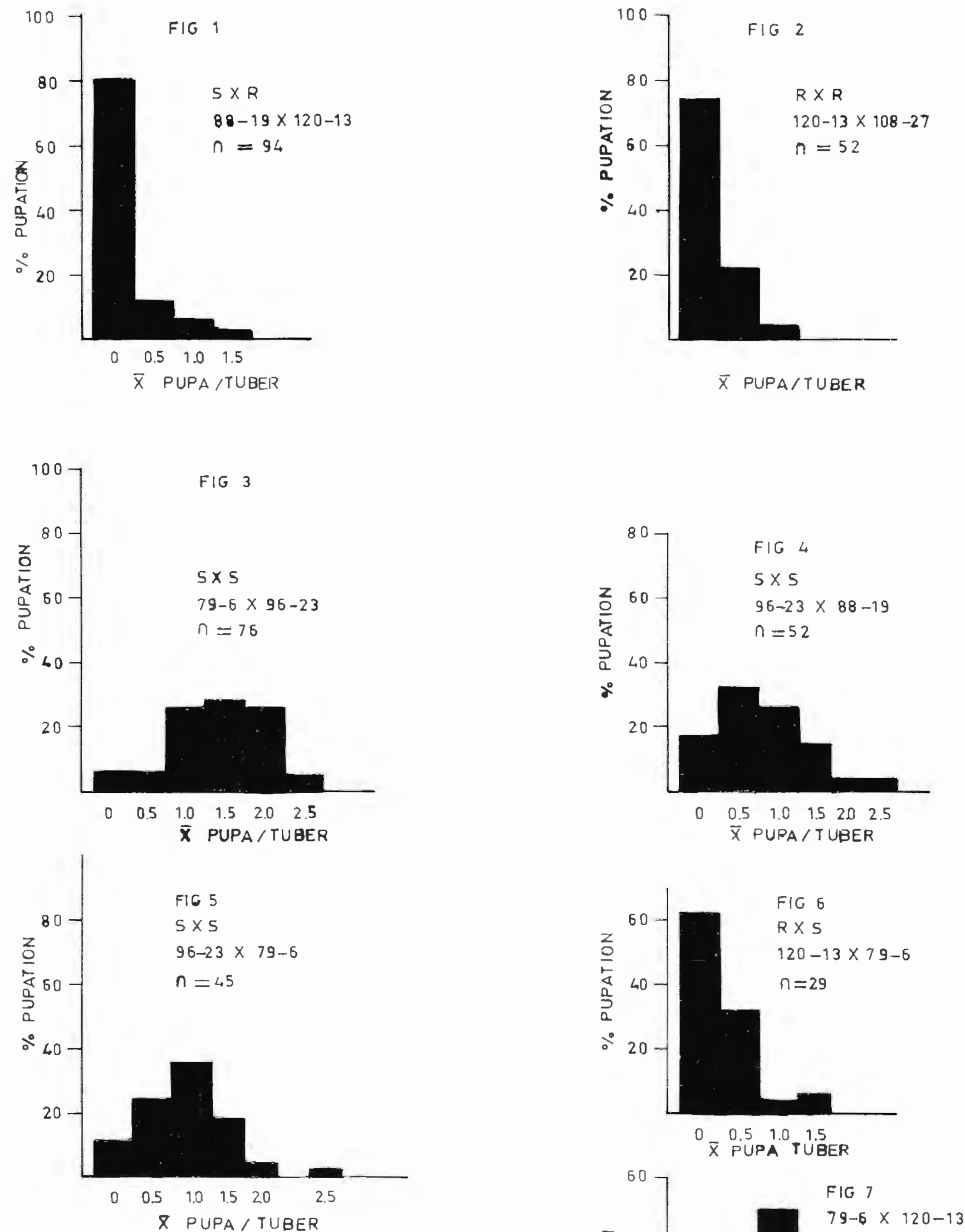
Potato Tuber Moth (PTM)

Species identification studies indicated that *Phthorimaea operculella* was the major species in Peru, Turkey and Tunisia. In Costa Rica, *Scrobipalpopsis solanivora* was the major species. Of lesser economic importance was *Scrobipalpopsis absoluta* and *Symentrischema plasiosema* from Peru.

Three thousand germ plasm clones were tested for resistance to the major potato tuber moth species, *Phthorimaea operculella. Solanum andigena* clones H/J 127, OCH 3813 and OCH 5244 were significantly less damaged. Fifteen clones also have been selected for antibiosis from 72 wild species obtained from Sturgeon Bay, Wisconsin. In another study, inheritance of resistance to tuber moth in tubers of 23 crosses having combined genes of *S. sparsipilum*, *S. chacoense* and *S. phureja* indicate that resistance is probably dominant and controlled by a few major genes (Fig. VI-1). Green tubers were less preferred as oviposition sites by 5-day-old PTM adults than brown skinned tubers; twice as many brown skinned tubers were oviposited during a 4-day-period.

Population dynamics of adult tuber moth were studied at a coastal desert (Lima) and alpine (Chocon) sites using commercial sex attractants. In Lima, populations averaged 805 moths/week (Jan-Apr.) and 53.6 percent of DTO 33 tubers harvested in April, 1980 were damaged by this pest (Fig. VI-2). In Chocon, a mean of 142 moths/week (Feb-May) were found with no resultant economic damage. Different formulations of sex attractants PTM 1 + PTM 2 (Laboratory of Insecticides and Fungicides, Wageningen, Holland) and PTM 1 (Zoecon Corp. USA) were tested in Lima during the winter season (Jun-Oct.). PTM 1 + PTM 2 attracted an average of 95 adults/week while 47 adults/week were attracted to the PTM 1 formulation. Since only 2 percent of DTO 33 tubers were damaged, insecticidal protection is not required for tuber moth control during winter season in Lima.

Research on importance of tuber moth control on potatoes grown from true seed was investigated in the tropical environments of San Ramon, Peru. Clone DTO 33, was significantly less damaged when the transplants were hilled up to basal leaves; no differences in damage were found when this clone was grown from seed tubers or true potato seed. Chemical control studies using Temik, Furadan, Aldrin at the time of planting indicated that none of these insecticides were effective in reducing tuber damage by this pest at harvest. Pyrethroid insecticide, "Fenvalerate" was tested at a coastal location (Cañete) and the treatment was compared with farmer's method of storage. The insecticide is superior in control of this pest and varieties treated with it showed



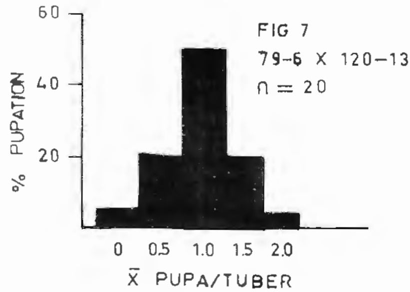


Figure VI-1. Mean potato tuber moth pupa/tuber: Percentage frequency histograms for F_1 progeny of representative crosses involving resistant (R) and susceptible (S) diploids.

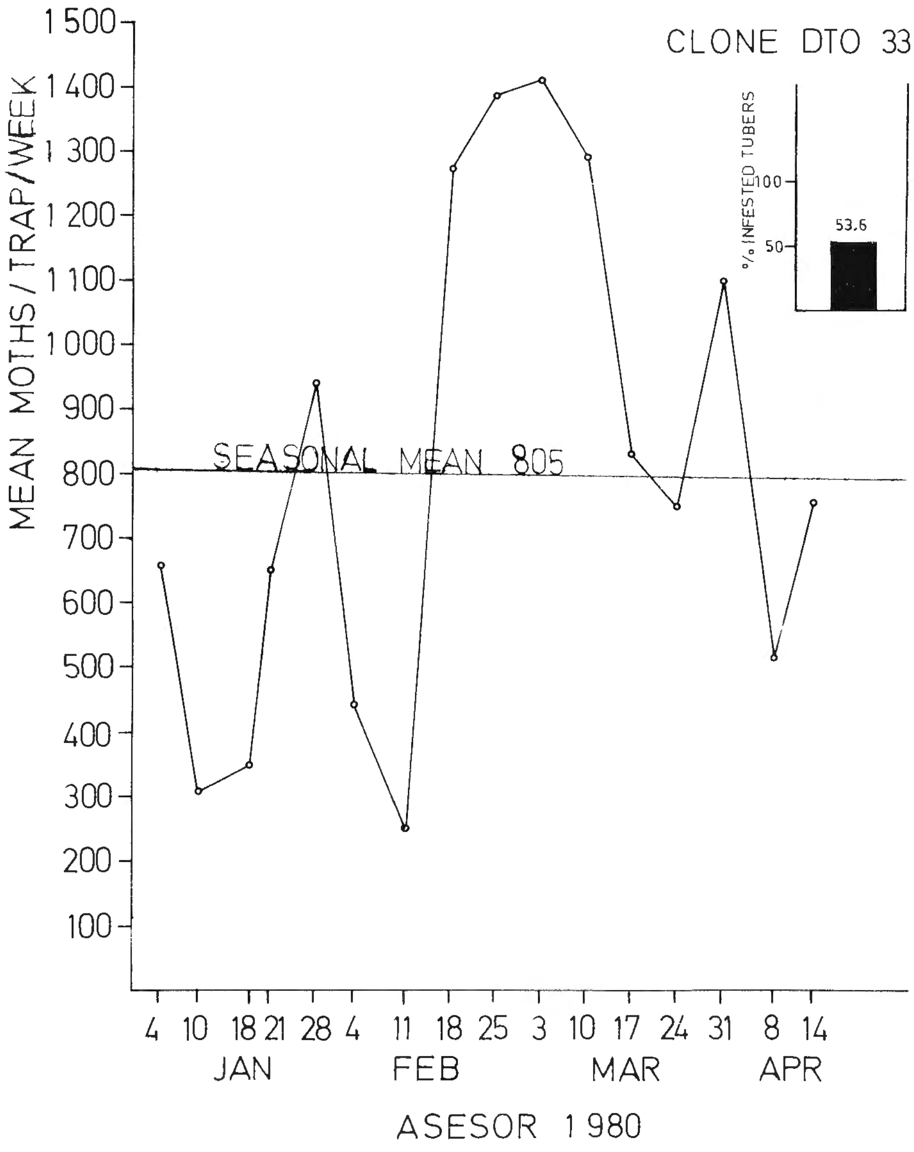


Figure VI-2. Populations of male potato tuber moths per field trap per week and tuber damage for clone DTO-33 during sex attractant evaluation in summer season, Lima.

significantly higher plant emergence and yield (Table VI-9). The andean weed, *Mintostachys* sp. (Fam: Labiatae) layered with the tubers and lime when applied as dust to tubers reduced damage by larvae of this insect. The weed *Mintostachys* sp. also reduced pupation.

A survey on the extent of damage in Tunisia, Algeria and Turkey revealed that PTM is responsible for up to 86 percent tuber damage when the tubers are stored up to 3 months. These

Table VI-9. Tuber damage by potato tuber moth under improved vs farmer's storage and its effect on plant emergence and yield in Cañete, 1980.

Varieties	Storage method	Insecticide treatment [1]	Tuber damage by PTM [2] %	Plant emergence %	Yield t/ha *
Mariva	Improved	Fenvalerate (Belmark)	0 a	87	17.90 a
	Farmer	Aldrin + BHC	20 b	51	8.80 b
Revolucion	Improved	Fenvalerate (Belmark)	0 a	96	15.00 a
	Farmer	Aldrin + BHC	25 b	47	6.20 b

* Means for each variety followed by different letters are significantly different at P = > 0.05 level using the Duncan's multiple range test.

[1] Fenvalerate (Belmark) 0.5% at 100 liters/2,000 kg tuber. BHC 2 kg & Aldrin 1.5 kg/1,200 kg tuber.

[2] Percent tuber damage at 2 months after storage.

losses occur despite the use of insecticides such as malathion dust.

Preliminary tests on chemical control of PTM in storage conducted in Tunisia and Turkey indicates that Decis, a pyrethroid compound, is as effective as parathion (Table VI-10). A few new insecticides are also being tested against PTM. Sex pheromone traps are used in several countries to monitor this pest in fields.

Andean Weevil

Six tuber-bearing *Solanum* species (*S. stenotomum*, *S. juzepczukii*, *S. tuberosum* ssp. *andigena*, *S. curtilobum*, *S. acaule* and *S. ajanhuiri*) were evaluated for andean weevil resistance under field conditions. Clones CIP 703181, CIP 700530 (*S. tubr. andigena*) and CIP 702008 (*S. juzepczukii*) had significantly less damage. There was

Table VI-10. Chemical control of potato tuber moth in storage, Turkey and Tunisia.

Treatments	Mean percent tuber damage at 90 days	
	Turkey	Tunisia
Propuxor (Unden 1% dust)	4.9	–
Parathion 1% dust	5.6	0.8
Actillic 2% dust	7.0	–
Decamethrin (Decis 2.5 EC)	7.7	4.4
Control	62.2	86.5
LSD P = 0.05	2.58	5.57

a significant negative correlation between percentage of tubers infested vs depth of tuberization ($r = 0.8664$). Clone OCH 12059 (*S. acaule*) in the field had no damage but when infested in the greenhouse with larvae, it showed very slight tuber damage. Foliar feeding damage of adults on this clone was also significantly less in comparison with other clones. Species of *S. acaule* and *S. curtilobum* had significantly less foliar damage.

Of 12 commercial varieties tested all were equally damaged. Eighty-two clones adapted to highland tropics were screened for resistance and seven clones, 374102.4, 374057.39, 375568.11, 375597.3, 375608.6, 375608.7, 376933.1 showed less than 10 percent tuber damage under field conditions.

Glandular Trichomes

A rapid, simple screening method was developed at Cornell University to identify glandular trichomes on potato leaves. Using a cotton swab dampened in catechol (substrate) solution and wiping the epidermis on the lower leaf surface of the terminal leaflet of the third leaf from the top, a color reaction was noted only when 4-lobed glandular trichomes type A, and simple trichomes type B, were present. This color reaction is due to enzymes such as polyphenol oxidase and peroxidase in the glandular trichomes of *S. berthaultii* which oxidize simple phenols.

A color index was used to determine the relationship between swab color vs densities of glandular trichomes (A & B) in F_2 progeny of a cross between *S. berthaultii* x *S. phureja*. The Pantone matching system (Sun Chem. Corp. USA) was used to distinguish each color. Mean number of glandular trichomes (A & B)/mm^2 were positively correlated with color intensity ($r = 0.72$, $Y = 1.83 + 3.10$). Correlation of color intensity vs type of glandular trichomes, indicated that Type A hairs were more significantly correlated than Type B hairs. This method enables the breeders to rapidly screen for glandular trichomes without microscopic examination of excised leaves.

F_3 progeny of crosses between *S. berthaultii* x Hudson evaluated in the field had fewer green peach aphids/plant. Results on the effect of glandular trichomes on PLRV transmission revealed that these trichomes are unable to reduce the primary infection of PLRV. Studies on antibiosis to green peach aphid were conducted using *S. brevidens*. Several clones had high levels of resistance to this insect.

Thrust VII

Physiologic and Agronomic Management

Mayor emphasis was placed in developing technology to produce potatoes in hot tropical environments. Studies on shading and mulching have shown that the reduction of air and soil temperature in hot tropical environment is most beneficial in terms of plant development and yield increase. This indicates that intercropping with annual crops and trees is important to enhance potato yield and to study potential use of the potato in the farming systems of the tropics.

Results of agronomic studies with true seed to produce potatoes under hot tropical environments indicates genetic material is available for good yield and uniform tuber production in terms of shape and color. Yield can be improved significantly by increasing the number of seedlings transplanted per hill or within the row. Tuber initiation at the time seedlings are transplanted has been detrimental to the final yield.

Physiological studies of high temperatures under controlled conditions are providing important data to explain the process of tuberization and mineral nutrition.

Potatoes From True Seed

Experiments using either direct field sowing or transplanting seedlings from nursery to field, demonstrate that transplanting is superior. Most agronomic research and evaluation of true potato seed (TPS) progenies has been under tropical environmental conditions at San Ramon and Lima in Peru.

Transplanting is usually with 25- to 30-day-old seedlings that are about 12 cm tall in the 4- to 5-leaf stage. At that stage some seedlings are initiating tubers, others have small tubers and the remainder only stolons. Seedlings were separated according to the growth stage to determine effect on yield under hot tropical conditions.

Seedlings transplanted without tuber initiation yielded significantly higher than those showing small tubers (Table VII-1). Although not significant, the yield difference between seedlings with and without tuber initiation indicate a detrimental effect of transplanting seedlings after tuber initiation. No difference in tuber size was apparent at harvest.

Comparisons were made at two

Table VII-1. Yields from seedlings transplanted at various stages of tuber formation at San Ramon (800 m).

Stage of transplants	DTO-33*
	t/ha
Stolons only	8.2 a
Tubers initiated	5.8 ab
Small tubers present	5.4 b

* Seed obtained from open-pollinated DTO-33 plants.

Table VII-2. Influence of method of transplanting seedlings on yield, tons/ha.

Transplant method	Lima (Summer) 1979	Lima (Summer) 1980	San Ramon 1980
Jiffy 7	11.8 a	16.5 a	7.0 a
Roots with soil plug	8.6 b	15.5 a	5.9 a
4 oz plastic cup	10.6 ab	12.9 b	3.0 b
Bare roots	8.3 c	11.7 b	2.2 b

field sites of seedlings grown in 4-ounce plastic cups using nursery growing medium and transplanted either with bare roots or roots covered with soil plugs, or in Jiffy 7s. No significant differences were observed between Jiffy 7 and seedlings with soil-plugs. In all trials, seedling transplants with bare roots had lowest yield (Table VII-2).

Potato production and tuber size depend on number of main stems per plant, i.e. main stems/m^2. A seedling originating from true seed has one main stem. Experiments at San Ramon and Lima evaluated the effect on yield when one to five seedlings were transplanted per hill. Results indicate significant yield increase when more than two seedlings are planted per hill (Table VII-3). Higher yields in all experiments were produced with four and five seedlings with no reduction in tuber size when compared with lower seedling density. Similar results were observed when transplanted seedlings were spaced 6 or 7 cm apart in the row.

Preliminary trials on rate of NPK indicate a rate of 160-160-100 NPK produced yields significantly superior to the lower rate of 80-80-80 NPK and to the control with no fertilizer added. A higher rate, above 160-160-100, reduced yield although not significantly. No significant yield differences resulted when the rate of 160-160-100 NPK was applied half at transplanting and the other half at earthing up, either between or at the side of the seedlings.

No significant differences in yield were obtained in San Ramon when the herbicides Metribuzin and Metobromuron were used 15, 8 and 1 days before transplanting and compared with manual weeding.

Table VII-3. Influence on yield of the number of transplants per hill, (t/ha).

	San Ramon (800 m)			Lima (240 m)
N° of transplants per hill	1979 575031 op*	1979 Bulk op	1980 DTO-33 op	1980 (summer) DTO-33 op
5	5.8 a	5.3 a	9.5 a	14.1 a
4	6.9 a	6.5 a	8.3 a	14.8 a
3	6.9 a	4.5 b	5.2 b	11.7 b
2	2.9 b	3.9 b	5.7 b	11.8 b
1	2.8 b	2.9 c	4.8 b	9.7 b

* OP refers to seed from open-pollinated plants.

Table VII-4. Yield of plants grown from transplanted seedlings grown from seed from cross- or open-pollinated plants.

	ton/ha mean	ton/ha range
Group 1 = 5 progenies cp	28.2	25.6 – 31.5
Group 2 = 12 progenies cp	24.8	19.6 – 30.6
Group 3 = 4 progenies bulks op	17.8	16.9 – 19.2
Group 4 = 3 progenies op	16.9	15.6 – 18.1

Best weed control was with both herbicides applied 8 and 1 days before transplanting.

Yield performance and tuber uniformity of several hybrids and open-pollinated TPS progenies from various genetic backgrounds were evaluated under high temperature conditions in Lima during the summer (transplant January 5, harvest April 10). Forty seedlings per progeny with three replications were transplanted with the roots covered by nursery soil-plug in a randomized complete block design.

The genetic background of cross-pollinated (Groups 1 and 2) and open-pollinated (Groups 3 and 4) plants which served as seed sources is as follows:

Group 1 cp — 4x tbr x 2x phu - hapl. tbr - hybr. FDR.

Group 2 cp — (adg x tbr) tbr; (tub x adg) tbr; tub x bulk adg.

Group 3 cp — Bulks op of (4x tbr x 2x phu - hapl. tbr - hybr FDR) F_1; tbr x neo-tbr; tbr.

Group 4 op — tbr; adg.

Yield results expressed as means and yield range for each group are in Table VII-4. Mean yields for the

Table VII-5. Best TPS progenies for yield and tuber uniformity.

	Yield ton/ha	Tuber uniformity Color *	Shape **
Group 1 cp			
Kennebec x W5295.7	31.5	W-P/e	R-O
W 231 x W5295.7	26.7	W-P/e	R-O
Group 2 cp			
A-16	30.6	P-W/S	R-O
A-51	29.0	P	R-O
Group 3 bulks op			
Tbr bulk op	19.2	W	R-O
4x - 2x bulk op	17.9	W-P/e	R-O
Group 4 op			
(BL-2)-9 op (tbr)	18.1	P-W/S	R-O
374050.1 op (adg)	16.9	P-W/S	R-O

* Tuber color: W = white color; P = pink color; W/S = scattered white; P/e = pink eyes.

** Tuber shape: R = round; O = ovate.

groups of hybrid progenies were superior to the open-pollinated progenies. Linear contrast among group means indicate that yields of hybrid groups were significantly higher than the open-pollinated groups in both years. The mean yield of the group of 4x x 2x crosses was also the highest mean between hybrid groups and was significant. The best progenies for yield and uniformity of tuber color and shape were selected from each group and are listed in Table VII-5.

Uniform progenies for tuber color and shape were in both hybrid and open-pollinated progeny groups. Most progenies in the two groups were uniform for tuber color and shape and the explanation of this is that the evaluated progenies were not chosen at random. Their selection was based on tuber uniformity when utilized in clonal selection. However, if tuber uniformity is considered a crucial character in the production of TPS progenies, hybridization is the tool to produce the required uniformity.

Results of these TPS progeny evaluations confirm that hybrids are superior yielders to open-pollinated progenies. However, some selected open-pollinated progenies could also play an important role in potato production from true seed in tropical countries.

Management for Hot Tropics

Experiments aimed to ameliorate adverse climatic conditions, especially high temperature, characteristic of hot tropical environments.

During the summer in the coastal desert (mean max./min. 28/19° C) soil mulch treatments were applied at the time of planting an Andigena and a Tuberosum clone. Of the treatments, the soil reflectant (2.5 t/ha lime) was most effective in reducing soil temperature (at 5 cm depth ranging from 7° C at the peak to 0° C at 7 am — Fig. VII-1). The other mulches reduced the peak temperature by 3° to 5° C, but prevented reradiation and hence were warmer than the control at night.

All treatments other than the lime soil reflectant retained more moisture in the soil (Table VII-6), therefore in those treatments any beneficial effects of reduction in soil temperature were confounded with improved moisture status. In contrast the advantage of the soil

Table VII-6. Influence of mulch treatments upon soil moisture content.

	Soil solution *	Percentage water **	
		Before	After
Control	33.3 a ***	11.8	15.9
Soil reflectant	33.4 a	12.3	16.8
Black plastic	32.2 b	17.6	24.5
Sawdust	29.4 c	11.4	16.7
Leaf reflectant	28.3 d	20.7	21.2
Paper	24.6 e	18.9	22.9

* Mean soil suction (centibars) at 25 cm depth measured at 8 a.m. prior to each irrigation.

** Percentage water by weight at 15 cm depth measured with a neutron probe the day before and two days after an irrigation.

*** Means not followed by some letter are significantly different at P = 0.05.

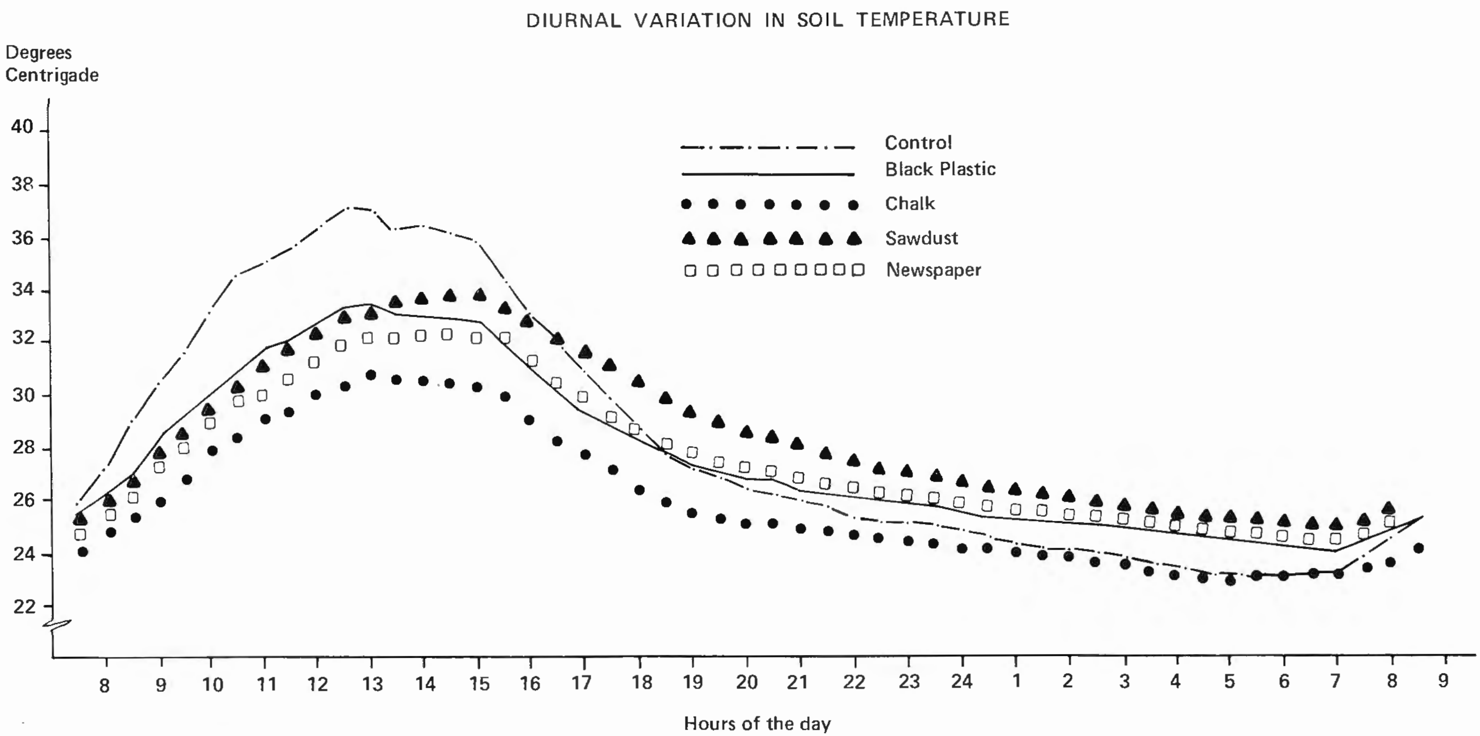


Figure VII-1. Diurnal variation in soil temperature (5 cm depth) under various mulch treatments in Peruvian coastal desert.

reflectant was solely due to decreased soil temperature. A statistical analysis of yield data indicate a marked advantage for the soil reflectant in the two clones, both in terms of total yield and the proportion of marketable tubers. In the comparison between control and soil reflectant, time to emergence was less in the latter, tuber initiation was 7-10 days earlier, also leaf area index was notably greater from 40 days onward, mainly due to more leaves as a result of increased branching. In contrast, however, there was little difference in maturity date. The incidence of secondary growth in both clones (due to high soil temperature) was much less under the soil reflectant than other treatments.

Experiments during the dry season at a tropical lowland site (mean max./min. 31/20°C) were mostly successfully harvested. The effects of spacing (Fig. VII-2), mulching (Fig. VII-3) and shading, both artificial (Fig. VII-4) and natural (Fig. VII-5) upon growth development and yield were studied. Preliminary data suggest a yield advantage for (a) closer plant spacing (Table VII-7), (b) shading during the midday period, and, (c) planting in the shade of the jungle and various crops. Mulch treatments, although hastening emergence (Fig. VII-3), did not in this series of experiments have beneficial effects upon yield (Table VII-7). Possibly any beneficial effect of reduced day temperature and improved soil moisture status was outweighed by adverse effect of a high night soil temperature.

The use of various indigenous mulch materials (rice hulls, dried grass, banana leaves) and shade crops (banana, cassava, maize) is being further studied. Since shade treatments offer a form of reducing both air and soil temperatures, the effects upon the physiology of the potato are being studied.

Artificial shading (50 percent light intensity) at a high jungle site (800 m) were noted to extend the period during which stomata were open. In addition the open period for stomata of DTO 33 was shorter than that of cvs. Mariva and Yungay, and may in some part explain the source limitation of yield for that clone. That shade permits stomata to remain open longer than under control conditions may, to some extent, offset the lower rate of photosynthesis due to less light energy under shade.

Table VII-7. Effects of density and mulch on final yields (t/ha) of two clones Yurimaguas (180 m).

Density	LT4 (76 days)		Desiree (88 days)	
plants/ha	Control	Mulch (rice husk)	Control	Mulch (rice husk)
44,000	15.9	12.4	13.6	15.9
63,000	15.8	11.5	14.1	14.7
114,000	26.0	24.6	14.8	24.0
200,000	30.7	26.4	27.1	23.0
$\bar{X}$	22.1	18.7	17.4	19.4

Standard error of the difference between two spacings within a variety = 2.7.
Standard error of the difference between mulch treatments within a variety = 1.9.

Figure VII-2. Between and in-row spacing experiments.

Figure VII-3. Early emergence due to soil mulch.

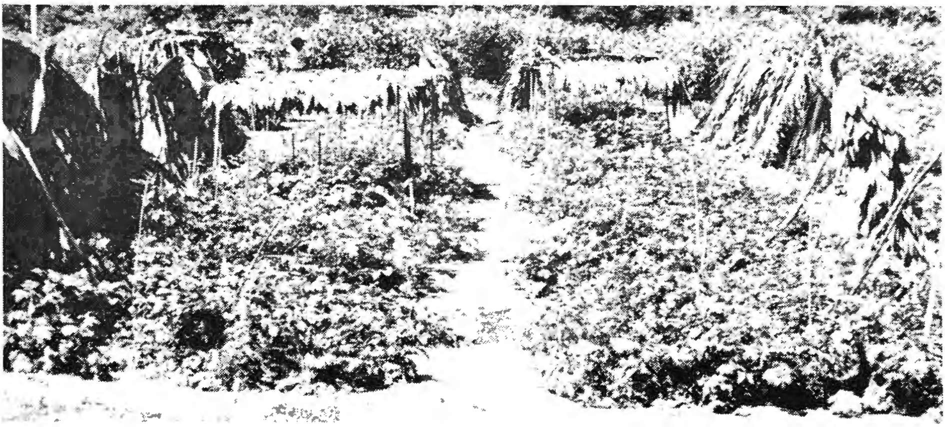


Figure VII-4. Artificial shade to cool soil at various times of the day.

Figure VII-5. Maize-potato intercropping. Maize was 2 months old when potato was planted.

The effect of applying rock phosphate to potatoes grown in acid soils of San Ramon and its possible benefit to subsequent crops of a potato, maize, cassava rotation is being studied. Besides the large increase of potato yields it has been found that the incorporation of 2.0 t/ha of rock phosphate (30 percent P_2O_5) to a soil that received a fertilizer formula 160-0-160 before the potato crop was planted, produced a 10-fold increase in yield of the following maize crop when compared with the yield obtained when only N and K were applied or when N and K plus 2.0 t/ha of lime were used. When a fertilizer formula 160-160-160 was used for potatoes, the addition of 2.0 t/ha of either rock phosphate or lime independently resulted in a three-fold increase in maize yields. During 1981, the effect on the third crop on the rotation will be studied.

The effect of two different NPK fertilization levels 80-80-80 and 160-160-160 in a potato crop where plants were spaced 20 and 30 cm in the row, was investigated under tropical conditions (800 m), using three Peruvian varieties. Yield increases of approximately 50 percent were obtained in favour of the higher fertilizer rate, while no effect of plant density could be observed.

Physiological Studies

In potato plants grown under controlled climatic conditions in water culture the endogenous regulation mechanisms of tuber initiation, tuber growth and assimilate storage as affected by environmental conditions were investigated.

Application of GA_3 to stolons causes cessation of tuber growth and, consequently, outgrowth of tuber buds as stolons, i.e. "regrowth." The same mechanism seems to be in operation when the environmental conditions lead to GA accumulation in the shoot and due to the mobility of GA presumably in the tuber as well.

The application experiments with GA_3 not only show morphological changes in tuber appearance but also changes in the assimilate storage physiology. Due to changes in enzyme activities starch synthesis is suppressed in GA_3 treated tubers accompanied by accumulation of soluble sugars.

After subjection of growing tubers to high temperatures, tuber growth ceases and the starch content decreases. The reduction in starch content at high tuber temperature is probably caused by a reduced starch synthesis activity as a result of a decrease in ADPG pyrophosphorylase activity.

Growth cessation of tubers at high temperatures is irreversible. Resumption of tuber growth is restricted to secondary induced tuber tissue resulting in malformed tubers. Assimilate storage in such tubers is also restricted to the secondary tissue despite the fact that the assimilates had to pass through the primary tissue.

In heat stressed tubers the potassium content is lower than in control tubers resulting in a higher content of soluble sugars in the storage tissue.

Cuttings from potato plants grown under different daylength regimes reflect the photoperiod treatment of the mother plants. With decreasing photoperiod of the mother plant, shoot and root weight of the cuttings decrease significantly. After reaching the critical photoperiod stolon and tuber formation occur. However, there was no correlation between the change in shoot and root development and in formation of stolons and tubers and the GA content of the cuttings. Whereas long day cuttings did not show any response on GA_3 application short day cuttings reacted very markedly indicating that the different GA response might be controlled by "anti-GA" or a specific "stimulus."

In imitating conditions of tropical soils, increasing root temperatures resulted in a stimulation of shoot growth and reduction or root development. The extent of reaction depended on the variety. The enhanced shoot growth at high root temperature, however, could not be correlated with the GA level of the shoot. Also the degree of heat tolerance was not reflected by the GA content although the heat tolerant variety DTO-28 contains a much higher level of conjugated GA than the heat sensitive varieties Mariva or Merpata. Formation of conjugated GA could be interpreted as an inactivation process to avoid accumulation of biologically active free GA. High root temperatures also suppressed stolon development regardless of the variety.

The cation content was affected differently when the root temperature was increased from 15° to 30° C. Whereas the K content of the shoot remained at almost the same level, both the Ca content and the Mg content decreased considerably resulting in an increase in the ratio of K + Mg/Ca. The decrease in the Ca content of the shoot at high root temperature is obviously caused by a reduced uptake and translocation of Ca whereas the decreased Mg content of the shoot derives from the strong Mg retention in the root system.

The shift in the cation balance with increasing root temperature strongly indicate a close relationship between malformed shoot tips and Ca deficiency. In addition the Ca content of potato shoots will also be affected by high Al levels.

Tubers from seedlings selected for (1) tuberization 3 weeks after transfer to 38°/22° C glasshouse conditions (transferred at 4 weeks age), (2) tuberization 7 weeks after transfer, and, (3) tuberization after retransfer to control conditions were either regrown under the glasshouse conditions or tested in San Ramon.

In the glasshouse at any sample date more plants of group 1 had tuberized than of group 2 or 3, such that at the termination of the experiment (47 days after emergence) 25 percent, 10 percent and 2 percent of groups 1, 2 and 3 respectively had tuberized. In San Ramon only groups 1 and 2 were tested; group 1 had more tubers per main stem at any sampling date, however, although tuber weight was greater in group 1 at earlier samples at termination of the experiment (11 weeks from planting) the two groups did not differ (Fig. VII-3). Later initiation was accompanied by a faster bulking rate possibly due to a greater leaf area per plant at tuber initiation.

Aluminum Toxicity

The tolerance to aluminum toxicity in eight clones and varieties using soils from different tropical locations of the Peruvian Amazon basin were studied under greenhouse conditions. When exposed to different levels of Al in the soil solution, the varieties Mariva, Revolucion, Desiree and CEX-91 showed a higher tolerance. The uptake, transport and accumulation of P, Al and other elements in different plant components and their possible correlation with the tolerance to Al toxicity is being investigated.

When lime ($CaCO_3$) and rock phosphate was utilized for correcting Al toxicity levels in the soil, the expected beneficial effects were obtained. However, rock phosphate had a superior effect not only correcting soil pH but also being an excellent phosphorus source for the potato. In San Ramon, rock phosphate application of 1.9 t/ha resulted in a marked increase in plant yields which, according to the variety used, was 10 to 20 times larger than the control plots. The soils at the experimental site had a pH of 4.8 with a CEC of 10 meg/100g and 14 percent of aluminum saturation. Phosphorus content of the soil was very low, 2.2 ppm.

Because of the low phosphorus content of the soil the application of lime has shown no significant effect on potato yields.

Thrust VIII

Storage for Developing Countries

Preliminary results on the quantification of light energy required for successful diffused light storage indicate that both radiation levels and duration of exposure are important components of "light quantity." Under Huancayo conditions various intensities of natural diffused light show that low radiation levels of approximately 3 watts/m^2 are adequate to control excessive sprout elongation and that higher intensities gave little additional effect. Increased duration of exposure, from 0 to 12 hours daily, to natural diffused light under Huancayo conditions resulted in decrease from 25.3 cm to 2.8 cm of sprout elongation following 180 days storage. These experiments are being repeated at Huancayo and also at San Ramon to evaluate possible interactions with storage temperature.

Initial trials on the effect of moisture loss alone on the field performance of stored seed tubers show considerable variability, although moisture loss alone, up to the maximum of 20 percent experienced in the trials, did not influence field emergence or yield when tubers were planted and maintained under good conditions at Huancayo. This series of trials is being continued.

Diffused light storage facilities at Huancayo have been expanded by construction of two additional large (15 t capacity) stores and a very simple low-cost rustic demonstration store. Diffused light storage capacity at Huancayo now totals about 80 tons.

Table VIII-1. Storage losses from a range of simple stores, Huancayo, Peru (variety Revolucion).

	Storage Losses (% initial weight)					
Months in store:	1	2	3	4	5	6
Store type						
4°C cold store	1.7	3.4	2.8	4.9	5.3	6.2
Naturally ventilated adobe store	1.8	3.2	5.9	6.8	11.8	19.6
Rustic wooden store	2.8	3.3	7.6	6.5	13.0	20.6
Straw/corn stalk clamp	3.5	5.2	6.8	9.5	13.6	22.9
Straw/soil clamp	3.9	5.9	10.9	11.2	21.4	30.4
Farm building	3.5	4.9	8.9	9.7	16.7	27.4

The second year on-farm diffused light seed storage trials were increased from 4 to 6 and the seed trays were replaced by simple collapsible wooden shelves or racks. Natural diffused light storage on all six farms resulted in reduced storage losses, improved seed quality in terms of sprout number and length, more rapid and uniform emergence, and increased yields.

Additional data (Table VIII-1) on the consumer potato storage losses following different storage durations in a range of simple stores at Huancayo has been collected. It illustrates appropriateness of different stores under different situations and as an aid to illustrate a research approach.

Development of management practices for the use of available chemical sprout inhibitors in simple stores for consumer potatoes continues. Further data under a wider range of conditions is required before firm recommendations can be made. For this reason this work is being extended to San Ramon, where three simple consumer potato stores have been constructed.

Regional Research

The CIP Regional Post-Harvest Research and Training Centers in Peru and the Philippines are operational and progress is being made towards establishment of the third Center in Tunisia.

Major emphasis during the year has continued on transfer of diffused light seed storage technology to farmers in countries where both the need and appropriateness of the technology has been identified. Many such projects, at different stages of development, are now ongoing. The methodology is initially to have national scientists with the help of CIP core and regional scientists gain personal experience and confidence in the technology by conducting locally needed research. This is followed by, or in some locations conducted simultaneously with, the establishment of on-farm demonstrations. Finally the local effectiveness of the technology is measured by monitoring farmer acceptance of the technology.

Several of these projects reconfirm results of CIP's on-farm trials and technical, economic and social factors which influence farmer acceptance of this technology in different countries are being evaluated. Examples of countries where this technology is being rapidly and readily accepted by both small and large farmers (Figs. VIII-1 and VIII-2), include Peru, Guatemala and the Philippines. In addition to these technology transfer projects, CIP regional and national program scientists are cooperating in evaluating the potential for use of diffused light seed storage technology in actual situations with more severe storage climates, as for example, in Turkey, Tunisia, Egypt and Bangladesh.

Diffused light seed storage technology is presently being researched and evaluated in 15 countries.

In India and Bangladesh, CIP core and regional scientists are cooperating with national scientists in evaluating the use of evaporative cooling technology in simple consumer potato stores.

Training

In November 1979 the first Philippine/CIP Regional Potato Storage Course was held with 16 participants from eight countries. The course followed the same pattern as previous courses in Peru. A further storage course in Kenya in May 1980 had 15 participating scientists from seven African coun-

Figure VIII-1. Demonstration diffused light seed store constructed on a potato producing cooperative in the coastal area of Peru as part of a INIA/CIP collaborative storage contract. As a result of this demonstration the same cooperative constructed a similar store with a capacity of 80 to 110 metric tons of seed tubers.

Figure VIII-2. Diffused light seed store of 100 metric tons capacity built by a group of 42 farmers in the Philippines.

tries. A third course was again in Peru in October/November 1980 with 10 participating scientists from eight Latin American countries.

Village Level Processing

In 1980 further modification of village level processing of equipment helped reduce costs and increased efficiency in addition to transferring technology to farmers, cooperatives and the Ministry of Agriculture.

Process Modification

The following improvements will be incorporated in the plans for 1981:

Eliminate the small storage. Our original plans called for small storages in conjunction with the processing plant. We found that the storage function is performed by the farmer.

Washers will be eliminated. Washing needed to remove soil from the tubers can be done in the peeling operation.

The peelers will be constructed from 55-gal oil drums instead of bronze plate and will be designed for easier operation.

Cooking tanks will be fabricated from 55-gal oil drums instead of present rectangular cooking chamber. The fire box will be reduced in size with a cost reduction resulting.

The mill and sifter will be relocated to be driven by the same motor used for peelers and cutters. As the mill is not operated at the same time as the peeler and cutter, the price of one motor is saved.

In the production of starch, a peeler will replace the washer. This will increase the capacity of the pulper, and also will keep considerable foreign material out of the washing tanks. The pulper is being redesigned to make fabrication easier.

Screening and washing tanks have been re-arranged to reduce labor and make a more efficient operation. The amount of tankage has been reduced by two-thirds.

The solar dehydrators worked well. Minor improvements will be made as we gain experience.

The overall results of the changes have been a more efficient plant at less equipment cost. It is anticipated that further changes will be minimal.

Transfer of Technology

Several staff members of the Ministry of Agriculture, Huancayo, were given 3-4 day short courses on operation of equipment. In 1981, the courses will be more formalized with additional training in principles of processing of potatoes.

Two procedures were used to demonstrate to farmers the operation of the equipment and the product that could be produced:

First, field days were organized with help of the Ministry. Over 45 potato producers attended the field days. The levels of interest and understanding were high.

Second, to assist those farmers who had a real interest in processing, the plant at Huancayo and the starch plant in Huasahuasi were made available on the following conditions:

> farmers supply the potatoes and all labor, CIP supplies supervision only,
>
> farmers pay a fee for use of the plant. This fee to be approximately equal to cost of depreciation plus maintenance plus consumables.

The above procedure gives farmers actual operating experience and helps them understand the costs of operating and maintaining a plant. Additionally, it provides them with products to be sold and helps them understand marketing functions.

Farmers who scheduled running time at the Huancayo plant included: Community, Sta. Rosa de Ocopa, Concepcion, scheduled 5 tons; Roberto Parraga Correa, Huancane-Jauja, 2; Hugo Zambrano, Chucillu-Jauja, 10; Alejandro Verastegui, Chucillu-Jauja, 1; Amancio Soto Romero, Bellavista-Pazos, 4; Saturnino Romero Aguirre, Pazos, 10; Cooperative, El Tigre Bravo, Jauja, 2; Eustaquio Cordova Lazo, Chupaca, 5. Actual deliveries were less than the amount the farmers originally scheduled which reflects their concern about selling the finished product. With some product to be sold, the farmers will soon work this out.

Of more significance was the production of starch from bitter potatoes. Normally, bitter potatoes can only be used for *chuño*, a tedious product to make. Now, bitter potatoes can also be used to produce starch. This may encourage production of potatoes in the frost zones where the only potato is the bitter type. Farmers using the Huasahuasi starch plant, which has only half the capacity of the Huancayo plant, included: Amilear Amarillo, Chata, 3 tons; Celso Moreno, Revolucion, 2; Gabina Garcia, Mariva, 2; Moises Casas, Chata, 1; Alberto Rojas, Yungay, 1; Lizardo Moreno, Revolucion, 1; Alejandro Valenzuela, Tomasa Condemayta, 1; Shirley Orihuela, Revolucion, 1.

The response in Huasihuasi was strongly favorable. This plant always had more potatoes than could be processed. The mayor of Huasihuasi has taken the initiative for better and more permanent facilities for his community.

Thrust IX

Tuber and True Seed Research

Germplasm Multiplication and Distribution

Pathogen-tested germplasm materials in many forms were exported during 1980 to developing countries, in accordance with accepted phytosanitary regulations (Table IX-1).

Rapid multiplication techniques developed in the past were used in CIP's Regional Programs to increase basic seed tubers. Several rapid multiplication techniques using different types of plant cuttings were adapted for local use in Turrialba, Costa Rica, in collaboration with the Costa Rican Ministry of Agriculture. The effect of potting mixes, rooting media and the use of a rooting hormone as well as other factors were evaluated until consistent results were obtained. The potential of using rapid methods of multiplication in increasing desirable potato clones in a national program is illustrated by: plants derived from sprout cuttings of cv. Atzimba were used for the production of single-node cuttings. When the latter were transplanted to the field in Costa Rica they yielded in excess of 20 t/ha. Tuberlets from leaf-bud cuttings of the bacterial wilt resistant clone MS 35-22, weighing between 3 and 12 g, yielded 0.5 kg per plant at harvest.

Seven professionals from six countries, as well as two technicians from the Costa Rican Potato Program, received training in rapid multiplication techniques. It is expected that more regional programs will adopt these methods of rapid multiplication.

Effect of Temperature on Seed Germination

The effect of a 15° to 30°C temperature range on seed germination of several Solanum species was studied. Seed of all species germinated well at 15° and 20°C but not at temperatures above 25°C (Table IX-2). At 30°C, the highest germination rates were obtained from accessions of diploid species, while the germination of 24

Table IX-1. Export of pathogen tested germ plasm in several forms.

Form	Number	Number of countries
Tubers of cultivars	3,564	30
In vitro plantlets	78	8
Tubers of TPS families	45,190	19
TPS	20,400	10
Stem cuttings	103	1

Table IX-2. Effect of temperature on seed germination of *Solanum* species.

Species	Ploidy	N° Accessions tested	% Germination			
			15°	20°	25°	30°
curtilobum	5	2	99	97.5	41.5	10.5
andigena	4	24	98.5	94.3	42.1	2.4
stenotonum	2	10	99.8	99.0	81.8	30.8
goniocalyx	2	5	100	97.4	97.8	36.0
ajanhuiri	2	1	100	93	94	41
phureja	2	5	99.4	96.6	96.2	33.8
All diploids	2	21	99.8	96.5	92.5	35.4

accessions of *S. andigena* were remarkedly low at the same temperature.

In another study, seed germination of five accessions each of *S. stenotonum* and *S. andigena* was studied at constant temperatures of 30° and 35°C. Percent seed germination of all accessions of *S. stenotonum* was 77.8 and 13.8 at 30° and 35°C, respectively, while accessions of *S. andigena* had an average of only 12.5 and 0.7 percent germination at the same temperatures.

These results indicate differences in germinability of seed at high temperatures between species and within species. Based on such information, three cultivars and two accessions of Solanum species were used in a study of a possible correlation between germinability at high temperature and plant adaptation to high temperatures.

Of the cultivars and accessions that were used in this experiment, the germination rate at 30°C of some cultivars such as Desiree and DTO-33 were relatively high (Table IX-3). Seed germination at 20°C following high temperature exposure was normal.

Table IX-3. Effect of temperature on seed germination.

	% Germination at 30°C ± 2
DTO-33	12.5
Desiree	30.0
Renacimiento	0
STN HUA 979	34.2
ADG 700387	0

Effect of Heat Treatment on Seed Germination

Studies were conducted to find a heat treatment that may eliminate

Table IX-4. Effect of temperature on seed germination of cv. Desiree

Temperature (°C)	Duration	Germination (%)
20	continuous	99.3
40	1 hour	98.2
60	"	98.7
70	"	98.1
75	"	86.6
80	"	0

seed-borne pathogens without decreasing seed viability significantly. Seed was exposed to temperatures ranging from 20° to 80° C. After the temperature treatments, germination was tested at 20° C.

As can be seen in Table IX-4, seed germination was excellent after one hour exposure to temperatures up to 75° C. Unfortunately, these temperatures are not effective in eliminating Potato Spindle Tuber Viroid (PSTV) since they are much below its thermal inactivation point of above 90° C. Therefore, the heat treatment was modified to increase the tolerance of seed to higher temperatures. A major modification introduced was based on the fact that seeds can tolerate higher temperatures when their moisture content is low. The modified procedure involved heating seed at 60° C for 24 hours and 70° C for 1 hour to reduce seed moisture content before they are subjected to high temperature treatments. Following the high temperature treatment it was found beneficial to soak seed for 24 hours in a 1500 ppm GA_3 solution. Before sowing, seeds were dusted with a fungicide to reduce the risk of seed contamination.

As a result of the above modifications, seed have been treated at higher temperatures and for longer periods without significant reduction in germination. Determining of survival of seed-borne pathogens following heat treatment will be done in 1981.

Tissue Culture Research

The in vitro collection of pathogen tested plants now contains 87 clones. In 1980, 50 different clones from the collection were multiplied by in vitro techniques resulting in 4,250 plantlets which were transferred to soil to serve as parent plants for production of export tubers.

Use of a medium containing 4 percent mannitol to reduce the frequency of plantlet transfer to fresh medium was reported in 1979 and is now in use to grow all of CIP's in vitro collection and is suitable for growing a wide range of genotypes. As a result, a duplicate of the collection is now kept at 10° C on this medium.

Plant Selection at Cellular Level

Considerable effort was devoted to solving numerous problems connected with research that may ultimately lead to plant selection at the cellular level for tolerance to salt and aluminum.

Thirty-four colonies of DTO-33 and 26 of DTO-2 were successfully grown from cell suspension cultures in the presence of different concentrations of salts (NaCl 160 mM, 80 mM; K Cl 3.5 mM, 1.75 mM; MG Cl_2 10 mM, 5 mM). They were transferred to shoot inducing medium to test the regenerated plants for salt tolerance.

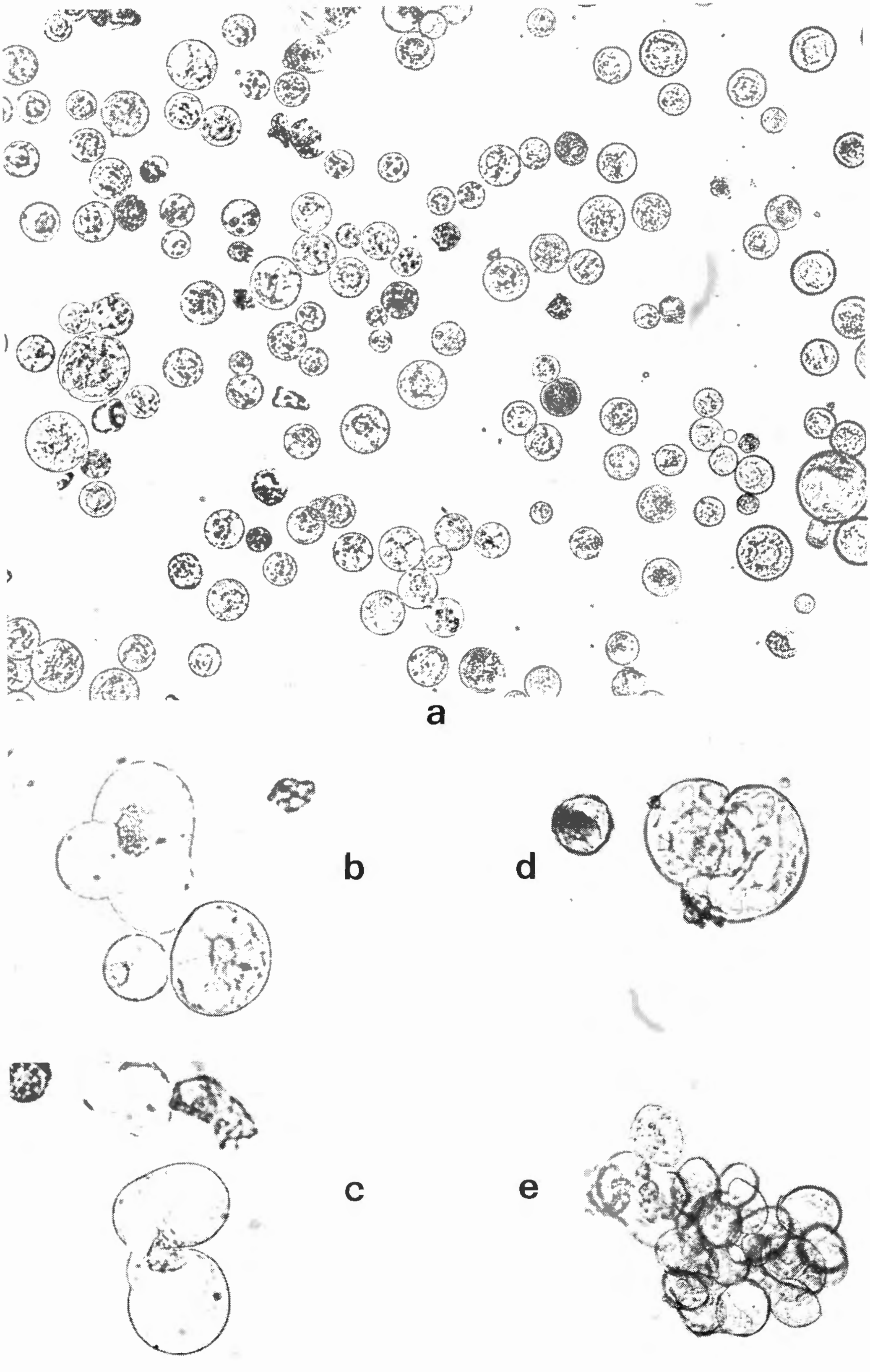
The addition of a 5 mM phthalate buffer to cell culture media proved to be effective in maintaining cell suspension cultures at low pH (3.8) for 2-3 weeks after incubation. This buffer is not toxic to cell cultures and can, therefore, be used for screening for aluminum tolerance at cellular level.

Isolation and Culture of Protoplasts

Attempts are in progress to develop media and conditions for plant regeneration from protoplast cultures, which can be suited to a wide range of genotypes.

(a) Isolation

The following solution was found to be effective and rapid for


a
b
d
c
e

protoplast isolation from different potato genotypes: pectolyase, 0.05 percent; cellulase R10, 1.00 percent; mannitol, 0.50 M; pH 5.6. After about 2 hours of incubation at 25° C viable protoplasts were obtained.

(b) Culture

Two culture media induced division of protoplasts and colony formation:

(a) medium 8P (KAO and MICHAYLUK 1975)
(b) medium B (SHEPARD and TOTTEN 1977).

First divisions occur after 5 to 7 days (Fig. IX-1). Large colonies developed from protoplasts of two clones and were transferred to medium for shoot induction.

The plating efficiency (= % colony formation from a single protoplast) is still low and has to be improved by further modifications.

Physiological Quality of Potato Seed Tubers

The effect of growth environment and storage conditions on sprouting capacity and subsequent field performance of seed tubers were studied. Low virus seed tubers were produced in Lima on coastal desert (240 m), in San Ramon, a high jungle site (800 m), and at Huancayo, an alpine location (3,300 m) and stored at 4° C and 12° C for 6 months. During storage, tuber samples were evaluated at monthly intervals for sprouting and rooting capacity. For this purpose samples were placed for 4 weeks in soil at 20° C in the dark, after which root and sprout weights were determined separately. The field growth performance of the stored tubers was evaluated in all three locations.

The results of the sprouting and rooting capacity test indicated that temperature during storage had no significant effect on sprout and root growth. The origin of seed tubers had a strong effect on sprout and root growth. The better sprouting and rooting capacity of seed tubers from Huancayo was demonstrated by a larger number of sprouts per tuber, more vigorous sprouts and more root weight per sprout.

During evaluation of subsequent field performance, seed tubers from Huancayo showed in all three growth locations a faster and higher percentage of emergence and a more vigorous haulm growth. In San Ramon and Huancayo this resulted in significantly higher yields (Table IX-5).

The results confirm experience that seed tubers produced in highland areas perform significantly better than seed tubers produced in warmer lowland areas for reasons other than the health status of seed tubers.

In another experiment, seed tuber quality was evaluated after storage for six months in the dark at 4° C, 12° C and ambient temperature and also in the light at ambient

Figure IX-1. Isolated protoplasts of clone DTO-2 undergoing cell division and colony formation.
(a) Freshly isolated protoplasts (350x).
(b) Increase in volume and budding after 2 days culture (530x).
(c) Nuclear division and beginning cell division, the dividing wall developing on one side after 8 days of culture (530x).
(d) Two daughter cells have been formed after 8 days of culture (530x).
(e) Colony formation after 3 weeks culture (350x).

Table IX-5. Effect of seed tuber origin and storage temperature on subsequent yield of Desiree in three locations.

Seed tuber origin	Storage	Yield in location of planting (ton/ha) Lima	San Ramon	Huancayo
Lima	4°C	31.2	8.2	14.6
	12°C	32.9	7.3	18.2
San Ramon	4°C	27.7	7.7	19.8
	12°C	27.3	8.5	17.1
Huancayo	4°C	34.2	11.0	26.8
	12°C	31.7	12.5	25.3

Origin is significant at 5% level in Lima and at 1% level in San Ramon and Huancayo.
Storage temperature is not significant.

temperature. Two cultivars were selected for this purpose: Desiree, which in previous experiments proved to be relatively insensitive to storage conditions, and Rosita, which is rather sensitive to storage environment and does not withstand heavy sprout removal. There was no significant difference in yields of Desiree under the four storage conditions. Yields of Rosita were significantly lower when stored in the dark at 12° C.

Seed tuber quality after storage in light at ambient temperatures was similar to seed tuber quality after storage at 4° C.

Breaking Dormancy of Seed Tubers

The objective was to compare methods of breaking dormancy in a wide range of genetic material. Table IX-6 shows that both Rindite and GA treatments were effective in breaking dormancy. GA_3 at concentrations higher than 50 ppm resulted in production of elongated sprouts and subsequently long weak stems. Although yields were not influenced by treatment, maturity was significantly earlier in treatments with Rindite, GA at 50 ppm and GA at 500 ppm. The results suggest that treatment with GA at 50 ppm may be a safe and reasonably effective alternative for the somewhat risky Rindite treatment.

Table IX-6. Effect of gibberellic acid and Rindite on breaking tuber dormancy. (Figures are averages of 10 cultivars with distinct genetic background.)

	Control (water)	Gibberellic acid* 10 ppm	50 ppm	500 ppm	Rindite**
Days between treatment and sprouting (sprout length 0.5 – 1 cm)	60	29	19	17	14
Number of sprouts per tuber	1.4	2.3	3.4	2.5	8.3
% emergence 20 days after planting	50	85	90	95	90
Days from planting to maturity	111	106	94	92	87
Yield (ton/ha)	28	26	25	26	25

* Tubers were soaked in gibberellic acid for 60 minutes.

** Tubers were treated with Rindite at rate of 2 ml/kg tubers; tubers were maintained for 72 hours after treatment in closed containers.

Regional Research & Training

The emphasis on improving quality and quantity of research evaluation and transfer in 1980 was organized according to its contribution to major project areas. Although some experiments are closely linked with the Thrust concept, the principal reason for their location at a particular site is relevance to much broader concept. This aspect will be examined in the research section of this part of the report.

Program Development

Region I

The Government has officially recognized CIP's regional office in Colombia. The general agreement is still being negotiated through the Ministry of Agriculture.

The seed production training course was differently structured with two separate parts in January and May to cover different periods of the growing season. Participants studied in Peru, Ecuador and Colombia. National scientists particularly in Ecuador and Colombia carried considerable responsibility for the training in those countries. Participants were from Argentina, Bolivia, Colombia, Chile, Dominican Republic, Ecuador, Peru and Venezuela.

In Brazil a Breeding and Genetics Symposium evaluated CIP and other germ plasm, analyzed release of new varieties during the last decade, and discussed ways of increasing inter-country cooperation. Breeders from five countries in South America and CIP participated.

A CIP evaluation team attended the annual research meeting of INTA (Argentina) to advise on ways to better coordinate research. A bacteriologist evaluated control measures to restrict spread of bacterial wilt which was first recognized about 2 years ago.

Region II

The regional headquarters at CATIE, Costa Rica was closed in November preparatory to its transfer elsewhere in Latin America in 1981. CIP was able to reduce its input in Central America due principally to the growing strength of the regional organization, PRECODEPA, which we were instrumental in setting up during its initial 2 years. Continued support to this organization was given through consultancies by CIP scientists in seed production, tuber moth, late blight and nematode control. The senior seed specialist completed his one-year sabbatical in Costa Rica during 1980 and subsequently returned to Lima.

Region III

The regional scientist based in Nairobi returned after a year at CIP/Lima. Rwanda staff remained at two. One associate Dutch scientist continued working with the Nairobi team. Several contacts were made between the team in Rwanda and research organizations working on potato in Burundi, Zaire and Uganda.

A storage course in Kenya used experience gained from the previous 3 year's low-cost storage studies. Active help was given by a British expert working in the country and a Dutch technical assistance expert working with the Kenyan Agricultural Development Corporation. In Rwanda training courses were conducted for local personnel and scientists from Burundi.

Region IV

The position of Regional Scientist changed at mid-year. In January a post-doctoral position as entomologist was established at Izmir to study problems of control of tuber moth. This work is closely correlated and directed by CIP/Lima. The Special Project in Tunisia continued.

Three major training activities took place. The fifth annual Francophone Production Course was in Tunisia. Potato scientists from both developed and developing countries point out that this is the only course anywhere of its type conducted in French. Instead of the usual training course in Izmir, a study tour was made by some previous trainees to Syria, Jordan and Turkey to see what potato research problems exist, what use has been made of previous training given by the Region and to promote mutual exchange of information. In August a trilingual workshop was conducted in Izmir to develop the theme of on-farm trials and to make some case studies of specific examples.

Preliminary discussions were held with the Tunisian authorities regarding establishment of a regional headquarters during 1982.

At the same time the Government indicated that it would request an extension of the existing Canadian bilateral project and would like CIP to continue its in-country collaboration. Both these proposals are proceeding.

Region V

The political unrest in the region worsened during the year and again activities were confined to Pakistan. The decision to transfer the regional headquarters elsewhere in 1981 had already been made and the major effort was put into developing a bilateral proposal to replace the CIP effort. This proposal concerns a countrywide series of on-farm experiments not covered by existing projects and a link with a social-economic study of potato marketing and utilization.

The proposal has been accepted in principle by a donor agency and the necessary preliminary studies are proceeding.

Region VI

The CIP scientist stationed in Nepal departed in late June to take up a vacant post in CIP/Lima. A 3-month consultancy was made to Nepal by a senior seed specialist to conduct training and assist in seed multiplication. CIP involvement in the future will be limited to short-term consultancies linked with the needs of the bilaterally assisted program.

Work in Bangladesh has continued to be supported by a potato specialist attached to the IADS team. A larger seed multiplication proposal based on the preliminary work during 1980 has been prepared for possible World Bank financing.

It is proposed to help Bhutan develop its potato program and a request was made that CIP provide a potato specialist. A major emphasis would be on seed production and germ plasm evaluation. A bilateral donor is interested in funding the project which may then lead to a much larger bilateral funding as is envisaged in the CIP Third Dimensional approach. In-country training and sponsorship of Bhutanese scientists to the CPRI courses at Simla, India had been one of the regional activities.

Activities in Sri Lanka have been transferred from Region VII to Region VI. The economics of this transfer are obvious. A senior CIP pathologist started a one-year sabbatical in mid-year which will make the transition of responsibility easier to assimilate. A national scientist started 6 months training on storage in the Philippines. He will continue in 1981 and collaborate on the training course and then return to Sri Lanka as the storage expert to train his compatriots and other scientists from Region VI.

Region VII

The Philippine Potato Program (PPP) is consolidating on past results. CIP has been playing a catalytic role and as a result a Potato Research and Development Program has been conceived and will be considered for funding.

In Korea, it was decided that a study team should review the situation and make recommendations on how to integrate the research efforts of various institutions in the country. The report calls for several changes and outlines a 5-year program. As the ROK is the most densely populated country in the region, any proposal to make the land more productive is being carefully considered.

During an October meeting in Bandung, Indonesia a group of countries in South West Asia (Indonesia, Sri Lanka, Thailand, Papua New Guinea and the Philippines) signed a provisional agreement to set up a common research and development program for potatoes (SAPPRAD). This will be initially coordinated by CIP until fully operational.

On-Farm Research for Optimizing Potato Productivity (OPP)

This strategy which was developed in conjunction with the Social Science Department was widely tested in the Regions this year. The experience shows that in many cases technology considered to be relatively stable or economically profitable frequently runs into difficulties at farm level. This experience is proving valuable for our regional staff especially those involved in country projects such as Tunisia and Rwanda. The staff gain a much greater assurance that the improved measures they propose are really going to satisfy the objectives of improving farmers' agroeconomic position.

Region I

Peru. Out of 21 OPP trials established in the Cañete coastal valley, 17 were under direct CIP control and four by national program personnel. The range of proposed treatments covered seed storage, biological control of root-knot nematodes, seed handling, irrigation and fertilization. In storage trials seed stored in diffused light, compared with farmers own seed, increased yield from 7.5 to 14.5 ton/ha, and was comparable to seed from cold storage. The costs of the diffused light store apportioned by tonnage and years, was economically more advantageous. Biological control of root-knot nematode was extremely effective giving a control even better than nematicides. However, under the situation pertaining to the Cañete crop in years of scarcity (as for 1980) there is no premium for potato quality, the market accepts both damaged and undamaged tubers. Thus in this year no economic benefit resulted from improved nematode control.

Ecuador. A late 1979 survey in el Carchi (northern Ecuador) was used to plan a series of trials to be conducted within INIAP's "Programa de Investigación en Producción." In July 1980 10 trials were planted.

The trials, which would be harvested in early 1981, were to test a balanced and more adequately timed mineral fertilization and chemical weed control.

Region III

Rwanda. On-farm research is a major focus of the Rwandan Potato Program (PNAP). In 1980 two series of on-farm trials were conducted totaling 31 trials. The first seven (first crop) suggested that planting in rows, desprouting and mineral fertilization should be contrasted with the farmer's system of planting in beds and using non-desprouted seed without fertilization. Although the proposed package gave consistent increases in yields it had very low potential for adoption by the farmers since fertilizers are scarce and probably beyond the reach of the producers.

Twelve of the 24 trials of the second campaign investigated chemical control of late blight either with the farmer's or with an improved variety. Spraying fungicide every 14 days gave the most convincing results with both the farmer's and improved varieties. Scarcity of fungicide, high cost of sprayers and for some locations non-availability of clean water for spraying might reduce adoption of this technique by individual small farmers. Organization of spraying cooperatives was seen as a possible solution.

The last 12 trials concerned improvement of the quality of farmer's own seed by positive and negative selections in the farmer's fields. The performance of the seed produced using the two methods will be compared to that of the farmer's traditional seed in a series of trials in early 1981.

Region IV

Tunisia. During the past 4 years on-farm research has been instrumental in improving and reinforcing the national seed multiplication program. A series of eight trials compared locally multiplied seed to imported seed during the early crop (Nov-Dec). The more physiologically mature "local seed" outyielded the imported in most cases. The profitability of using the locally multiplied seed for the early crop was clearly demonstrated. Consequently more emphasis will be placed on supply of seed for the early crop during future 'multiplication campaigns of the national seed program.

In the late crop 18 trials were planted comparing the seed provided by the program to the farmer's own seed as in previous years. As a result of these "demonstration trials" demand for local seed multiplied by the seed program is far higher than actual production.

Turkey. A total of 33 trials were planted in the Gundalan valley. The alternatives tested were: planting with a semi-automatic planter, presprouting, chemical control of rhizoctonia and scab, and use of physiologically young seed. All alternatives gave promising results either by increasing yields or by improving quality of the harvest. The economic analysis showed that the use of a semi-automatic planter, presprouting and the physiologically young seed had high benefit/cost ratios which makes them attractive to the farmers.

Algeria. The results of the six trials conducted late 1979-beginning 1980 were analyzed and used to plan a new series of simpler, one-factor trials considering presprouting, planting in the middle of the ridge and pre-emergence irrigation. Despite great interest shown by the Algerian Research Institute, some logistic difficulties impaired the follow-up of the four trials planted during the last quarter of 1980.

Region V

A survey in two traditional potato growing areas in the Punjab and north west frontier province of Pakistan was to obtain information on economics of farm practices and potato production. It was apparent that the Punjab farmers see shortage of hand labor as a major factor and thus consider more mechanization as a necessity whereas shortage of good quality seed is frequently quoted by the research staff as the major constraint. To complement the survey 10 agronomic trials on seed management and inputs were started and will be used as the basis for 1981 on-farm trials.

Region VII

In the Philippines a CIP postdoctoral scientist collaborated with the national potato program in surveys which stressed the value of small simple trials (for farms of about 0.5 ha.). Ten simple one-factor trials were planted in April and included these variables: (1) elimination of expensive chicken manure; (2) use of larger seed pieces; (3) minimum soil preparation. Six more complicated trials were conducted on larger farms.

The elimination of the chicken manure decreased yield by an average of 15 percent which is largely compensated by the financial saving due to the high cost of the manure. Nevertheless considering the cumulative loss of organic matter, it was decided that rather than suggesting that farmers drop the use of the manure, it was preferable to seek increased efficiency of use for this input to improve its contribution to yield.

The larger seed pieces gave a significant increase in yield but were not economically profitable. Minimum land preparation decreased yield and economic return and was consequently discarded from future trials.

During the last quarter of 1980 planting of a series of 30 trials was initiated. These trials will test a better timing of the application of fertilizers, improved seed quality, a proposed control of thrips and seed storage under indirect light.

Considerable time was devoted to training the team of the extension agents who are implementing the on-farm activities of the Philippines Potato Program.

Germ Plasm Evaluation, Multiplication and Distribution

Region I

The CIP regional headquarters in Colombia has the responsibility with the national program to duplicate the world potato germ plasm collection. Fifty-three families of *S. andigena* have been received as unrooted cuttings. From breeding material sent to Colombia since 1976 with resistance to late blight, bacterial wilt and cyst nematodes, 529 clones have been selected for yield trials. At Medellin, advanced clones are being screened for late blight resistance. The level of natural infection is excellent and 20 clones have been selected with considerable field resistance.

In Brazil, the performance of advanced breeding material from CIP in 1980 has improved considerably. More than 800 clones with good yield, uniformity and tuber quality were selected for further trials. The clone DTO-28 again gave a good yield in some areas of the country.

Advanced clones have continued to be supplied to both Peru and Bolivia. More than 1,000 clones were given to the National Research Institute and the Agrarian University in Peru and 37 percent have passed to the next testing stage. Of the frost resistant material sent to Bolivia in 1979, 46 remaining clones were tested at two locations. Five were rated as outstanding for tuber type. Out of 114 new clones sent in 1980, 24 were selected as good performers at both locations and gave 50 percent more yield than the local check varieties. Unfortunately, 1980 was a mild season and the clones were not subjected to normal high levels of natural frost. It is not planned to send more material until a full evaluation of that already selected has been made.

In Argentina, a collaborative program for selection of progenies with resistance to leafroll virus was reiniciated in the north central region of the potato area. In Chile, a further test of growing conditions in the extreme south of the country (latitude 52° S) was made with a view to establishing a possible virus free distribution area for *S. tuberosum* clones. The quality of seed tubers was excellent and virus disease virtually absent.

Region II

CIP assisted the program in Costa Rica to produce basic seed of locally important varieties and clones and also adapted several rapid multiplication techniques to local conditions. A senior CIP seed scientist assisted this project while on sabbatical and gave training to seven professionals from six countries in the region. Three of these, Mexico, Guatemala and Costa Rica, have a direct regional responsibility for the multiplication of pathogen tested clones within PRECODEPA.

Region III

The germ plasm multiplication and distribution center operated jointly by CIP and Kenyan Agricultural Research Institute (KARI) at the Plant Quarantine Station in Muguga, harvested a total of 37 clones this season. These were mostly CIP imports but also included some North American commercial varieties and other varieties from Peru and Mexico. As the germ plasm was received from a wide range of climatic extremes performance and visual evaluation will be variable. All will be distributed within Kenya and surrounding countries for full scale trials in 1981.

Within Kenya non-replicated observations were planted at the highland station of Mau Narok (3,100 m) and at Nairobi University (1,800 m) with materials from Muguga. At Mau Narok the objective was to assess resistance to late blight attack. One particular clone, CIP 720084, gave exceptionally high yield compared with others. A fairly good correlation between yield and blight ranking is not absolute as can be seen in Table RRT-1.

At Mau Narok clones CIP 720055 and CIP 800224 yielded 53.8 and 71.1 tons/ha illustrating the difference in growing conditions between the two sites. Clones CIP 800224 and 800225 in all experiments continue to be very high yielding and stable for blight resistance although with small tuber size and are rather late.

The national program in Rwanda, where CIP has a two-man team, tested 41 varieties, 10 clones and 45 tuber families from Europe, North America, Kenya and CIP-Lima. Good blight resistance was shown by 24 clones from tuber families, 1 clone from Belgium and one variety, India 1055. A total of 22 clones showed some resistance to bacterial wilt. Five recommended local varieties were tested at four locations and results indicate all have similar production potential. Using rapid multiplication techniques with sprout cuttings an acceptable yield of 20 tons/ha was obtained by rooting in sand and then transplanting. Stem cutting was only successful when rooting hormones were used.

Region IV

At the regional headquarters, Izmir (Turkey), the germ plasm evaluation center tested materials in the spring and autumn seasons (Table RRT-2).

Germ plasm was distributed to other countries of the region as indicated in Table RRT-3.

Table RRT-1. Ten best clones – Nairobi 1980 (unsprayed).

Clone/Variety	Blight ranking	Yield tons/ha
CIP 720055	1	13.9
800224	2	14.2
800225	3	7.4
Hydra	4	6.5
Huancayo	5	8.5
Dextra	6	9.4
Renova	8	6.1
Y-67-20-40	10	9.9
Estima	12	7.6
CIP 800223	18	6.7

Table RRT-2. Germ plasm trials – Izmir, 1980.

	Spring		Autumn	
	Planted	Selected	Planted	Selected
New and observations	114	36	520	197
Micro yield plots	67	26	19	13
Macro yield	18	9	9	8
Regional yield trial	12	Nil	12	12 *
PLRV trial	71 (fam)	81 (clones)	48	32

* Retained only for pathological work.

In Tunisia where a CIP scientist is stationed on a special project a total of 94 clones were retained from germ plasm received from Turkey. The largest proportion had combined virus resistance (62) specific PVY resistance (9) while the rest had generally good characteristics.

In the seed production project, 680 tons were produced. The original intention had been to reserve 200 tons for November planting but because of demand all was sold in August. The crop from this seed had only 6 to 9 percent visible virus infection.

Region V

In continuation of the leafroll screening program, 1,249 clones were planted from 14 tuber families at Faisalabad, Pakistan. A total of 78 were retained on the basis of resistance and yield. These were again sown in the autumn season.

Frost tolerance studies in the north-west of the country continued and 145 clones from 21 families were sown. After surviving temperatures of -2°C on 14 occasions 14 clones were selected.

Region VI

India received the following germ plasm materials from CIP: 14 clones, 11 tuber families for hot lowland areas, 20 varieties also for hot areas, 19 clones for CPRI Simla and 6 clones with *Macrophominia* resistance. This is also supplemented by true seed of lines carrying virus and cyst nematode resistance. As all these materials

Table RRT-3. Distribution of germ plasm (Izmir), Spring 1980.

Country	Number	Heat tolerant	Late blight	Type		
				PVY	PLRV	Others
Syria	30		8	2	4	16
Jordan	16	8		3	2	3
Egypt (Cairo)	17	2		4	4	7
Egypt (Assiut)	34	34				
Tunisia	3		1	1		2
Morocco	16		2	6	7	1
Dubai	16	11				5
Algeria	24	6		3		15

are handed over to CPRI to use and distribute, CIP does not have a direct input in their subsequent utilization.

In Nepal original imports have been reduced, because of limited staff to evaluate, to 90. Clones CIP 720045, 720044, 800223, 800244, K80 a (5), K79 a (1) and Roslin Eburu appeared to have a high degree of field resistance to late blight. Clones 800244 and R. Eburu were particularly promising and if the latter also has wart resistance it could be used to replace the current Kufri Jyoti variety which has poor storage qualities and culinary characteristics.

Clones with high resistance to wart combined with a useful degree of late blight resistance are Cruza 28, F 3134, I 5242, 685 BHU, CIP 750847, NE 4449 in the high hills and Cardinal and SLB/Z434 for the plains area.

Further testing of earlier selections shows that the clone CFJ from Mexico is no longer preferred because of its late maturity. Other clones Cruza 27, I 1095, I 1062 and Jaerla consistently outyielded the control Kufri Jyoti.

Bangladesh. During the first year that CIP's representative was in the country, 200 genotypes from several countries were evaluated. Some CIP clones and certain European varieties gave a satisfactory performance.

The frequent secondary growth due to the higher temperatures in the latter part of the season is a disadvantage of most *S. tuberosum* cultivars. This suggests the need for development of a heat tolerant variety characterized by quick bulking to offset the short season. Development of this type of variety would permit planting after late paddy, currently not feasible due to high temperatures during bulking. Preliminary studies have suggested the feasibility of a single seed multiplication in the north of the country.

Region VII

It was expected that the regional germ plasm center in the Philippines would be fully operational during 1981. All agronomically suitable sites were logistically difficult to operate and caused severe damage. In spite of these difficulties the general area seemed suitable as cuttings and tubers from the greenhouse at Baguio were successfully grown throughout the year in the sandy soil. No serious disease problem was evident. In anticipation of the need for rapid multiplication methods several techniques were tested. Single-node methods using peat moss as the major component of the medium gave a greater bulk of roots than the stem cuttings technique. The latest site is located in an area protected from typhoons with adequate access and will be fully operational in 1981.

Heat Tolerance and Tropical Potato Production

Region I

In Colombia main effort was on selecting bacterial wilt resistant clones for hot tropical conditions. In a collaborative project with ICA (at Medellin) four CIP clones, six ICA clones and four commercial Colombian varieties showed resistance. The best selections were CIP BR-63-65 and ICA 75-886-4. BR 63-65 maintained its highly tolerant rating received in the 1979 trials.

In Brazil research concentrated on agronomic practices for good emergence and growth. At Belen and the Amazon basin, 13 tuber families introduced from Brazilia were planted. Although there was some emergence only two clones produced tubers. The reason is not clear but it might include aluminum toxicity, high soil temperature due to shallow planting or fungus attack. In another later planting some techniques successful at CIP's station at Yurimaguas (use of tree canopies, depths of planting, planting dates and mulching) are being tested. Also for the first time heat tolerant clones such as DTO-28 are available.

Region II

In Costa Rica, 2,700 clones were evaluated for bacterial wilt resistance and heat tolerance. The wilt resistant clone, MS 35-22, is now with the national program for seed multiplication after showing resistance under local conditions over three seasons. Agronomic research on the control of bacterial wilt in Turrialba has shown that some measure of control can be achieved by weed control, good soil management and mulching. It is recommended that this, combined with tolerant clones, be tested as a package in areas where the disease is less severe than at Turrialba.

Region III

In Kenya experiments were again planted at coastal sites using CIP clones DTO-28 and LT-1, both having heat tolerance, and the varieties Desiree and Patrones which also appear to adapt to hot conditions. Yields averaged approximately 0.5 kg per plant, which is acceptable. As a result of this experience it is proposed to have another experiment in late 1980 introducing agronomic techniques, such as tree shade and mulching coupled with the best of the selected clones and varieties.

Region VI

A collaborative project started with **Sri Lanka** in which CIP heat tolerant germ plasm is first multiplied in favorable highland conditions and then part of the production tested at several lowland stations where high temperatures are normal. Various agronomic practices will also be tested. As suitable germ plasm is identified, it can be rapidly multiplied from the residual stocks of clean clones retained in the highland areas.

Region VII

In the **Philippines** heat tolerance for potatoes in lowland areas is matched by the need for bacterial wilt resistance, the major disease complex. A total of 15 clones were evaluated for tolerance to this disease and clones CIP 750826, MS 86-28 and CIP 750815 showed a useful degree of tolerance. CIP 750815 had the best emergence and highest yield of 16 tons/ha. Use of flat "hills" rather than concave or convex hills gave best production.

Production of Potatoes Using True Potato Seed

Region I

In conjunction with EMBRAPA, the Brazilian research institute, a project has started with trials at three locations of progenies from CIP, University of Wisconsin, New Zealand and Brazil. Four families gave a good yield. In southern Brazil some relevant agronomic data was obtained, but the density of transplanted seedlings was severely affected by cold weather rain. A more extensive program is planned for 1981.

Region III

Use of true seed about doubled the national average yield for tuber seed in Rwanda. The seed was stored for 2 to 3 months after collection then planted in trays of sterilized soil and transplanted to the field after 30 days. Open-pollinated seed of the variety Condea yielded 15 ton/ha. Tuber seed on the research farm produced yields of 20 to 24 tons. The lower cost of production has convinced farmers who are independently adopting the technique. The next stage is to test seed specifically selected for this technique.

Region VI

In Bangladesh seed was supplied for the first agronomic experiments for planting in the 1980 season. There is considerable interest in the technology as a research project. Adoption depends on how the system can be adapted to the extremely short growing season.

In Sri Lanka results of using open-pollinated seed of the Australian variety Coliban show reasonable uniformity of progeny although tubers were slightly small.

Region VII

Two studies in the Philippines were breaking dormancy of true seed with various levels of gibberellic acid and establishment of TPS seedlings using salt treatment of the seed.

At low elevations in both greenhouse and field conditions germination was poor without seed treatment. In the laboratory using a 1,000 ppm GA treatment, germination was 76 percent. In the field there was no difference in uniformity of the germination with or without use of the pre-treatment with salt.

At a mid-elevation site (840 m altitude), the GA seed treatment of Conchita, Desiree and Waitangy gave 90 percent germination. GA and salt treatment combined gave up to 90 percent establishment in the field.

Four more experiments have been planted for harvest in 1981: (1) effect of numbers of plants per hill; (2) age of seedlings on establishment and yield; (3) progeny testing of hybrid lines from New Zealand; (4) effect of different fertilizer applications and control of thrips.

Low Cost Storage and Processing

More adaptive investigations than innovative research are underway in the regions. Both farmers and researchers have rapidly picked up the essential points and are modifying existing buildings or applying the principles using local materials for construction.

Region I

In Colombia low cost seed stores using diffused light were built at three locations. Measurements of weight losses, seed quality and yield show that losses were low and emergence faster and more vigorous from the seed stored in the light. A strong private sector interest has emerged.

In Peru the national research institute has demonstrated the storage principles on the coastal area and in the Andes. The principle is being adopted mainly on the coast where farms are larger and more commercially oriented.

In the sierra of Ecuador diffused light stores appeared to have little advantage over traditional practices. Partly this may be the lower temperatures at high altitudes which in any case inhibit sprouting.

Region II

Low cost storage improvement is the regional responsibility of two countries, Guatemala and Honduras, under the PRECODEPA organization. As such CIP only supports the program as requested.

Region III

The original storage investigations have continued with the Agricultural Development Corporation and Ministry of Agriculture. The principal objectives are to test simple structures of applications for the small farmer which maintain adequate security of the produce. Wherever possible relatively unskilled craftsmen are involved in the construction to ensure its simplicity.

On the ADC farms a naturally ventilated bulk store for ware potatoes with flap control of ventilation and use of sprout suppressant have been tested. A more simple design which dispenses with flap control and has continuous ventilation while using sprout suppressant has also been tested. For the small farmer a modification of the traditional African house with thatched roof and mud walls is used with various forms of container for storage of the potatoes within the house.

The interim conclusions support the idea that where ventilation of the tubers is allowed even at low rates, 4-month storage is feasible in cheap structures within the normal dwelling house especially if sprout suppressant is used. The chemical inhibitor is necessary if tubers are to be safely stored longer than 2 months. The economics of this type of storage for ware potatoes is reliable for small quantities up to 700 kgs. Thus it is only feasible for very small farmers. The cost of constructing the naturally ventilated store of slightly larger capacity of 2 1/2 to 3 tons is not yet low enough to be economic; therefore, further development is still needed.

Region IV

In the seed production area of Gundalan, modifications of local ware stores have been made and a form of diffused light storage introduced for seed potatoes. Winter temperatures below freezing necessitate care when exposing potatoes to light as frost damage is possible. Down on the Mediterranean coast at Menemem the results from the use of diffused light store have been promising. Another is being built in Bozdag to attract the attention of farmers.

Region VI

In India, post-harvest technology is mainly in collaboration with the laboratory at IARI and the National Physical Laboratory that are working on solar drying.

At IARI the work has been concerned with rates of moisture loss of chips with different forms of dryer. Problems are depth of loading drying trays and the range of 60-70° C between night and day temperatures inside the drier. More sophisticated designs are being considered for improving the night drying including recirculating heat stored in an insulated reservoir. Various forms of chip processing and treatment have been investigated with respect to optimum chip thickness and treatment for color improvement.

In Bangladesh, a new type of store was designed for potatoes using the principle of drawing air into the store over damp charcoal screens. The principle of obtaining an evaporative cooling action to help store the ware potatoes is being tested to release cold store capacity for seed potatoes.

In Nepal, diffused light stores for seed potatoes have been constructed at several locations. The work is being carried out by a PhD student from Switzerland attached to the bilateral team.

Region VII

The storage experiments have been highly successful in the highland areas of Baguio, Philippines. This is reported elsewhere. A postdoctoral position was utilized in the Philippines to look at the socioeconomic consequences of this and other technologies. One surprising fact to emerge from the initial studies is that yields in general in the Baguio area are much higher than previously thought. This casts doubt on the ready acceptance of newly introduced technologies particularly if they add to the already high costs of production.

Social Science Department

Social scientists contribute to achievement of CIP's mandate through research, training and dissemination of information on socioeconomic aspects of potato production and use and on technological change in developing countries.

During 1977-80 interdisciplinary methods were developed for identifying farmers' production problems and evaluating new technologies at the farm level. Broader issues of potato agriculture, marketing, consumption, and farmer adoption of new practices are now being studied. An aim of the department's research is to develop a "social science of the potato" which facilitates exploitation of the potato as a major world food crop.

A 3-year agroeconomic research project in the Mantaro Valley, highland Peru, was completed in 1980. On-farm research to optimize potato productivity was conducted in seven countries. Studies of potato marketing and consumption were made in Peru and Rwanda. Socioeconomic country studies of potato production and utilization were completed for India and Rwanda. A comparative study of Peruvian potato agriculture in world perspective neared completion. Research on farmer adoption of rustic seed storage technology began. A data bank was established for statistics on world potato production and use.

Most of this work has been done by interdisciplinary teams with social and natural scientists from CIP and national program scientists in the respective countries.

I – Optimizing Potato Productivity (OPP)

CIP makes a concerted effort to bring its potato research closer to the final clients: the farmers. On-farm research helps identify farmers' production problems, sharpen research priorities and facilitates the transfer of appropriate new technology.

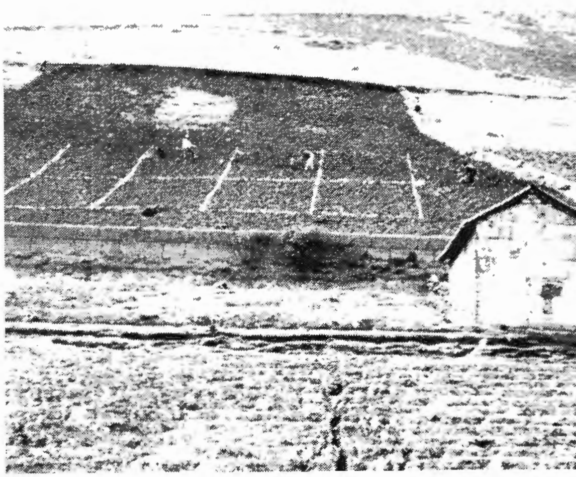
Mantaro Project

Mantaro Valley project objectives were to gain experience with farm-level potato research, to sensitize CIP and national program leaders to usefulness of this type of work, to develop appropriate procedures for conducting on-farm research within national programs and to prepare materials for training courses.

Farm-level surveys and trials over 3 years illustrate how natural and socioeconomic conditions can influence production and the potential for improvement through technological change. Three broad agroecological zones were used: Valley Floor, below 3,450 meters; Intermediate Zone, left and right valley slopes between 3,450 and 3,950 meters; and High Zone, above 3,950 meters. Production problems differed between the zones. For example, seed quality problems (physiological condition, pests and diseases) were more serious on the Valley Floor than in the Intermediate and High Zones. On-farm trials indicated that potentials for improving seed source and management (storage and selection) were greater on the Valley Floor than at higher elevations.

The CIP experiment station, situated on the Valley Floor, has promising technologies rapidly adopted by farmers in that zone but are not appropriate for, or adopted by, farmers in higher zones. This highlights the importance of carefully determining farmer needs under different ecological conditions.

Within a single agroecological zone production problems and potential changes may differ between types of farm. For example, on the Valley Floor per-hectare yields of large seed growers are much higher than those of small subsistence-oriented producers. This is largely because the large farmers have capital necessary for input purchase and risk taking; they also have subsidized credit and a more stable and attractive coastal market for their produce. Some large growers obtain yields as high as the local experiment station. In contrast many small farmers in the same zone have low yields which could be markedly increased through the application of technologies recommended through experiment station. However, not all recommendations are likely to be adopted by small farmers. For example, use of certified, and strictly selected, seed tubers has been recommended. But, our research indicates these practices



Research to optimize potato productivity includes farm-level experiments comparing new technologies against farmers' current practices. A field is marked out here for on-farm research activities.

would not be profitable for many farmers because: (1) farmers' seed is not as poor as usually assumed, (2) available certified seed is not as good as assumed, and (3) cost of seed selection and changing seed sources are greater than often recognized. On the other hand, farmers' insect control is often deficient, and low-cost improvement could generate high rates of return.

In the 1979/80 crop year, 32 trials were conducted on farmers' fields. Planning was based on earlier farm surveys and results of the 1978/79 trials. "Package Trials" evaluated three technological packages on 20 small farms in the Intermediate Zone. The packages included fertilizer, tuber seed selection at planting time, and insect control, all at four levels: (a) "farmer," (b) "low," (c) "medium," and (d) "high-cost" input levels.

The low-cost package increased average yields slightly above the farmers' level, and its improved insect control raised quality and market value of harvested potatoes. The net income increased substantially and the rate of return was high. The medium- and high-cost packages increased yields and net income more substantially than the low-cost package, but they had much lower rates of return (Table SSD-1).

"Factorial Trials" on 12 farms complemented package trials by evaluating agronomic and economic performance of the three variables making up the technological packages. The proposed fertilization and seed selection increased yields, but the proposed insect control had no effect on yield. Seed selection at planting time increased yield, but at a high cost in terms of the volume of small and damaged seed discarded. As a result, additional returns barely covered the additional cost. The proposed fertilization was less costly than seed selection and generated a much higher rate of return. Modified timing and placement of locally available insecticides was quite profitable, lowering input costs while increasing the quality and market price of harvested tubers. Positive yield interactions were found between the fertilization and seed variables and also between fertilization and insect control. Fertilization had the greatest impact on yield but insect control had a higher rate of return (Table SSD-2).

Regional Research

CIP's strategy for optimizing potato productivity helps define actual problems faced by farmers and provides agronomic and socioeconomic evaluations of new production technologies under farmers' conditions. It is proving to be useful to those concerned with promoting agricultural development with improved technology.

The Social Science Department coordinates implementation of this strategy in CIP's regions and is continuously refining the on-farm research approach. The ultimate goal is development of simple, low-cost methodologies that are used by developing country research programs in improving potato production and use.

In addition to the 41 trials of the Mantaro Valley, 171 on-farm trials for optimizing potato productivity were conducted in seven countries within four of CIP's regions in 1981: Peru and Ecuador

Table SSD-1. Agroeconomic results of 20 on-farm package trials in Mantaro Valley, Peru, 1979/80.

	Treatment			
	Farmer	Low-cost	Medium-cost	High-cost
Ave. yield (t/ha)	18.4	19.9	24.2	29.3
Ave. change net income (US$/ha)	–	187	635	1,232
Ave. change variable cost (US$/ha)	–	9	295	439
Ave. rate return *	–	20.8	2.2	2.8

* Defined as change in net income divided by change in variable cost.

in Region I; Rwanda in Region III; Turkey, Tunisia, Algeria in Region IV, and the Philippines in Region VII (Table SSD-3). Most trials (94 percent) used a simple experimental design comparing the farmer's present practice against an alternative technology in adjacent plots (Figure SSD-1).

Major production factors considered for improvement in the 1980 trials were seed management, seed source, fertilizer management and rates, and improvement of farmer's own seed (Table SSD-4).

In five of the seven countries (excluding Peru and Turkey) the leading role in this on-farm research was by national potato workers, and CIP backstopped the effort, mainly in planning, analysis and overall interpretation of the results.

Specific results of the on-farm trials are reported under the Regional Research Section of CIP's 1980 Annual Report.

Experience gained through implementing the optimizing potato productivity strategy is being consolidated in a series of training documents which outline procedures for use by national and regional potato workers. In 1980 three of these documents were published; plans are for publication of another seven in 1981.

II – Andean Potato Seed Systems

European and North American experiences with potato certification and results of experiment station research from around the world have led to the widespread belief that better potato seed can play a key role in improving

Table SSD-2. Agroeconomic results of 12 factorial experiments, Mantaro Valley, Peru, 1979/80.

Treatment [1]	Average yield (t/ha)	Average change in net income	Average change in variable cost	Average rate of return
		(. . . . . US$/ha	. . . .)	
Farmer (sfc)	17.6	–	–	–
Sfc	18.8	69	153	0.4
sFc	19.0	250	20	12.5
sfC	17.5	90	- 2	*
SFc	22.5	562	173	3.2
SfC	18.1	-27	151	**
sFC	19.7	353	17	20.8
SFC	22.1	576	171	3.4

* Net income increases with lower input expenditure.

** Net income declines.

1 Abbreviations:
- s = seed: farmer selection, ave. wt. 37 g.
- S = seed: farm seed, small tubers and tubers with damage by insects, fungi and bacteria eliminated, ave. wt. 56 g.
- f = N-P-K: ave. 86-115-106 kg/ha generally applied at planting.
- F = N-P-K: 150-180-100 kg/ha, 1/3 N applied at planting, 2/3 at hilling.
- c = insect control: generally Aldrin and Furadan applied in furrow at planting and regular applications of foliar insecticidess.
- C = insect control: 25 kg/ha Aldrin around base of plant at hilling and phosporic and systemic insecticides applied at appearance of larva of *Liriomiza patagonica* and *Stenoptica* sp.

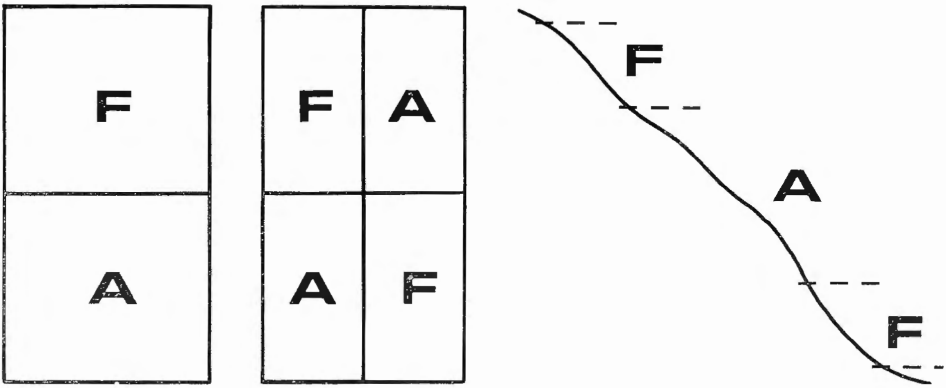


Figure SSD-1. Most trials to optimize potato production followed one of these simple designs comparing an alternative (A) to the farmer's current practice (F).

farmers' yields and incomes. Experiment station data show significant yield differences between potato crops grown with certified and non-certified seed, and that virus diseases can depress yields from 30 to 80 percent.

Despite these findings, most farmers in developing countries do not use certified seed (hereafter called improved seed). A study evaluated the socioeconomic factors limiting improved seed use in the Andes, with special reference to Peru, and to determine how these limiting factors might be reduced.

After a descriptive analysis of the technical and institutional characteristics of certified seed schemes, an economic model is developed to explain the observed seed use patterns in Colombia, Ecuador and Peru. Farm-level surveys and experiments generated necessary data for use of the model. Production functions were estimated for different regions, agroclimatic zones and types of farmers, and supply and demand elasticities for improved seed were calculated. A binomial logit model was used to identify factors affecting use of improved seed.

The study's main results, summarized:

Little or no significant yield difference between farmer seed and the improved seed currently available in the highlands of Colombia, Ecuador and Peru. In contrast, significant differences were found in experiments on Peru's coast (Cañete Valley). Given the small observed yield differences between farmer and improved seed, the high price of improved seed discourages highland farmers from buying this input.

Agroclimatic conditions and availability of irrigation water have a stronger difference on potato yields and use of improved seed than did other variables, such as seeding rate and fertilizer levels.

Table SSD-3. Number of OPP trials and farmer cooperators, 1980.

CIP Region	Nº of trials	Nº of farmer Cooperators
I	31	24
III	31	19
IV	63	42
VII	46	45
Total	171	130

Table SSD-4. Percentage of OPP trials and number of countries where specific production factors were considered.

Factors	Nº of trials (n = 171)	Nº of countries (n = 7)
Seed management	19	4
Seed source	14	2
Fertilizer management/rate	14	4
Improvement of farmer's seed	9	2
Planting method/density	8	4
Rhizoctonia control	7	1
Late blight control	6	1
Organic matter	4	1
Seed storage	4	2
Irrigation	3	2
Nematode control	3	1
Insect control	2	1
Seed size	2	2
Scab control	2	1
Weed control	2	1

Participation of farm people in on-farm trials, as here in Rwanda, helps researchers better understand farmers' problems and also helps farmers understand and adopt new techniques.

Increasing the productivity (yield potential) of improved seed is a necessary condition for increasing farmer use of this input in the study areas. Additional measures which reduce the farm-level price of improved seed could also stimulate its greater use.

III – Country Studies

Few comprehensive studies are available on potato production, distribution and use in developing countries. To fill gaps in knowledge about the present and potential role of the potato in the developing world, CIP has contracted social scientists to prepare country studies covering aspects of production, distribution, utilization and public programs related to the crop.

Country studies, in collaboration with national institutions, are to present a comprehensive picture of the potato industry in selected countries with diverse patterns and trends of potato cultivation, marketing and use. Early country studies covered Ecuador and Chile, two South American countries with relatively high consumption levels but distinct ecological and socioeconomic conditions. A Kenya study documented the history and present role of the potato in an East African country where potatoes have only recently achieved the importance of a major highland crop. The 1980 studies cover India and Rwanda.

India Country Study

India has one of the fastest growth rates in potato production in the world and is an excellent case to understand how potato production can be rapidly increased. However, potato producers in India have encountered marketing bottlenecks. A socioeconomic study examined recent trends in India's potato production and use.

The study confirms India's fast growing potato area, production and yields. India now ranks fourth in area and sixth in potato production in the world. Within the country, growth of potato production has outstripped growth of all other crops. Its area has increased nearly three-fold and production more than six-fold in 3 decades. India now produces about 10 million tons of potatoes per year on 790,000 hectares, with average of nearly 13 t/ha. Although still a minor crop, potatoes now account for about 2 percent of value of Indian agricultural production.

Contributing to this progress are development of new, high-yielding, disease-resistant varieties suited to various agroclimatic zones and establishment of a viable seed production system for the plains, based on the "seed plot technique." Construction of cold storages has been crucial for the seed system and also for ware potato marketing. Other major contributing factors have been extension service and Government promotional programs, increase in irrigation facilities, and development of short duration varieties of paddy, maize and jowar, which led to introduction of entirely new crop rotations into which potatoes fit well as a short-cycle cash crop. Improvement of transport and communications have connected even remote areas with markets.

India has six agroclimatic zones suited for potato culture. Potato planting and harvesting is underway in some part of the country throughout the year. Potato cultivation is most intense in the Indo-Gangetic plains of the North, which account for nearly 90 percent of total production.

A small number of large potato producers account for a substantial share of marketed potatoes. But most growers are small farmers with small cash resources, who try to sell the crop immediately after harvest. This often leads to sudden accumulation of stocks in northern assembling markets and frequent price crashes.

Fast development of cold storages in recent years created capacity now adequate for about a third of the crop. Nearly all cold storages are in the assembling markets. Considerable damage results when potatoes are shipped during hot weather from stores to distant main consuming markets.

Annual per capita potato consumption in India has doubled since 1962 but remains only about 8 kg, low compared with other leading potato growing countries. The share of potato in the national food basket increased from 3 percent in 1950-51 to about 8 percent in 1978-79. Potato is still consumed mainly as a vegetable. Except for a few peak harvest months, energy from potato is costlier than that from other vegetables. Prices per kg are higher than rice or wheat except in the main producing belts.

Potential is great for increasing potato production and consumption provided they can be supplied to consumers at reasonable prices. This requires increasing yield rates, holding the line on costs and streamlining the marketing and distribution system.

Rwanda Country Study

Rwanda is one of the smallest, most densely populated and poorest countries in Africa. The country is landlocked, with poor communication links to sea ports. Over 90 percent of the population is rural. The country is experiencing a food deficit, especially in rural areas. A Rwanda country study provided basic information for establishing a national potato program to improve production. The potato has been grown there for more than 80 years, but only recently has it become an important food crop. Production, estimated at 200,000 tons per year on 30,000 hectares (average yield 7 t/ha), is about 6 percent of the value of all food crops. These production figures imply an average annual per capita consumption of 45 kg (see "Rwanda Consumption Study" below).

Major producing regions are in high altitudes on the northern volcanic slopes and along the Congo-Nile ridge. These two areas produce 90 percent of Rwanda's potatoes.

Potatoes are grown on small family farms, most with less than 1 hectare of land. Farmers grow two crops annually. Chemical fertilizers, pesticides or herbicides are not used. Less than 10 percent of the crop is marketed.

Potato improvement programs are directed toward intensifying production in present producing areas and expansion of the crop in lower areas. Since 90 percent of the crop is consumed on farm, the major goal of these programs should be to improve food supply on the farm. Production must be increased with minimal reliance on purchased inputs, as few farmers have cash incomes to purchase these inputs. Technology is required to increase yields with little or no cash expense. Farmers often must replace their planting material after poor crops in the main season, so varieties with improved genetic potential can be introduced even in the subsistence sector. Improved farm storage would be useful to stabilize food supply, improve seed quality and stabilize market prices, which fluctuate widely in producing areas.

IV — Potato Consumption and Marketing

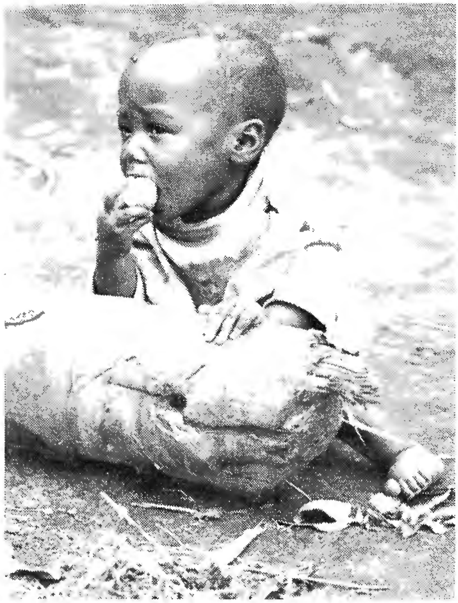
Myths about marketing and consumption hinder research and policy initiatives to exploit the potato's potential as a food crop in developing countries. Consumption and marketing studies are assemblying information to dispell these myths and provide policy makers with a more solid basis for appraising the value of the potato as a food crop in their countries. Work in 1980 was in Rwanda and Peru.

Rwanda Consumption Study

When the Rwanda Potato Improvement Program (PNAP) began in 1979 little was known of Rwanda potato consumption. The official consumption estimate based on production and population figures was 45 kg/capita. A national survey (1971) reported very low consumption rates. Yet, PNAP leaders observed growing potato demand, sharp production increases, and great farmer interest in potato production technology. Better consumption data was needed for planning research and extension.

A study from May to November 1980 looked into the history, present status and prospects of potato consumption. Topics included regional consumption; seasonality; purchasing, storage and preparation habits; varietal preferences; taboos, dietary status and potential for increased consumption.

Results show that as late as 1940 the potato was a taboo food not consumed by most people. Famine in the 1940's stimulated consumption, and, in turn, production. A national average consumption of 85-95 kg now seems more realistic than 45 kg/capita. This, in turn, indicates higher production than currently assumed. Potatoes are among the most preferred foods nationally. Regional annual consumption differences ranging from 26 to 261 kg/capita correlate with agroecological variations. Average urban consumption rates indicate need for research to improve ware potato storage and marketing; price fluctuation is a major factor limiting urban consumption. Despite varietal preferences, most people will accept improved varieties. Potato taboos and wasteful preparation techniques are areas of concern for integrated extension efforts. Consumption problems are now considered in PNAP overall planning and research.



Children in Rwanda like potatoes although years ago customs prohibited kids from eating them. Old men told a CIP anthropologist of eating potatoes on the sly while tending family cattle as youngsters.

This is one way potatoes go to market in Rwanda.

Peru Consumption Study

Potato consumption was studied at five sites: Cañete (irrigated coastal potato producing area), Pamplona (urban low-income neighborhood), Mantaro Valley (traditional highland producing area), San Ramon (humid high jungle), and Yurimaguas (low Amazon jungle). Potato consumption is declining in traditional highland production areas in favor of coastal urban-style foods, such as rice and bread. Coastal producers often prefer potatoes over alternatives but sell them to purchase cheaper foods. Improved transportation has increased availability and consumption of potatoes in the Amazon lowlands, where potatoes are an expensive luxury food. Amazon consumption is highest among wealthy immigrant families from the highlands or Lima. Potatoes are a preferred food in Pamplona, however, poor families can afford to consume only small quantities. In a Pamplona test with varieties from the Mantaro Valley and San Ramon, women preferred highland potatoes. Some varieties produced in San Ramon tasted better than others from the same zone.

Peru Marketing Study

Peru has a serious agricultural problem. In the 1970's per capita food supplies fell and imports skyrocketed. Research in central Peru studied how markets link potato producers and consumers and how poor market performance might limit production.

Two distinct potato production and marketing systems in central Peru include one for the highlands and one for the coast. In the highland system, subsistence and commercial producers differ on the basis of varieties grown, quantities sold, market outlets, and perceptions of the marketing system. Most potatoes marketed in the central highlands are sold by a small number of commercial producers who supply Lima through an established network of intermediaries. Small producers — the majority — supply their own and local consumption needs by selling potatoes directly to retailers or consumers in regional fairs and markets.

In contrast, in the coastal system marketing functions, including grading, bagging and sometimes harvesting, are done by intermediaries who ship potatoes directly from farmers' fields to Lima.

Over the last decade per capita potato consumption fell by nearly 25 percent in Peru. It is sometimes assumed that this drop in consumption is due to the action of unscrupulous market intermediaries who limit supplies and inflate prices artificially. This research indicates that the basic cause is declining production, which resulted partly from government policies promoting food imports and putting little emphasis on research, extension and production incentives.

V — Potato Agriculture in Comparative Perspective

Peru, one of the most ecologically diverse countries in the world, offers an excellent natural laboratory for biological and agronomic research on the potato under different conditions. Similarly, Peru presents the social scientist a superb opportunity to study distinct farming systems and how the potato fits, or might potentially fit, into these systems. Since CIP conducts experimental resarch in four Peruvian regions (Cañete and La Molina

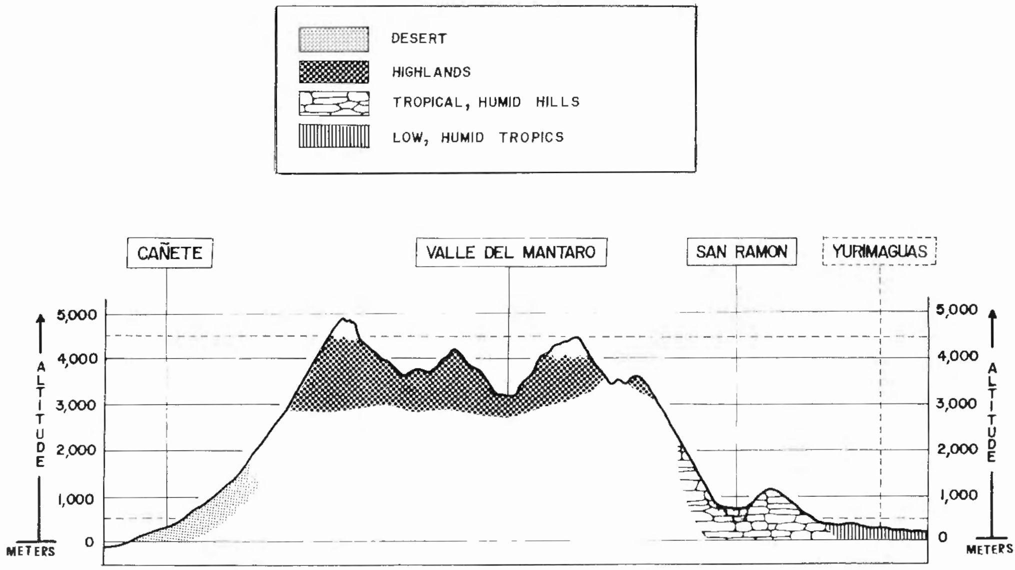


Figure SSD-2. **A cross section of the central Andes showing types of region, approximate elevations and CIP research sites.**

on the arid coast, Mantaro Valley in the highlands, San Ramon of the humid, high jungle, and Yurimaguas in the lowland, hot tropics), a social science project was launched to comparatively study farming systems in each zone, with an emphasis on the potato (Fig. SSD-2). Also, an effort was made, through a literature review, mapping exercise

Table SSD-5. Characteristics of agricultural systems in four Peruvian regions.

Characteristics	CAÑETE	MANTARO	SAN RAMON	YURIMAGUAS
Ecological zone	Arid coast	Tropical highland	Mid-elevation, humid tropics	Lowland, humid tropics
Farming system type	Irrigated commercial	Small-scale subsistence	Mixed-shifting cultivation and tropical estate agriculture	Shifting cultivation
Principal crops or crop types	Cotton, potatoes, maize	Andean tubers, grains, vegetables	Coffee, tropical fruit, cassava, maize	Rice, cassava, plantains
Method of land preparation	Plow cultivation	Plow cultivation	Clearing by fire, no tillage, plow cultivation on estates	Clearing by fire, no tillage, digging stick
Manuring or use of chemicals	Intensive	Intensive	Limited on small farms, widely used on estates	Extremely rare
Cropping pattern	Monocrop	Monocrop	Intercropping; relay planting	Intercropping; relay planting
Backyard garden	Well-defined frequently fenced	Well-defined	Dispersed tropical trees and yard plants, no fencing	Dispersed tropical fruit trees and yard plants, no fencing
Agricultural calendar: sociocultural factors	Fixed dates, government regulated	Fixed dates, community and individual decision	Dates highly variable; individual decision	Dates highly variable; individual decision
Social unit of production	Cooperatives, individual households	Individual households	Cooperatives, individual households	Individual households
Present status of potato production on farms	Modernized geared for export to urban areas	– Traditional technology – Advanced seed production	– Experiments by farmers at elevations above 1,000 m. – Geared for home consumption as supplemental vegetable	Non-existent

and short field studies, to determine how the Peruvian sites relate to other world agricultural zones. This research illustrates how farming systems reflect ecological conditions and how they vary substantially between zones (Table SSD-5). Moreover, striking parallels can be noted when comparing the Peruvian cases with other world areas of similar environments.

At Cañete on the arid coast, agriculture is irrigated, characterized by the plow cultivation of agro-industrial crops (cotton, maize, potatoes) and geared toward export to urban markets. Potatoes are an important cash crop; improved varieties are monocropped, rotated often with cotton, and intensively fertilized. Planting and harvest dates are regulated by the government. Potato yields are relatively high, frequently above 20 tons per hectare. Main farmer-perceived production problems are seed cost, irrigation, insect damage, and saline soils.

High above Cañete in the Peruvian mountains another type of farming system distinct from the coastal pattern is similar in many ways to farming in high, cool tropics worldwide. In contrast to Cañete, potato production in the Mantaro Valley is more traditional, except among a few sophisticated seed growers. Generally, potatoes — including indigenous varieties — are monocropped and rotated with Andean tubers or grains. Fields are small, dispersed, and cultivation is with hand implements or oxen, except in a few level areas where mechanical traction is possible. Farmers in this zone are troubled by climatic problems (frost, hail, drought), insect damage, lack of capital, poor soil, and potato diseases.

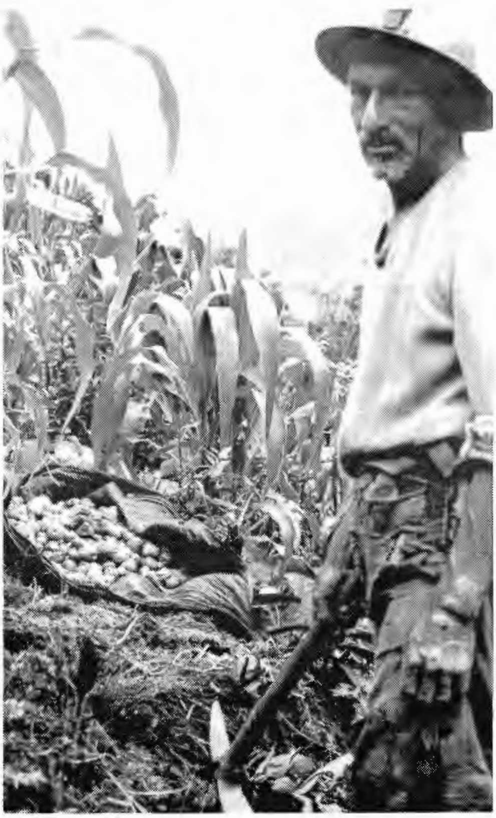
On the eastern slopes of the Andes potato production differs drastically from either highland or coastal systems. As conditions become warmer and wetter, monocropping gives way to multicropping and relay planting in which planting dates of several crops in the same field are staggered. As many as 15 crops may be in a single field. The altitudes between 1,000 and 2,000 m reflect a transition zone in which crops from the highlands overlap with those of the lowlands. Below 1,000 m, farmers have difficulty in growing potatoes although they experiment extensively with varieties brought from the highlands. A form of no-tillage

Salinity is a problem for this potato grower in the coastal Cañete Valley of Peru, as it is in other arid irrigated farming areas.

slash and burn cultivation is widespread at this elevation.

At San Ramon, in a high jungle valley, where CIP operates an experiment station, another type of tropical farming system is encountered: tropical plantation estate based on tree crops (coffee, citrus, mangos, papaya, coconuts) and other tropical crops (bananas, cassava, corn). Typical of such mid-elevation, humid areas around the world, agriculture here is quite diverse, characterized by vegetational stratification and intercropping.

A few hundred meters above San Ramon on the rainy eastern slopes of the Peruvian Andes, potatoes are grown in the same fields with maize and other crops. This type of multiple cropping with potatoes is common in many other warm, rainy areas of the world.



Also, the tropical plantation estate is subject to "bust and boom" price cycles. If potatoes could be economically grown in these farming systems, they might help smooth out the "bust" side of the cycle by providing a locally marketed crop as well as food for farmers and the generally large body of seasonal migrant laborers who come for the harvest of tree crops.

CIP has its fourth potato research station at Yurimaguas in the Amazon Basin, a hot-humid, rain catching jungle of great territorial expanse. The predominant form of agriculture, is slash-and-burn shifting cultivation, practiced by at least 250 million people worldwide.

It is characterized by clearing by fire, little tillage, planting by a dibble stick or hoe, an absence of manuring or chemical fertilizer, and multicropping. Farmers do not grow potatoes in this region. However, an area worth investigating in terms of future potato production might be along the river banks where gardens are intensively cultivated during the dry season and where moisture is available. Backyard gardens are on every farmstead, consisting of dispersed tropical fruit trees and yard plants.

The extrapolation of results and the transfer of improved technology between these similar zones might help reduce duplication of research efforts and bring to these zones needed and ecologically adapted technology. Peru, however, does not have extensive areas of wet-rice cultivation. The major thrust of understanding how potatoes might fit into this important farming system will no doubt come largely from experimentation in Asia.

VI — Farmer Acceptance of Rustic Seed Stores

The Social Science Department continued its cooperative research with post-harvest Thrust VIII by assisting in a follow-up evaluation of farmer acceptance of rustic, diffused light seed stores in the Philippines. Purpose of the research is to better understand farmer response to improved potato technology to aid in continually refining and adapting the technology to farmer circumstances. The Philippine case offered an excellent opportunity to study farmer reaction to a new technology due to a strong demonstration effort by the Philippine National Program starting in 1978. The case is interesting in that the first demonstration store was constructed by a group of farmers (no single farmer was willing to take the chance alone), followed by eight demonstration stores at various places up the mountain trail through Benguet and Mountain Provinces of Northern Luzon. In November 1979 and September 1980, a CIP anthropologist and post-harvest technologists cooperated with Filipino National Potato Program workers in conducting surveys of farmer acceptance.

Survey results show that within 2 years at least 124 farmers altered their storage practices, mainly introducing diffused light and better ventilation. Most farmers have altered existing stores, replacing a few corrugated tin sheets with translucent plastic sheets to permit entry of indirect light into the store. Many have also improved ventilation by spreading their seed rather than deep pilling. There is, however, a range of alterations, from spreading seed in front of an existing store window to construction of a 100 ton store by an association of 42 farmers who had previously stored independently.

The acceptance of the new seed storage technology must be understood against the background of present storage practices and why some farmers felt a need for change.

The larger farmers often ship seed tubers to Manila for cold storage, an increasingly expensive process which frequently results in high spoilage. Others stored potatoes in their houses in total darkness which results in extensive sprouting and loss of seed quality. Since the region is one in which seed potato production seems to be on the upswing, largely through the efforts of a seed improvement program, many farmers were receptive to the idea of improving their storage practices. Under these circumstances, CIP research in Peru cn the use of diffused light and the design of low-cost rustic stores was valuable.

Highlights include:

1. Among the farmers surveyed in 1979, larger farmers (in terms of landholdings) adopted first followed by smaller farmers.
2. There was no significant difference in age and educational levels of adopters compared to regional averages for potato producers.
3. Except for the case of the farmers association that constructed a completely new store, all other farmer-adopters made simple, low-cost changes in existing storage structures.
4. Half of the farmers learned of the new technology from Filipino National Potato

Surveys in the Amazon basin provide important information on lowland tropical farming systems into which the potato may be incorporated in the future.

Program workers; one quarter learned from other farmers and another quarter from seeing demonstration stores.

CIP Social Scientists in cooperation with Thrust VIII will continue to monitor the acceptance or rejection of the rustic seed store technology. Similar studies are planned in other countries where the technology has also been introduced.

In cool, highland potato growing areas, steep slopes are often cultivated, as in the southern end of the Mantaro Valley in Central Peru.

VII – World Potato Statistics

Information on levels and trends of potato production and use is essential for assessing the actual and potential importance of the crop at the country level and for establishing regional research priorities. CIP has established a statistical data bank on its computer to satisfy "in-house" research needs and to provide a useful information service to others. Statistics from the Food and Agriculture Organization of the United Nations, United States Department of Agriculture and World Bank are stored for all potato producing countries. Variables available yearly for 1961-79 include area and yield of potatoes and value and volume of potato production, imports and exports.

Details of potato utilization (fresh food, processed, feed, seed, waste) are available for early 1960's and mid-1970's. Prices for major agricultural commodities and statistics on land use, levels and growth rates of national income and population are also included for specific years. Programs facilitate calculating, tabulating and graphing key variables and relations. The data bank is updated yearly, and information is made available to all interested parties. Among the developing regions, production is increasing most rapidly in the Far East.

Training & Communications Department

CIP's training and communications functions, which include the library, were joined to form the Training and Communications Department during 1980. The three functions are closely interrelated and operate as a unit toward accomplishing CIP's training mission. Improvement of potato production in the developing world depends largely on national program scientists and extensionists capably disseminating new, as well as known, technology. This training and communications union, as a single force, concentrates energies toward achieving CIP's goal of collaborating with developing countries.

Summary reports from each of these functions:

Training

CIP's training program has eight categories:

- Regional Activities
- Lima Specialized Courses
- Lima Individualized Training
- Scholarships
- Training of Training Assistants
- Mid-Career Training
- Training of CIP Scientists
- Preparation of Training Materials

Regional Activities. All training events forming part of regional or country programs are considered a regional activity. Previously, these have been mainly production-oriented short courses, symposia, or workshops.

In 1980 a total of 27 regional activities involved 383 national program scientists and extensionists. These events totaled 4,006 days of training, or 73 percent of the days of training where national personnel were directly involved. These activities are reported in more detail in the section on Regional Research and Training.

Lima Specialized Courses. Topics better treated at CIP headquarters in Lima because of available personnel or facilities are conducted as specialized courses. The demand for these courses emerges from national programs through CIP's regional structure. Headquarters source research scientists meet this demand by organizing short, intensive courses.

A course on principles of storage was conducted in Spanish for 12 participants from Latin America in 1980. It represented 240 days of training and 4.4 percent of days of training for national personnel.

Lima Individualized Training. If demand is insufficient to justify organizing a course, source scientists frequently accept candidates on an individual basis. This becomes on-the-job experience, working closely with a scientist. The

training period normally is longer but structured to meet specific needs of the national program scientists.

Twenty-one national scientists from 13 countries received 714 days of such training in 1980, representing 13 percent of the days of training involving national program personnel.

Scholarships. Traditionally, CIP sponsors scholarships for advanced degrees for scientists from national programs. The objective is two-fold: to permit attainment of the advanced degree, and to conduct specific potato-associated research of priority to the scholar's home country.

During this reporting year, CIP sponsored 19 master and doctoral scholarships. Fourteen of these scholarships from seven different countries, were carried over into 1981. Ten of these were for doctoral degrees and four were for master degrees. Six of the 14 were fully supported by Core funds

Trainees from Latin America at a specialized storage course. A member of the Peruvian national program (right) assisted CIP as an instructor in this training course.

and two were fully supported by bilateral funds. Six were research assistantships as a part of research contracts and thus required only partial Core funding.

Additionally, during 1980 CIP sponsored 21 research assistantships for Peruvian students, mainly from the National Agrarian University at La Molina. Under this concept the students assist CIP scientists conduct priority research while at the same time they use portions of the results to meet master degree theses requirements.

Days of training are not calculated for this category because it would distort CIP's direct input.

Training of Training Assistants. Preparing national program scientists and extensionists to conduct training is a relatively new effort for CIP. The objective is to impart knowledge and also to enable national program personnel to train others upon return to their countries. Ideally, the national scientists or extensionists work with CIP scientists for a reasonable period of time, usually a complete research cycle of work. During this time, expertise of CIP scientists and training officers are combined into a training program for the participants home country. Training materials to complement the program are also developed and prepared. Thus upon the participant's return home, the program is ready to be launched without delay.

Three scientists in 1980 — from Bolivia, Sri Lanka, and Honduras — participated in this type of training. It represented 267 training days and 4.9 percent of the days of training for national scientists and extensionists.

Mid-Career Training. Both national and CIP research programs benefit from visiting national scientists who conduct research together with CIP source research scientists. It provides the opportunity for national scientists to conduct priority research for their countries under top supervision and better conditions as well as to gain an understanding of CIP's mission and methods of operation. Additionally, CIP scientists are provided an insight relating to research needs of countries with potential for improving potato production.

CIP hosted three visiting scientists, from Sri Lanka, Ethiopia, and India in 1980. Their research contributions, as evidenced by the regional reports, have been significant. Spending a total of 256 days conducting research they made up 4.7 percent of the days of training.

Training CIP Scientists. As CIP researchers discover improved potato production techniques, sharing this information among regional and headquarters scientists becomes increasingly important. This was achieved during the 1980 internal review with three workshops on germplasm management, true seed, and principles of storage. The workshops lasted from one-half to 2 days and permitted an up-date on theory as well as hands on refresher experiences.

Another facet is language training for staff members. During 1980 a total of 143 CIP staff members received English, Spanish or French training either at headquarters or at institutes outside CIP.

Preparation of Training Materials. Concentrating information on potato production and research into an easily assimilated framework for national program scientist and extensionist use is an effort that supports most other categories

A CIP technician shows indicator plants in the virology greenhouse to a mid-career scientist from Chile (right) and an individual specialist trainee from the Philippines (center).

of the training program. It is one of the most important contributions that CIP makes to national programs. These materials, including technical information bulletins, slide sets, and manuals, are reported in more detail in the section on communications.

Special Training Projects

Two special training projects were funded in 1980. Most training activities will take place in 1981, however. Unique characteristics of each include:

"Technology Transfer on Root and Tuber Crops" is funded by the United Nations Development Programme (UNDP). It involves collaboration of the Centro Internacional de Agricultura Tropical (CIAT), the International Institute for Tropical Agriculture (IITA), and CIP. While each Center has a separate plan of work, included are five workshops in which CIP unites with one or both of the other institutions to treat a topic of common interest. The remainder of CIP's work plan includes 10 short courses on principles of storage, agroeconomic methodologies, and potato seed production. These courses are additive and do not replace activities previously planned with Core funds. The objective is to allow trained national scientists and extensionists to organize and conduct the short courses thereby horizontally transferring technology to other researchers, extensionists and farmers from the host countries or surrounding countries. Most organizers and instructors have previously participated in CIP training activities, thus an opportunity is offered for CIP to obtain the multiplier effect of previous training. This project began July 1, 1980 and ends June 30, 1982.

CIP's electron microscope is used by a mid-career scientist who conducted some of his research in Peru.

"Basic Seed Production Training for Peru" is funded almost entirely by the Swiss Development Cooperation. The Cooperation provides services of a technician and operating funds to execute an 8-month training program focusing on production of basic seed using four rapid multiplication techniques. CIP makes available its scientists and facilities to conduct training and additionally provides overall administrative support. This project, which began September 1, 1980 and ends April 30, 1981, concentrates on three highland experiment substations of the Peruvian Instituto Nacional de Investigación Agraria (INIA).

Post Doctorals

Post doctoral positions are a traditional part of CIP's training contribution. It is treated as a separate item in this report because these are administratively in the training budget but post doctoral participants are senior staff members within the research departments to which they are assigned. In CIP's view it is an opportunity for young PhD's to conduct special research projects over a predetermined length of time in an international setting with the possibility of beginning foreign technical assistance careers. Their research results are incorporated into various Thrust reports.

Communications

CIP's communication function concentrates on production of selected publications and audiovisuals. An integral part of the training-communications-library triad, it also has a much broader role to meet demands of the Center's administrative responsibilities and research program.

A Spanish editor and publications manager joined the Training & Communications Department in April. This position provides improved service and a better linkage between the Department and other Center activities. Additionally, maintenance contracts for equipment to process publications and audiovisuals were made or renewed and several departmental staff members received training to up-grade their skills.

Some 650 publication and audiovisual jobs were processed during 1980. The following summary is by major category of work–administrative, research, or training support:

Administrative Support. All materials that communicate what CIP is or what it does are in this category. Included also are forms and other materials that assist in managing the Center. The annual report, budget document, and accounting responsibility report are examples of this type of work.

A total of 174 jobs including 14 publications and 160 visuals were prepared to support administrative matters. This constituted 26.7 percent of the communications effort.

Research Support. All tasks that assist CIP scientists in communicating research progress or results, such as planning conference reports, circulars and editing and audiovisual services for paper presentations are reported in this category.

A total of 232 jobs including 48 publications and 184 visuals were prepared supporting this aspect, comprising 35.7 percent of the total communications effort. Included were 10 CIP Circulars in English and Spanish and 4 planning conference reports.

CIP welcomes visitors to its facilities and considers visitors a special audience that requires special attention. In 1980 a total of 840 visitors from 56 countries visited CIP headquarters facilities, up from 785 visitors representing 43 different nationalities the previous year.

Training Support. All efforts that synthesize existant production or research information into frameworks used in training activities are in this category. It includes such items as technical information bulletins, slide sets, and manuals.

The 244 jobs included 46 publications and 198 visuals developed and prepared by CIP scientists working with training and communications officers. This represented 37.5 percent of the total effort.

Two items merit further discussion. The first is the effort CIP has embarked upon to provide training materials to national programs in a form that can be easily assimilated and possibly adapted for use in reaching farmers. These materials, mainly technical bulletins, are prepared at an intermediate technical level and are intended to be used by national scientists and extensionists in country courses or individual study. The topics are relevant to improving potato production. This project was accelerated significantly with the arrival of the Spanish editor and publications manager, since all are prepared in English and Spanish. With the establishment of the francophone region in late 1981 it is expected the French language will also be included. During 1980 seven new bulletins were produced and distributed while at the end of the year some 23 topics were in progress. Complementing slide sets are in progress.

The second, somewhat related to the first, is a 3-year grant from the W.K. Kellogg Foundation for a special project for development of training materials. The objective of this project is to produce training materials for use by headquarters and regional scientists in training national program scientists and extensionists. While the grant was made in late 1979, it was not until March of 1980 that a training materials specialist joined the Training & Communications Department. During the remainder of the year the specialist focused on two areas of work: evaluation of activities where the materials would be used and development of five publications and slide sets and a series of posters. As with the other training materials it is anticipated these will also be used and adapted by national scientists and ultimately aid in getting the information to farmers in developing countries.

Library

As a special library designed to provide services primarily to CIP scientists at Lima headquarters, at its highland station at Huancayo, and in its regional network of transfer stations, the library also provides support for the training program and conducts an exchange program with 235 libraries in 56 countries.

Selected items continued to be added to its specialized concept in 1980. These related mainly to breeding resistance; virology, with emphasis on potato leaf roll virus (PLRV); seed and plant propagation; and post harvest technology. Additionally, there was a latent interest in appropriate technology and the transfer of technology.

The library's loan service to CIP scientists and visitors in the training program doubled the past year, attributable partly to increasing specialized searches, publishing acquisitions in the weekly internal newsletter, and after-hours service to visiting scientists and extensionists of the training program. A total of 428 interlibrary loans were made.

In direct support of the training program several bibliographies on potato processing, storage, nematology, and seed production were prepared or updated for headquarters and regional training activities. Another bibliography was prepared for a virology planning conference. National scientists and extensionists value highly the opportunity to visit and make use of selected items from the library as some of this information is not readily available at the working level of most national programs.

Locally, needs of some 200 scientists, extensionists, professors of the National Agrarian University at La Molina, and students from various universities conducting potato-associated research were met.

A catalogue of serial publications containing 383 periodical titles, including those by subscription, exchange, or donation, was distributed to the 235 libraries with whom CIP has exchange agreements. Ninety-two of these are in Spanish-speaking countries.

Exchange of information and services were strengthened at several national and international seminars attended by one or several of the library staff. Further, a library assistant participated in a course on agricultural librarianship organized by the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Costa Rica and sponsored by the W.K. Kellogg Foundation in collaboration with the Centro Interamericano de Documentación e Información Agrícola (CIDIA).

Table T&C-1. Accessions to the library and major services rendered.

	1979	1980	Totals to Date
Book Collection Additions	436	980	3,6[illegible]5
Journals by Subscription	65	72	72
Periodicals	396	383	383
Annual Reports	58	76	470
Proceedings	15	3	161
Loans to CIP Staff & Training Program	2,243	4,084	– N/A
Processed Reprints	310	199	2,554
Local Interlibrary Loans	200	428	– N/A
International Exchange Agreements	168 libraries in 47 countries	235 libraries in 56 countries	335 libraries in 56 countries

Publications by CIP Scientists

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Staff

(as of December 31, 1980, or serving a major portion of 1980)

Richard L. Sawyer, PhD . . . . Director General
Roger Rowe, PhD . . . . Deputy Director General
William Hamann, BS . . . . Assistant to Director General

Research Staff

Orville Page, PhD . . . . Director

Breeding and Genetics

Humberto Mendoza, PhD . . . . Department Head
Charles Brown, PhD . . . . Geneticist
Zósimo Huamán, PhD . . . . Geneticist
Masaru Iwanaga, PhD . . . . Cytogeneticist
Juan Landeo, PhD . . . . Breeder
Peter Schmiediche, PhD . . . . Breeder
Paul Thompson, PhD . . . . Geneticist

Nematology and Entomology

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

Pathology

William Hooker, PhD . . . . Acting Head of Department
Fritz Elango . . . . Mycologist
Jan Henfling, PhD . . . . Mycologist
Carlos Martin, PhD . . . . Bacteriologist
Anwar Rizvi, PhD . . . . Virologist-Breeder
Luis Salazar, PhD . . . . Virologist
Edward French, PhD . . . . Pathologist (on leave)

Physiology

Sidki Sadik, PhD . . . . Department Head
Robert Booth, PhD . . . . Physiologist
Adolph Krauss, PhD . . . . Physiologist

Patricio Malagamba, PhD	Physiologist
David Midmore, PhD	Physiologist
Burkhard Sattelmacher, PhD	Physiologist
Lieselotte Schilde, PhD	Physiologist
Roy Shaw, BS	Physiologist
Siert Wiersema, MS	Physiologist

Taxonomy

Carlos Ochoa, MS	Department Head

Research Support

Orville Page, PhD	Department Head
Dennis Cunliffe, Ing. Agr.	Superintendent – Lima, Yurimaguas
Marco Soto, PhD	Superintendent – Huancayo San Ramón
Joseph K. Campbell, PhD	Visiting Agr. Engineer
Enrique Grande	Field Foreman – Huancayo
César Paredes, Ing. Agr.	Field Foreman – San Ramón
Eduardo Belda, Ing. Agr.	Field Foreman – Yurimaguas

Regional Research and Training Staff

Kenneth Brown, PhD	Director
Primo Accatino, PhD	Coordinator of Research Transfer
James E. Bryan, MS	Senior Seed Production Specialist

Region I – South America

Oscar Malamud, PhD	Regional Representative
Andre Devaux, Ing. Agr.	Associate Research Scientist

Region II – Central America, Mexico and the Caribbean

Michael Jackson, PhD	Regional Representative

Region III – Tropical Africa

Sylvester Nganga, PhD	Regional Representative
Dennis Goffinet, PhD	Research Scientist (Rwanda)
Eisse Luitjens, Ir.	Associate Research Scientist
Peter Van Der Zaag, PhD	Research Scientist (Rwanda)

Region IV – Middle East and North Africa

Marciano Morales Bermudez, MS	Regional Representative
Anton Haverkort, Ir.	Associate Research Scientist
Brian Honess, DTA	Seed Production Specialist
Willem Shrage, Ir.	Research Scientist (Tunisia)

Region V – Southeast Asia

Gary Robertson, MS	Regional Representative

Region VI — India, Nepal and Bangladesh

Hari Kishore, PhD .... Regional Representative

Region VII — Southeast Asia

Lindsay Harmsworth, BS .... Regional Representative
Michael Potts, PhD .... Agronomist
Bharat L. Karmacharya, PhD .... Research Scientist (Philippines)
Richarte Acasio, MS .... Research Scientist

Social Science Department

Douglas Horton, PhD .... Department Head
Roger Cortbaoui, PhD .... Agronomist/Economist
Aníbal Monares, MS .... Economist (on leave)
Susan Poats, PhD .... Anthropologist
Luis Quintanilla, MS .... Economist/Statistician
Robert Rhoades, PhD .... Anthropologist

Training and Communications Department

Manuel Piña, PhD .... Department Head
Hernán Rincón, PhD .... Spanish Editor/Publications Manager
Rainer Zachmann, PhD .... Training Materials Officer
Carmen Siri, PhD .... Training Materials Officer
Frank J. Shideler, MS .... Senior Editor
Hilda Berger .... Spanish Writer
María de Boisset, BA .... Photographic & A-V Technician
Carmen de Podestá, MA Inf. Sc. ...... Librarian/Information Officer
Martha Crosby, BA .... Assistant Librarian

Communications Support

Gabriela Bahamonde .... Word Processing
Elsa Franco .... Duplication/Distribution
Godofredo Lagos .... Printing
Víctor Madrid .... Art Work
Jorge Palacios, Dip. .... Language Instructor

Administrative Staff

Office of the Executive Officer

Adrián Fajardo, MS .... Executive Officer
Víctor Barreto, BA .... Assistant Executive Officer
Fernando Canalle, Ing. Civ. .... Supervisor
Georgio de Gasperi .... Supervisor
Ana Dummett .... Social Worker
Germán Rossani, MD .... Medical Officer

Accounting

Leonardo Hussey .... Controller
Oscar Gil, CPA .... Senior Accountant

Jorge Bautista . . . . Accountant
Blanca de Joo, CPA . . . . Accountant
Guillermo Romero . . . . Accountant

Scientific Associates

The following scientists are staff members of the Universidad Agraria or the Ministry of Agriculture and Food of Peru. They make significant contributions to CIP's program through direct departmental research.

Carmen Felipe Morales, PhD . . . . Agronomist
Enrique Fernández-Northcote, PhD . . . . Virologist
César Fribourg, MS . . . . Virologist
Teresa Ames de Icochea, PhD . . . . Mycologist
Sven Villagarcía, PhD . . . . Agronomist

Scientific Assistants

Breeding and Genetics

Luis Calúa, MS
Walter Amoros, MS
Freddy Arana, MS
Ricardo Wissar, MS

Nematology and Entomology

Jesús Alcazar, MS
María Palacios, Biol.
Angela Matos, Ing. Agr.
Marcia Bocangel, BS
Renate Kaltenbach, BBA
Alberto González, MS

Pathology

Jorge Abad, MS
Carlos Chuquillanqui, BS
Wilman Galíndez, Ing. Agr.
Lilian de Lindo, Ing. Agr.
Charlotte Lizarraga, BS
Josefina de Nakashima, Biol.
Ursula Nydegger, Tech. Dip.
Hans Pinedo, Ing. Agr.
Soledad de Rodríguez, Biol.
Herbert Torres, MS
Ernesto Velit, Biol.

Physiology

Nilda Beltran, BS
Donald Berrios, Ing. Agr.
Rolando Cabello, Ing. Agr.
Nelson Espinosa, Q.F.
Rolando Estrada, Biol.
Nelly de Fong, Biol.
Norma González, Q.F.
Rolando Lizarraga, Ing. Agr.
Jorge Roca, Biol.
Alberto Yupanqui, MS

Taxonomy

Matilde Orillo, Biol.
Alberto Salas, BS

Research Support

Lauro Gomez
Nelson Meléndez, Tech. Dip.

Social Science

María Isabel Benavides, BA
Hugo Fano

Social Science Special Project (IDRC)

Jorge Alarcón, BS
Efraín Franco, MS
Patricia Moreno, BS
Luis Tomassini, MS
Ludy Ugarte, BA

Financial Statements

INTERNATIONAL POTATO CENTER - CIP

FINANCIAL STATEMENTS
DECEMBER 31, 1980 AND DECEMBER 31, 1979

SUPPLEMENTARY INFORMATION
DECEMBER 31, 1980

CONTENTS

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

oreno
atiño y Asociados
ASOCIADOS CON PRICE WATERHOUSE

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

April 10, 1981

REPORT OF INDEPENDENT ACCOUNTANTS

To the Board of Trustees
International Potato Center - CIP

In our opinion, the accompanying balance sheet and the related statement of source and application of funds present fairly the financial position of International Potato Center - CIP at December 31, 1980 and the source and application of funds for the year, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year. 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.

The financial statements of International Potato Center - CIP for the year ended December 31, 1979, were examined by other independent accountants whose report dated March 21, 1980, expressed an unqualified opinion on those statements.

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 1980 US$	1979 US$
CURRENT ASSETS		
Cash on hand and in banks	135,610	225,377
Accounts receivable		
Donors	461,169	661,295
Advances to principal and support staff	43,757	50,545
Loans due from principal and support staff-short term (Note 2)	78,764	-
Advances to third parties for research work	54,024	77,403
Other (Note 3)	202,781	198,558
	840,495	987,801
Inventories		
Laboratory, spares and other supplies	544,470	272,201
Vehicles and other fixed assets replaced to be sold	116,502	103,909
	660,972	376,110
Prepaid expenses and other assets	79,241	129,238
Total current assets	1,716,313	1,718,526
LOANS DUE FROM PRINCIPAL AND SUPPORT STAFF - LONG TERM (Note 2)	374,905	-
FIXED ASSETS (Note 4)	4,705,702	4,344,104
	6,796,925	6,062,630

LIABILITIES, CAPITAL BALANCES AND UNEXPENDED FUNDS

	At December 31 1980 US$	1979 US$
CURRENT LIABILITIES		
Bank loan and overdrafts (Note 2)	111,795	26,074
Other loan (Note 5)	100,747	-
Accounts payable to vendors and third parties	272,728	355,981
Other	160,628	137,419
Total current liabilities	645,898	519,474
GRANT RECEIVED IN ADVANCE (Note 6)	139,736	-
PROVISION FOR SEVERANCE INDEMNITIES, net of advances of US$ 12,028 in 1980 and US$ 14,004 in 1979	135,291	109,406
LONG TERM DEBT		
Bank loan (Note 2)	362,373	-
CAPITAL BALANCES AND UNEXPENDED FUNDS		
Capital		
Capitalization of fixed assets	4,705,702	4,344,104
Unexpended funds		
Working funds	632,000	571,000
Core programs	121,487	328,213
Special projects	54,438	190,433
	807,925	1,089,646
	5,513,627	5,433,750
CONTINGENT LIABILITIES (Note 7)		
GRANTS PLEDGED (Note 8)		
	6,796,925	6,062,630

INTERNATIONAL POTATO CENTER - CIP

STATEMENT OF SOURCE AND APPLICATION OF FUNDS (Note 1)

	For the year ended December 31, 1980 US$	1979 US$
SOURCE OF FUNDS		
Operating grants		
Unrestricted	3,530,832	3,330,212
Restricted	3,834,406	3,452,048
	7,365,238	6,782,260
Special projects grants, net of US$ 44,051 paid to donors in 1979	477,534	540,648
Capital grants	329,306	480,387
Working fund grants	632,000	571,000
Other income, net	160,967	127,946
	8,965,045	8,502,241
APPLICATION OF FUNDS		
Core operating expenses		
Potato research program	2,117,039	1,904,342
Research support	676,293	620,835
Regional research and training	2,569,270	2,415,435
Library, documentation and information service	329,825	215,356
General administration	843,650	607,257
General operating costs	868,641	818,769
	7,404,718	6,581,994
Special projects	423,096	350,214
	7,827,814	6,932,208
Capital		
Additions to fixed assets	329,306	480,387
	8,157,120	7,412,595
UNEXPENDED FUNDS	807,925	1,089,646

INTERNATIONAL POTATO CENTER - CIP

NOTES TO FINANCIAL STATEMENTS
DECEMBER 31, 1980 AND DECEMBER 31, 1979

1 OPERATIONS AND SUMMARY OF ACCOUNTING POLICIES

The International Potato Center - CIP was constituted in 1972, in accordance with an Agreement for Scientific Cooperation between the Government of Peru and North Carolina State University, United States of America, signed in 1971 and expiring in 1991.

The CIP is a non-profit organization, located in Lima, Peru. The CIP's principal objective is to contribute to the development of the potato and tuberous roots, at the national and international level, by carrying out research programs, preparation and training of scientists, organization of conferences, forums, seminars and all other activities in accordance with its objectives.

In accordance with existing legal dispositions and the 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 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. The 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 the exchange rate which approximate the official exchange rate at the year end. Translation gain and losses are included in the statement of source and application of funds as other income, net.

b) Grants received and their application are accounted for on an accrual basis. Restricted operating grants and unrestricted grants are accounted for in the period indicated by the donor and, when grants are used abroad, the expenditure is accounted for 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, may be treated as income in the next year in order to absorb the corresponding expenses, otherwise the unexpended balances are recorded as liabilities.

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

Special projects grants are recorded in the year they are received and the related expenses are applied against the repective income when incurred.

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

d) Fixed assets are recorded as application 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.

e) Indemnities to local staff are provided in full in accordance with legal dispositions in Peru.

LOANS TO PRINCIPAL AND SUPPORT STAFF

The CIP has funded loans to principal and support staff for home and vehicles purchases. The balance of the loans granted at December 31, 1980 are presented in the balance sheet as follows:

	US$
Loan-current portion, including interest receivable of US$ 4,765	78,764
Loan-long term portion, including other loans of US$ 8,124	374,905

The above mentioned loans have been financed through a bank loan obtained from Citibank N.A., New York totalling US$ 447,871, bearing interest of 1 1/2% over New York base rate (the same rate charged to the staff loans). The short-term portion payable within one year in accordance with the amortization program to be made by the principal and support staff totals US$ 85,498 and is shown together with interest payable of US$ 8,652 under current liabilities-bank loan and overdrafts in the balance sheet.

3 ACCOUNTS RECEIVABLE - OTHER

This account includes at December 31, the following:

	1980 US$	1979 US$
Advance to contractors and others	50,904	35,604
Current account of Proyecto Suelos Tropicales - Yurimaguas of North Carolina University	73,109	109,126
Travel advances and revolving funds to principal and support staff	62,501	51,938
Deposit in guarantee (Note 7)	4,359	-
Other	11,903	1,890
	202,781	198,558

4 FIXED ASSETS

Fixed assets at December 31, comprise the following:

	1980 US$	1979 US$
Buildings and construction in progress	1,730,586	1,624,469
Research equipment	670,081	614,376
Vehicles and aircraft	776,560	728,970
Furniture, fixture and office equipment	441,346	391,017
Operating equipment	151,978	115,090
Installation	633,288	599,890
Site development	162,935	150,042
Communication equipment	71,415	52,737
Other	67,513	67,513
	4,705,702	4,344,104

5 OTHER LOAN

This account comprises a loan from Proyecto Regional Cooperativa de la Papa (PRECODEPA) totalling US$ 100,747 (including US$ 747 of interest payable) due on February 10, 1981 bearing interest of 20.69% per annum.

6 GRANT RECEIVED IN ADVANCE

During 1980 an additional donation of US$ 139,736 was granted by the Federal German government to be utilized by the CIP during the year 1981.

7 CONTINGENT LIABILITIES

A constructor has filed a lawsuit against the CIP claiming a payment of S/. 6,394,000 (approximately US$ 18,587) that includes S/. 5,000,000 for damages. The CIP has deposited S/. 1,500,340 (US$ 4,359) in a local bank as guarantee (Note 3). In management's opinion and its legal advisor's no significant liability will arise from this contingency for the CIP.

8 GRANTS PLEDGED

During 1980 the following donations were pledged for special projects to be received and applied in 1981 and 1982:

	1981 US$	1982 US$
Swiss-Nepal	65,600	-
International Development Research Center	37,366	-
Federal German Government	71,429	-
W.K. Kellog Foundation	35,000	-
United Nations Development Program	73,600	85,000
	282,995	85,000

oreno
atiño y Asociados
ASOCIAOOS CON PRICE WATERHOUSE

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

April 10, 1981

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 1980, which are covered by our report dated April 10, 1981 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 I

INTERNATIONAL POTATO CENTER - CIP

ACCOUNTS RECEIVABLE - DONORS
DECEMBER 31, 1980

	US$
Rockefeller Foundation	954
Ford Foundation	13,606
International Development Research Center	11,375
Belgian Government	325,607
Swiss Government	75,257
Canadian International Development Agency	18,970
United Nations Development Program	15,400
	461,169

Exhibit 2

INTERNATIONAL POTATO CENTER - CIP

FIXED ASSETS
DECEMBER 31, 1980

	Balance as of 1.1.80	Additions	Replacements		Balance as of 12.31.80
			Additions	Retirements	
	US$	US$	US$	US$	US$
Buildings, and construction in progress	1,624,469	106,117	-	-	1,730,586
Research equipment	614,376	55,271	4,465	4,031	670,081
Vehicles and aircraft	728,970	44,702	71,241	68,353	776,560
Furniture, fixture and office equipment	391,017	41,130	24,873	15,674	441,346
Operating equipment	115,090	33,120	30,260	26,492	151,978
Installation	599,890	21,141	18,956	6,699	633,288
Site development	150,042	12,893	-	-	162,935
Communication equipment	52,737	14,932	3,746	-	71,415
Other	67,513	-	-	-	67,513
	4,344,104	329,306	153,541	121,249	4,705,702

Exhibit 3

INTERNATIONAL POTATO CENTER - CIP

SOURCE OF FUNDS
DECEMBER 31, 1980

	US$	US$
CORE OPERATING GRANTS:		
Multi-purpose		
Danish International Development Agency, Denmark	418,960	
Swiss Development Cooperation, Switzerland	370,943	
International Technical Assistance, The Netherlands	275,000	
	1,064,903	
Less:		
Applied to capital	298,263	
Applied to working funds	61,000	
	705,640	
Core unrestricted grants		
Swedish Agency for Research Cooperation	795,181	
Overseas Development Administration, United Kingdom	502,950	
International Development Agency, Canada	557,245	
Federal German Government	580,276	
Philippines Government	25,000	
Belgian Government	155,050	
	2,615,702	
Plus:		
Balance from previous years	209,490	
Total Unrestricted	2,825,192	3,530,832
Core restricted		
Agency for International Development, USA	1,700,000	
Australian Development Assistance Bureau	196,116	
Federal German Government	84,255	
Interamerican Development Bank	760,000	
Belgian Government	139,514	
European Economic Community	692,298	
French Government	120,000	
Rockefeller Foundation	23,500	
	3,715,683	
Plus:		
Balance from previous years	118,723	3,834,406
		7,365,238
Carried forward:		7,365,238

	US$	US$
Brough forward:		7,365,238
SPECIAL PROJECTS GRANTS:		
Swiss Development Cooperation, Switzerland	105,600	
Federal German Government	9,063	
International Development Research Center	109,166	
International Development Agency, Canada	54,265	
United Nations Development Program	36,400	
Balance from prior years		
W.K. Kellog Foundation	35,000	
Swiss Development Cooperation, Switzerland	19,978	
International Development Agency, Canada	21,679	
Ford Foundation, training and research in Colombia and Ecuador, net of reduction of US$ 27,393 in 1980	15,252	
Federal German Government	39,943	
International Development Research Center	26,614	
Ford Foundation	2,605	
Federal German Government, training and socio-economics	1,779	
Refrigeration Research Foundation	190	477,534
CAPITAL GRANTS:		
Transferred from multi-purpose funds	298,263	
Belgian Government	31,043	329,306
WORKING FUNDS:		
Transferred form multi-purpose funds	61,000	
Balance from previous years	571,000	632,000
OTHER INCOME, net		160,967
		8,965,045

Exhibit 4

INTERNATIONAL POTATO CENTER - CIP

MOVEMENT OF SOURCE AND APPLICATION OF FUNDS OF SPECIAL PROJECTS
DECEMBER 31, 1980

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	124,695	4,372	129,067	(1,767)
Training and research activities in Colombia and Ecuador	54,607	39,355	8,583	47,938	6,669
	181,907	164,050	12,955	177,005	4,902
Federal Germany -					
Training fellowships	13,063	2,221	10,842	13,063	-
Regional Seed Production Specialist	77,962	38,019	74,021	112,040	(34,078)
	91,025	40,240	84,863	125,103	(34,078)
Swiss Development Cooperation, Switzerland -					
Potato improvement - Nepal (First Phase)	187,500	241,649	-	241,649	(54,149)
Potato improvement - Nepal (Second Phase)	196,800	63,463	119,093	182,556	14,244
	384,300	305,112	119,093	424,205	(39,905)
International Development Agency, Canada -					
Potato improvement - Tunisia	275,438	199,494	64,110	263,604	11,834
United Nations Development program -					
Technology transfer on Root and Tubes Crops	36,400	-	2,272	2,272	34,128
Refrigeration Research Foundation -					
Training on potato storage	2,500	2,310	190	2,500	-
International Development Research Center -					
Agro-Economic research on potato production	233,035	134,621	81,389	216,010	17,025
Potato Dehydration	37,366	-	19,988	19,988	17,378
	270,401	134,621	101,377	235,998	34,403
Swiss Development Cooperation, Switzerland -					
Basic Seed Potato Production Training	35,000	-	4,181	4,181	30,819
PRECODEPA - Second Phase	25,000	13,610	720	14,330	10,670
	60,000	13,610	4,901	18,511	41,489
W.K. Kellog Foundation -					
Develop training material	35,000	-	33,335	33,335	1,665
	1,336,971	859,437	423,096	1,282,533	54,438

THE INTERNATIONAL POTATO CENTER

Schedule 1: FUNDS PROVIDED AND COSTS
For the year ended December 31,1980
(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) 3,691.8		1,326.4	1,119.9	215.6	431.3	485.1		113.5	ø
Restricted Core										
USAID	1,700.0		642.4	588.0	75.8	194.0	199.8	23	-	
ADAA	198.6		47.1	151.5	-	-	-	-	-	
Federal Germany	144.6		69.5	52.4	-	13.0	1.7	12	8.0	
IDB	760.0		184.5	361.2	38.4	87.9	88.0	30	-	
Belgium	191.9		-	168.2	-	23.7	-	14	-	
E.E.C.	692.3		431.1	101.1	-	80.0	80.1	30	-	
Rockefeller Foundation	27.0		-	27.0	-	-	-	-	-	
French	120.0		92.3	-	-	13.8	13.9	30	-	
Total Restricted Core	3,834.4		1,466.9	1,449.4	114.2	412.4	383.5		8.0	ø
Total Operating Costs	7,526.2		2,793.3	2,569.3	329.8	843.7	868.6		121.5	ø
Capital Grants										
Belgium	31.0	31.0								
Transferred from multi-purpose	298.3	298.3								
Total Capital	329.3	329.3								
Special Projects										
Ford Foundation	(2) 17.8			11.2		1.7		15	4.9	
Federal Germany	50.8			75.8		9.1		12	(34.1)	
Swiss Dev. Coop.	114.2			107.8		15.5		15	(9.1)	
Swiss - PRECODEPA	11.4		.7	-		-		-	10.7	
CIDA	75.9	3.6		53.0		7.5		14	11.8	
UNDP	36.4			1.8		.5		15	34.1	
Refrigeration Res. Foundation	.2			.2		-		-	-	
IDRC	98.4		70.8	-		10.6		14	17.0	
IDRC-UNA	37.4	9.1	10.9	-		-		-	17.4	
W.K. Kellogg Foundation	35.0			33.3		-		-	1.7	
Total Special Projects	477.5	12.7	82.4	283.1	-	44.9	-		54.4	ø
Working Funds										
Transferred from Multi-purpose	61.0									
Balance from previous year	571.0									
Total Working Funds	632.0								632.0	ø
TOTAL FUNDS AND COSTS	8,965.0	342.0	2,875.7	2,852.4	329.8	888.6	868.6		807.9	ø

1) Includes $161,000 from earned income
2) Net of $27,393 reduced by the donor

THE INTERNATIONAL POTATO CENTER

Schedule 2: EARNED INCOME AND APPLICATIONS

For the year ended December 31, 1980

(Expressed in thousand of U.S. dollars)

	Approved Budget	Actual
Sources of Earned Income		
Interests on Deposits	100	55.6
Sale of Crops & Materials	10	21.6
Sale of Fixed Assets	60	36.1
Indirect Costs charges on Special Projects & Current Accounts	47	97.8
Adjustment prior year	20	50.4
Rate of Exchange adjustment	10	(5.4)
Other	3	2.1
Sub-Total	250	258.2
Less: Auxiliary Services Deficit	(25)	(97.2)
TOTAL	225	161.0
Application of Earned Income		
Applied to Core Operations	225	161.0

THE INTERNATIONAL POTATO CENTER

Schedule 3: COMPARATIVE STATEMENT OF ACTUAL EXPENSES

AND APPROVED BUDGET FOR THE YEAR ENDED DECEMBER 31, 1980

(Expressed in thousand of U.S. dollars)

	Operating Unrestricted		Operating Restricted		Capital	
	Budget	Actual	Budget	Actual	Budget	Actual
Programs						
Potato Research		1,326.4		1,466.9		
Regional Research & Training		1,119.9		1,449.4		
Library, Doc. & Info. Services		215.6		114.2		
General Administration		431.3		412.4		
General Operating Costs		485.1		383.5		
Contingencies		-		-		
	3,852.8	3,578.3	3,834.4	3,826.4		
Capital						
Operating Equipment					45.5	33.1
Research Equipment					49.4	55.3
Vehicles & Aircraft					32.0	44.7
Furnitures, Fixtures & Off. Equip.					44.8	41.1
Installation & Utilities					20.8	21.2
Constructions & Buildings					76.0	106.1
Site Development					-	12.9
Communication Equipment					31.5	14.9
					300.0	329.3
Analysis of Variances						
Budget Surplus						
- Lower earned income	(64.0)					
- Grant shortfall	(67.7)					
- Net surplus		113.5		8.0		
Deficits						
- Covered by Core Operating surplus	(29.3)				29.3	
TOTAL BUDGET VS. EXPENSES AND APPLICATION OF VARIANCES	3,691.8	3,691.8	3,834.4	3,834.4	329.3	329.3

CIP's Worldwide Approach for Improved Potato Production

Transferring technology generated by CIP research to the ultimate farmer-user follows a route to CIP Regional Centers and from there through national programs. The front and inside front cover maps of this 1980 Annual Report of the International Potato Center reflect the worldwide scope of CIP activities. The maps also indicate special contract research sites that make available expertise and facilities from a variety of countries. An important phase of technology transfer is on-farm research in which findings are sought or tested under actual farming conditions in a cooperative effort by farmers and scientists.

Peru, one of the most ecologically diverse countries of the world, is a natural laboratory for biological and agronomic research on the potato (see page vi).

A study comparing Peruvian sites with other world agricultural areas shows that farming systems reflect ecological conditions and variations among zones. Striking parallels are also noted when comparing world areas of similar environments.